



# OpenShift Container Platform 4.9

## Installing

Installing and configuring OpenShift Container Platform clusters



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## Abstract

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

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# CHAPTER 1. OPENSIFT CONTAINER PLATFORM INSTALLATION OVERVIEW

## 1.1. OPENSIFT CONTAINER PLATFORM INSTALLATION OVERVIEW

The OpenShift Container Platform installation program offers you flexibility. You can use the installation program to deploy a cluster on infrastructure that the installation program provisions and the cluster maintains or deploy a cluster on infrastructure that you prepare and maintain.

These two basic types of OpenShift Container Platform clusters are frequently called installer-provisioned infrastructure clusters and user-provisioned infrastructure clusters.

Both types of clusters have the following characteristics:

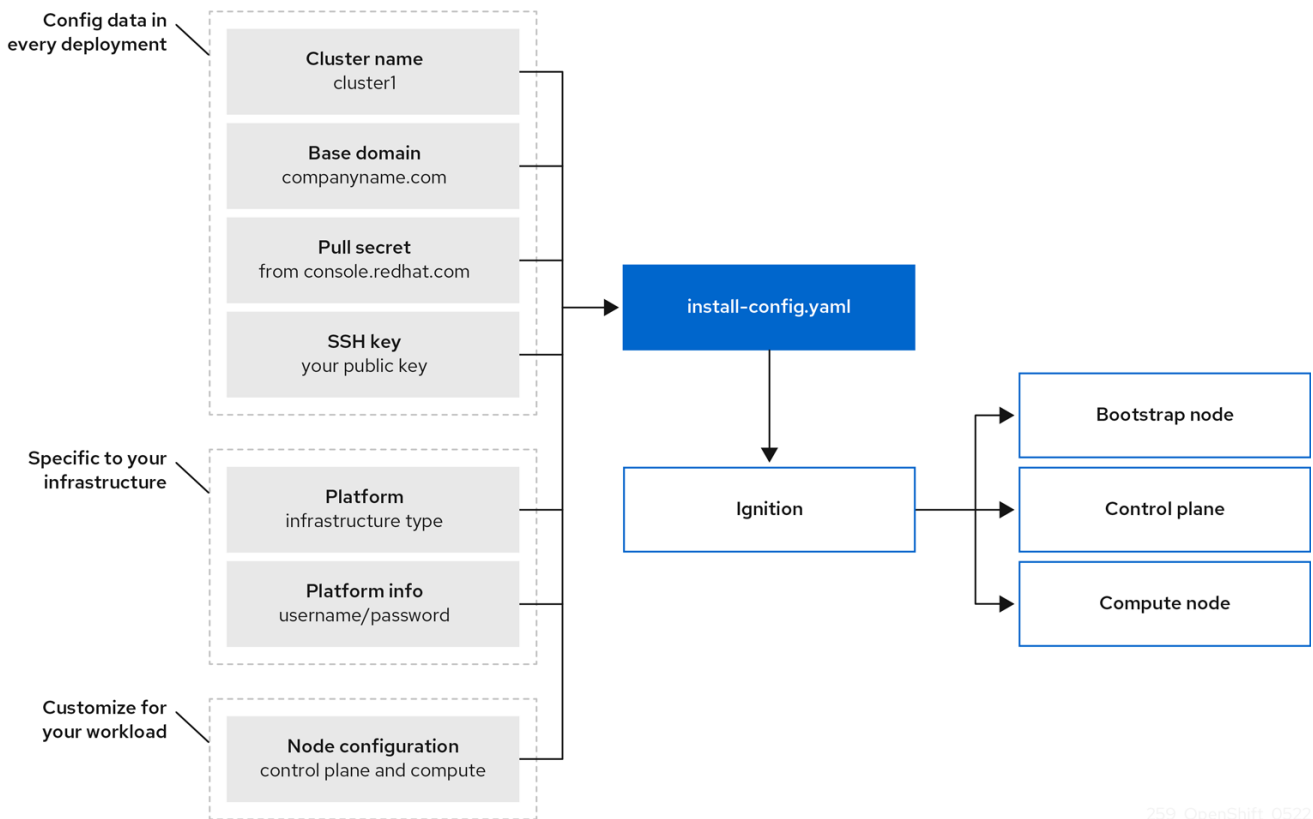
- Highly available infrastructure with no single points of failure is available by default
- Administrators maintain control over what updates are applied and when

You use the same installation program to deploy both types of clusters. The main assets generated by the installation program are the Ignition config files for the bootstrap, master, and worker machines. With these three configurations and correctly configured infrastructure, you can start an OpenShift Container Platform cluster.

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

The following diagram shows a subset of the installation targets and dependencies:

Figure 1.1. OpenShift Container Platform installation targets and dependencies



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

Every control plane machine in an OpenShift Container Platform 4.9 cluster must use RHCOS, which includes a critical first-boot provisioning tool called Ignition. This tool enables the cluster to configure the machines. Operating system updates are delivered as an Atomic OSTree repository that is embedded in a container image that is rolled out across the cluster by an Operator. Actual operating system changes are made in-place on each machine as an atomic operation by using rpm-ostree. Together, these technologies enable OpenShift Container Platform to manage the operating system like it manages any other application on the cluster, via in-place upgrades that keep the entire platform up-to-date. These in-place updates can reduce the burden on operations teams.

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

### 1.1.1. Installation process

When you install an OpenShift Container Platform cluster, you download the installation program from the appropriate [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. This site manages:

- REST API for accounts
- Registry tokens, which are the pull secrets that you use to obtain the required components

- Cluster registration, which associates the cluster identity to your Red Hat account to facilitate the gathering of usage metrics

In OpenShift Container Platform 4.9, the installation program is a Go binary file that performs a series of file transformations on a set of assets. The way you interact with the installation program differs depending on your installation type.

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

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



### IMPORTANT

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

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

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



### IMPORTANT

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

### The installation process with installer-provisioned infrastructure

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

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

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

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

### The installation process with user-provisioned infrastructure

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

If you do not use infrastructure that the installation program provisioned, you must manage and maintain the cluster resources yourself, including:

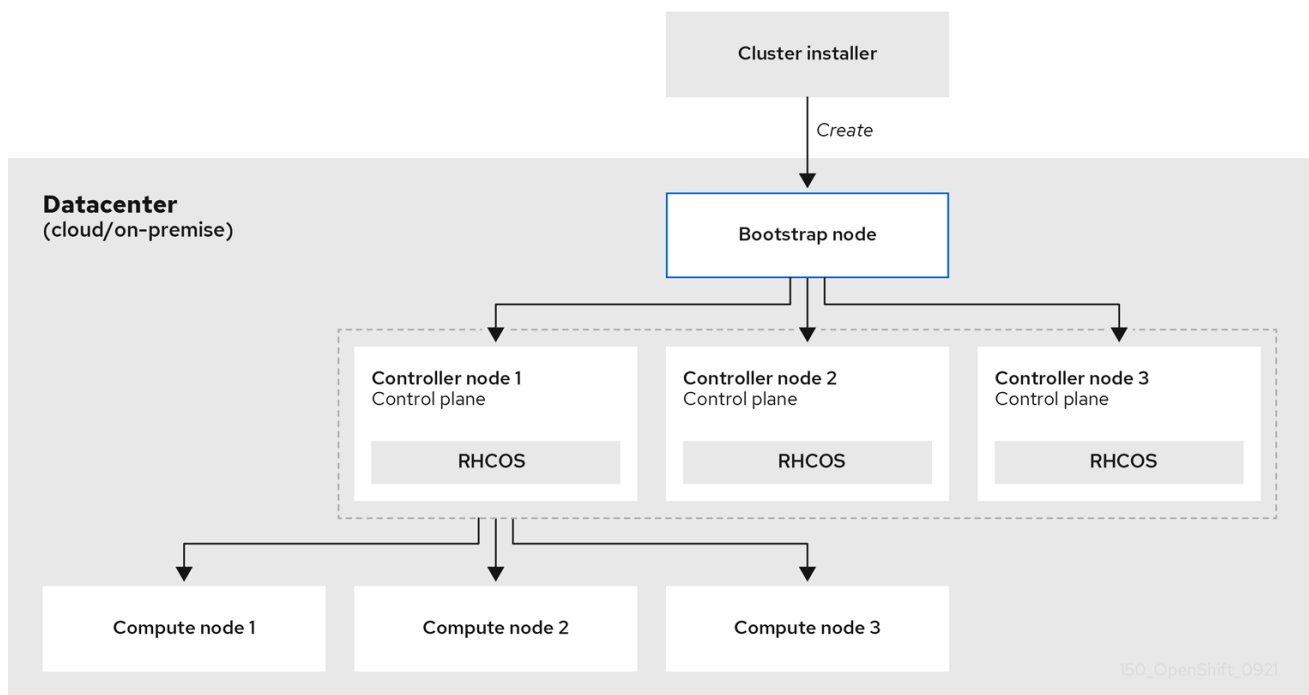
- The underlying infrastructure for the control plane and compute machines that make up the cluster
- Load balancers
- Cluster networking, including the DNS records and required subnets
- Storage for the cluster infrastructure and applications

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

### Installation process details

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

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



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



## IMPORTANT

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

Bootstrapping a cluster involves the following steps:

1. The bootstrap machine boots and starts hosting the remote resources required for the control plane machines to boot. (Requires manual intervention if you provision the infrastructure)
2. The bootstrap machine starts a single-node etcd cluster and a temporary Kubernetes control plane.
3. The control plane machines fetch the remote resources from the bootstrap machine and finish booting. (Requires manual intervention if you provision the infrastructure)
4. The temporary control plane schedules the production control plane to the production control plane machines.
5. The Cluster Version Operator (CVO) comes online and installs the etcd Operator. The etcd Operator scales up etcd on all control plane nodes.
6. The temporary control plane shuts down and passes control to the production control plane.
7. The bootstrap machine injects OpenShift Container Platform components into the production control plane.
8. The installation program shuts down the bootstrap machine. (Requires manual intervention if you provision the infrastructure)
9. The control plane sets up the compute nodes.
10. The control plane installs additional services in the form of a set of Operators.

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

### 1.1.2. Verifying node state after installation

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

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



## NOTE

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

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

## Prerequisites

- The installation program resolves successfully in the terminal.

## Procedure

1. Show the status of all worker nodes:

```
$ oc get nodes
```

### Example output

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

2. Show the phase of all worker machine nodes:

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

### Example output

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

openshift-machine-api	example-zbbt6-worker-0-8b4c2	Running	49m
openshift-machine-api	example-zbbt6-worker-0-jkbqt	Running	49m
openshift-machine-api	example-zbbt6-worker-0-ql5b	Running	49m

### Additional resources

- [Following the installation](#)
- [Validating an installation](#)

### Installation scope

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

### Additional resources

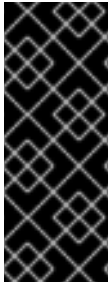
- See [Available cluster customizations](#) for details about OpenShift Container Platform configuration resources.

## 1.2. SUPPORTED PLATFORMS FOR OPENSIFT CONTAINER PLATFORM CLUSTERS

In OpenShift Container Platform 4.9, you can install a cluster that uses installer-provisioned infrastructure on the following platforms:

- Amazon Web Services (AWS)
- Google Cloud Platform (GCP)
- Microsoft Azure
- Red Hat OpenStack Platform (RHOSP) versions 16.1 and 16.2
  - The latest OpenShift Container Platform release supports both the latest RHOSP long-life release and intermediate release. For complete RHOSP release compatibility, see the [OpenShift Container Platform on RHOSP support matrix](#).
- Red Hat Virtualization (RHV)
- VMware vSphere
- VMware Cloud (VMC) on AWS
- Bare metal

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



## IMPORTANT

After installation, the following changes are not supported:

- Mixing cloud provider platforms
- Mixing cloud provider components, such as using a persistent storage framework from a differing platform than what the cluster is installed on

In OpenShift Container Platform 4.9, you can install a cluster that uses user-provisioned infrastructure on the following platforms:

- AWS
- Azure
- Azure Stack Hub
- GCP
- RHOSP versions 16.1 and 16.2
- RHV
- VMware vSphere
- VMware Cloud on AWS
- Bare metal
- IBM Z or LinuxONE
- IBM Power

Depending on the supported cases for the platform, installations on user-provisioned infrastructure allow you to run machines with full internet access, place your cluster behind a proxy, or perform a *restricted network installation*. In a restricted network installation, you can download the images that are required to install a cluster, place them in a mirror registry, and use that data to install your cluster. While you require internet access to pull images for platform containers, with a restricted network installation on vSphere or bare metal infrastructure, your cluster machines do not require direct internet access.

The [OpenShift Container Platform 4.x Tested Integrations](#) page contains details about integration testing for different platforms.

### Additional resources

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



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

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

### 2.1. SELECTING A CLUSTER INSTALLATION TYPE

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

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

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

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

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

If you want to use OpenShift Container Platform but do not want to manage the cluster yourself, you have several managed service options. If you want a cluster that is fully managed by Red Hat, you can use [OpenShift Dedicated](#) or [OpenShift Online](#). You can also use OpenShift as a managed service on Azure, AWS, IBM Cloud, or Google Cloud. For more information about managed services, see the [OpenShift Products](#) page. If you install an OpenShift Container Platform cluster with a cloud virtual machine as a virtual bare metal, the corresponding cloud-based storage is not supported.

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

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

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

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

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

You can deploy an installer-provisioned infrastructure cluster without specifying any customizations to the cluster or its underlying machines to [AWS](#), [Azure](#), [GCP](#), or [VMC on AWS](#). These installation methods are the fastest way to deploy a production-capable OpenShift Container Platform cluster.

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

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

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

If you want to reuse extensive cloud infrastructure, you can complete a *user-provisioned infrastructure* installation. With these installations, you manually deploy the machines that your cluster requires during the installation process. If you perform a user-provisioned infrastructure installation on [AWS](#), [Azure](#), [Azure Stack Hub](#), [GCP](#), or [VMC on AWS](#), you can use the provided templates to help you stand up all of the required components. You can also reuse a shared [VPC on GCP](#). Otherwise, you can use the [provider-agnostic](#) installation method to deploy a cluster into other clouds.

You can also complete a user-provisioned infrastructure installation on your existing hardware. If you use [RHOSP](#), [RHOSP on SR-IOV](#), [RHV](#), [IBM Z or LinuxONE](#), [IBM Z or LinuxONE with RHEL KVM](#), [IBM Power](#), or [vSphere](#), use the specific installation instructions to deploy your cluster. If you use other

supported hardware, follow the [bare metal installation](#) procedure. For some of these platforms, such as [RHOSP](#), [vSphere](#), [VMC on AWS](#), and [bare metal](#), you can also customize additional network parameters during installation.

#### 2.1.4. Do you need extra security for your cluster?

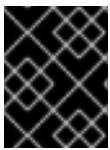
If you use a user-provisioned installation method, you can configure a proxy for your cluster. The instructions are included in each installation procedure.

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

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

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

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



#### IMPORTANT

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

## 2.2. PREPARING YOUR CLUSTER FOR USERS AFTER INSTALLATION

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

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

- [Persistent storage](#)
- [An identity provider](#)
- [Monitoring core OpenShift Container Platform components](#)

## 2.3. PREPARING YOUR CLUSTER FOR WORKLOADS

Depending on your workload needs, you might need to take extra steps before you begin deploying applications. For example, after you prepare infrastructure to support your application [build strategy](#), you might need to make provisions for [low-latency](#) workloads or to [protect sensitive workloads](#). You can also configure [monitoring](#) for application workloads. If you plan to run [Windows workloads](#), you must enable [hybrid networking with OVN-Kubernetes](#) during the installation process; hybrid networking cannot be enabled after your cluster is installed.

## 2.4. SUPPORTED INSTALLATION METHODS FOR DIFFERENT PLATFORMS

You can perform different types of installations on different platforms.



### NOTE

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

Table 2.1. Installer-provisioned infrastructure options

	AWS	Azure	GCP	RHO SP	RHO SP on SR- IOV	RHV	Bare meta l	vSph ere	VMC	IBM Z	IBM Powe r
Default	✓	✓	✓			✓	✓	✓	✓		
Custom	✓	✓	✓	✓	✓	✓		✓	✓		
Network customization	✓	✓	✓	✓				✓	✓		
Restricted network	✓		✓	✓		✓	✓	✓	✓		
Private clusters	✓	✓	✓								
Existing virtual private networks	✓	✓	✓								

	AWS	Azure	GCP	RHO SP	RHO SP on SR- IOV	RHV	Bare meta l	vSph ere	VMC	IBM Z	IBM Powe r
Government regions	✓	✓									
China regions	✓										

Table 2.2. User-provisioned infrastructure options

	AW S	Azu re	Azu re Sta ck Hu b	GC P	RH OS P	RH OS P on SR- IOV	RH V	Bar e me tal	vSp her e	VM C	IB M Z	IB M Z wit h RH EL KV M	IB M Po wer	Pla tfo rm agn osti c
Custom	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Network customization					✓			✓	✓	✓				
Restricted network	✓			✓			✓	✓	✓	✓	✓	✓	✓	

	AW S	Azu re	Azu re Sta ck Hu b	GC P	RH OS P	RH OS P on SR- IOV	RH V	Bar e me tal	vSp her e	VM C	IB MZ	IB MZ wit h RH EL KV M	IB M Po wer	Pla tfo rm agn osti c
Sha red VP C hos ted out sid e of clus ter proj ect				✓										

## CHAPTER 3. MIRRORING IMAGES FOR A DISCONNECTED INSTALLATION

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



### IMPORTANT

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

### 3.1. PREREQUISITES

- You must have a container image registry that supports [Docker v2-2](#) in the location that will host the OpenShift Container Platform cluster, such as one of the following registries:
  - [Red Hat Quay](#)
  - [JFrog Artifactory](#)
  - [Sonatype Nexus Repository](#)
  - [Harbor](#)

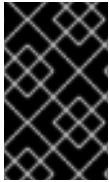
If you have an entitlement to Red Hat Quay, see the documentation on deploying Red Hat Quay [for proof-of-concept purposes](#) or [by using the Quay Operator](#). If you need additional assistance selecting and installing a registry, contact your sales representative or Red Hat support.

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

### 3.2. ABOUT THE MIRROR REGISTRY

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

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



### IMPORTANT

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

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

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

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



### NOTE

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

### Additional information

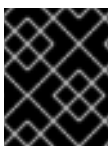
For information on viewing the CRI-O logs to view the image source, see [Viewing the image pull source](#).

## 3.3. PREPARING YOUR MIRROR HOST

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

### 3.3.1. Installing the OpenShift CLI by downloading the binary

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



### IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

### Installing the OpenShift CLI on Linux

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

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.



2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

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

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

```
$ echo $PATH
```

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

```
$ oc <command>
```

### Installing the OpenShift CLI on Windows

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

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

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

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

### Installing the OpenShift CLI on macOS

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

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.

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

```
$ echo $PATH
```

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

```
$ oc <command>
```

## 3.4. CONFIGURING CREDENTIALS THAT ALLOW IMAGES TO BE MIRRORED

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



### WARNING

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



### WARNING

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

### Prerequisites

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

### Procedure

Complete the following steps on the installation host:

1. Download your **registry.redhat.io** [pull secret from the Red Hat OpenShift Cluster Manager](#) and save it to a **.json** file.
2. Generate the base64-encoded user name and password or token for your mirror registry:

```
$ echo -n '<user_name>:<password>' | base64 -w0 1
BGVtbYk3ZHAtdXs=
```

- 1 For **<user\_name>** and **<password>**, specify the user name and password that you configured for your registry.

3. Make a copy of your pull secret in JSON format:

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

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

4. Save the file either as `~/.docker/config.json` or `$XDG_RUNTIME_DIR/containers/auth.json`. The contents of the file resemble the following example:

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

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

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

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

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

The file resembles the following example:

```
{
  "auths": {
    "registry.example.com": {
      "auth": "BGVtbYk3ZHAqXs=",
      "email": "you@example.com"
    },
    "cloud.openshift.com": {
      "auth": "b3BlbnNo...",
      "email": "you@example.com"
    },
    "quay.io": {
      "auth": "b3BlbnNo...",
      "email": "you@example.com"
    },
    "registry.connect.redhat.com": {
      "auth": "NTE3Njg5Nj...",
      "email": "you@example.com"
    },
    "registry.redhat.io": {
      "auth": "NTE3Njg5Nj...",
      "email": "you@example.com"
    }
  }
}
```

### 3.5. MIRROR REGISTRY FOR RED HAT OPENSIFT

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

If you already have a container image registry, such as Red Hat Quay, you can skip these steps and go straight to [Mirroring the OpenShift Container Platform image repository](#).

#### Prerequisites

- An OpenShift Container Platform subscription.
- Red Hat Enterprise Linux (RHEL) 8 with Podman 3.3 and OpenSSL installed.
- Fully qualified domain name for the Red Hat Quay service, which must resolve through a DNS server.
- Passwordless **sudo** access on the target host.
- Key-based SSH connectivity on the target host. SSH keys are automatically generated for local installs. For remote hosts, you must generate your own SSH keys.
- 2 or more vCPUs.
- 8 GB of RAM.

- About 9.6 GB for OpenShift Container Platform 4.9 Release images, or about 444 GB for OpenShift Container Platform 4.9 Release images and OpenShift Container Platform 4.9 Red Hat Operator images. Up to 1 TB per stream or more is suggested.



## IMPORTANT

These requirements are based on local testing results with only Release images and Operator images tested. Storage requirements can vary based on your organization's needs. Some users might require more space, for example, when they mirror multiple z-streams. You can use standard Red Hat Quay functionality to remove unnecessary images and free up space.

### 3.5.1. Mirror registry for Red Hat OpenShift introduction

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

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

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

The *mirror registry for Red Hat OpenShift* is limited to hosting images that are required to install a disconnected OpenShift Container Platform cluster, such as Release images or Red Hat Operator images. It uses local storage on your Red Hat Enterprise Linux (RHEL) machine, and storage supported by RHEL is supported by the *mirror registry for Red Hat OpenShift*. Content built by customers should not be hosted by the *mirror registry for Red Hat OpenShift*.

Unlike Red Hat Quay, the *mirror registry for Red Hat OpenShift* is not a highly-available registry and only local file system storage is supported. Using the *mirror registry for Red Hat OpenShift* with more than one cluster is discouraged, because multiple clusters can create a single point of failure when updating your cluster fleet. It is advised to leverage the *mirror registry for Red Hat OpenShift* to install a cluster that can host a production-grade, highly-available registry such as Red Hat Quay, which can serve OpenShift Container Platform content to other clusters.

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

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

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

**NOTE**

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

**Procedure**

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

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

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

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

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

**NOTE**

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

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

**NOTE**

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

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

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



## NOTE

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

## Procedure

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

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

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

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

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



## NOTE

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

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

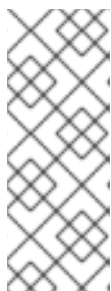
**NOTE**

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

## 3.6. UPGRADING THE MIRROR REGISTRY FOR RED HAT OPENSIFT

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

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

**NOTE**

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

### 3.6.1. Uninstalling the mirror registry for Red Hat OpenShift

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

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

**NOTE**

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

### 3.6.2. Mirror registry for Red Hat OpenShift flags

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

Flags	Description
<b>--autoApprove</b>	A boolean value that disables interactive prompts. If set to <b>true</b> , the <b>quayRoot</b> directory is automatically deleted when uninstalling the mirror registry. Defaults to <b>false</b> if left unspecified.



Flags	Description
<b>--initPassword</b>	The password of the init user created during Quay installation. Must be at least eight characters and contain no whitespace.
<b>--initUser string</b>	Shows the username of the initial user. Defaults to <b>init</b> if left unspecified.
<b>--quayHostname</b>	The fully-qualified domain name of the mirror registry that clients will use to contact the registry. Equivalent to <b>SERVER_HOSTNAME</b> in the Quay <b>config.yaml</b> . Must resolve by DNS. Defaults to <b>&lt;targetHostname&gt;:8443</b> if left unspecified. <sup>[1]</sup>
<b>--quayRoot, -r</b>	The directory where container image layer and configuration data is saved, including <b>rootCA.key</b> , <b>rootCA.pem</b> , and <b>rootCA.srl</b> certificates. Requires about 9.6 GB for OpenShift Container Platform 4.9 Release images, or about 444 GB for OpenShift Container Platform 4.9 Release images and OpenShift Container Platform 4.9 Red Hat Operator images. Defaults to <b>/etc/quay-install</b> if left unspecified.
<b>--ssh-key, -k</b>	The path of your SSH identity key. Defaults to <b>~/ssh/quay_installer</b> if left unspecified.
<b>--sslCert</b>	The path to the SSL/TLS public key / certificate. Defaults to <b>{quayRoot}/quay-config</b> and is auto-generated if left unspecified.
<b>--sslCheckSkip</b>	Skips the check for the certificate hostname against the <b>SERVER_HOSTNAME</b> in the <b>config.yaml</b> file. <sup>[2]</sup>
<b>--sslKey</b>	The path to the SSL/TLS private key used for HTTPS communication. Defaults to <b>{quayRoot}/quay-config</b> and is auto-generated if left unspecified.
<b>--targetHostname, -H</b>	The hostname of the target you want to install Quay to. Defaults to <b>\$HOST</b> , for example, a local host, if left unspecified.
<b>--targetUsername, -u</b>	The user on the target host which will be used for SSH. Defaults to <b>\$USER</b> , for example, the current user if left unspecified.
<b>--verbose, -v</b>	Shows debug logs and Ansible playbook outputs.
<b>--version</b>	Shows the version for the <i>mirror registry for Red Hat OpenShift</i>

1. **--quayHostname** must be modified if the public DNS name of your system is different from the local hostname.
2. **--sslCheckSkip** is used in cases when the mirror registry is set behind a proxy and the exposed hostname is different from the internal Quay hostname. It can also be used when users do not want the certificates to be validated against the provided Quay hostname during installation.

## Additional resources

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

## 3.7. MIRRORING THE OPENSIFT CONTAINER PLATFORM IMAGE REPOSITORY

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

### Prerequisites

- Your mirror host has access to the internet.
- You configured a mirror registry to use in your restricted network and can access the certificate and credentials that you configured.
- You downloaded the [pull secret from the Red Hat OpenShift Cluster Manager](#) and modified it to include authentication to your mirror repository.
- If you use self-signed certificates that do not set a Subject Alternative Name, you must precede the **oc** commands in this procedure with **GODEBUG=x509ignoreCN=0**. If you do not set this variable, the **oc** commands will fail with the following error:

```
x509: certificate relies on legacy Common Name field, use SANs or temporarily enable  
Common Name matching with GODEBUG=x509ignoreCN=0
```

### Procedure

Complete the following steps on the mirror host:

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

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

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

- b. Export the local registry name and host port:

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

For **<local\_registry\_host\_name>**, specify the registry domain name for your mirror repository, and for **<local\_registry\_host\_port>**, specify the port that it serves content on.

- c. Export the local repository name:

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

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

- d. Export the name of the repository to mirror:

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

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

- e. Export the path to your registry pull secret:

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

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

- f. Export the release mirror:

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

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

- g. Export the type of architecture for your server, such as **x86\_64**:

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

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

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

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

3. Mirror the version images to the mirror registry:

- If your mirror host does not have internet access, take the following actions:
  - i. Connect the removable media to a system that is connected to the internet.
  - ii. Review the images and configuration manifests to mirror:

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

- iii. Record the entire **imageContentSources** section from the output of the previous command. The information about your mirrors is unique to your mirrored repository, and you must add the **imageContentSources** section to the **install-config.yaml** file during installation.
- iv. Mirror the images to a directory on the removable media:

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

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

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

- 1** For **REMOVABLE\_MEDIA\_PATH**, you must use the same path that you specified when you mirrored the images.

- If the local container registry is connected to the mirror host, take the following actions:
  - i. Directly push the release images to the local registry by using following command:

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

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

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



#### NOTE

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

4. To create the installation program that is based on the content that you mirrored, extract it and pin it to the release:
  - If your mirror host does not have internet access, run the following command:

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

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

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



### IMPORTANT

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

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

If you are in a disconnected environment, use the **--image** flag as part of `must-gather` and point to the payload image.

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

```
$ openshift-install
```

## 3.8. THE CLUSTER SAMPLES OPERATOR IN A DISCONNECTED ENVIRONMENT

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

### 3.8.1. Cluster Samples Operator assistance for mirroring

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

The format of the key for each entry in the data field in the config map is **<image\_stream\_name>\_<image\_stream\_tag\_name>**.

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



### NOTE

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

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

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

## 3.9. MIRRORING OPERATOR CATALOGS FOR USE WITH DISCONNECTED CLUSTERS

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



### IMPORTANT

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

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

### Additional resources

- [Using Operator Lifecycle Manager on restricted networks](#)

### 3.9.1. Prerequisites

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

- Workstation with unrestricted network access.
- **podman** version 1.9.3 or later.
- If you want to filter, or *prune*, the default catalog and selectively mirror only a subset of Operators, see the following sections:
  - [Installing the opm CLI](#)
  - [Filtering a SQLite-based index image](#)
- If you want to mirror a Red Hat-provided catalog, run the following command on your workstation with unrestricted network access to authenticate with **registry.redhat.io**:

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

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

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

### 3.9.2. Extracting and mirroring catalog contents

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

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

#### 3.9.2.1. Mirroring catalog contents to registries on the same network

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

##### Procedure

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

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

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

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

- 1** Specify the index image for the catalog that you want to mirror. For example, this might be a pruned index image that you created previously, or one of the source index images for the default catalogs, such as **registry.redhat.io/redhat/redhat-operator-index:v4.9**.

- 2 Specify the fully qualified domain name (FQDN) for the target registry and namespace to mirror the Operator contents to, where **<namespace>** is any existing namespace on the registry. For example, you might create an **olm-mirror** namespace to push all mirrored content to.
- 3 Optional: If required, specify the location of your registry credentials file. **{REG\_CREDS}** is required for **registry.redhat.io**.
- 4 Optional: If you do not want to configure trust for the target registry, add the **--insecure** flag.
- 5 Optional: Specify which platform and architecture of the index image to select when multiple variants are available. Images are passed as '**<platform>/<arch>[/<variant>]**'. This does not apply to images referenced by the index. Valid values are **linux/amd64**, **linux/ppc64le**, **linux/s390x**, and **.\***
- 6 Optional: Generate only the manifests required for mirroring, and do not actually mirror the image content to a registry. This option can be useful for reviewing what will be mirrored, and it allows you to make any changes to the mapping list if you require only a subset of packages. You can then use the **mapping.txt** file with the **oc image mirror** command to mirror the modified list of images in a later step. This flag is intended for only advanced selective mirroring of content from the catalog; the **opm index prune** command, if you used it previously to prune the index image, is suitable for most catalog management use cases.

### Example output

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

- 1 Directory for the temporary **index.db** database generated by the command.
- 2 Record the manifests directory name that is generated. This directory is referenced in subsequent procedures.



### NOTE

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

### Additional resources

- [Architecture and operating system support for Operators](#)

### 3.9.2.2. Mirroring catalog contents to airgapped registries



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

## Procedure

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

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

- 1** Specify the index image for the catalog that you want to mirror. For example, this might be a pruned index image that you created previously, or one of the source index images for the default catalogs, such as **registry.redhat.io/redhat/redhat-operator-index:v4.9**.
- 2** Specify the content to mirror to local files in your current directory.
- 3** Optional: If required, specify the location of your registry credentials file.
- 4** Optional: If you do not want to configure trust for the target registry, add the **--insecure** flag.
- 5** Optional: Specify which platform and architecture of the index image to select when multiple variants are available. Images are specified as '**<platform>/<arch>[/<variant>]**'. This does not apply to images referenced by the index. Valid values are **linux/amd64**, **linux/ppc64le**, **linux/s390x**, and **.\***

## Example output

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

To upload local images to a registry, run:

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

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

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

2. Copy the **v2/** directory to removable media.
3. Physically remove the media and attach it to a host in the disconnected environment that has access to the mirror registry.

- If your mirror registry requires authentication, run the following command on your host in the disconnected environment to log in to the registry:

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

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

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

- Specify the **file://** path from the previous command output.
- Specify the fully qualified domain name (FQDN) for the target registry and namespace to mirror the Operator contents to, where **<namespace>** is any existing namespace on the registry. For example, you might create an **olm-mirror** namespace to push all mirrored content to.
- Optional: If required, specify the location of your registry credentials file.
- Optional: If you do not want to configure trust for the target registry, add the **--insecure** flag.
- Optional: Specify which platform and architecture of the index image to select when multiple variants are available. Images are specified as '**<platform>/<arch>/<variant>**'. This does not apply to images referenced by the index. Valid values are **linux/amd64**, **linux/ppc64le**, **linux/s390x**, and **.\***



## NOTE

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

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

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

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



## IMPORTANT

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

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

### Additional resources

- [Architecture and operating system support for Operators](#)

### 3.9.3. Generated manifests

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

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

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

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

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



## NOTE

The manifests directory name is referenced in subsequent procedures.

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

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



## IMPORTANT

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

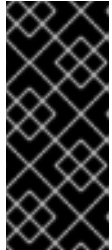
- The **imageContentSourcePolicy.yaml** file defines an **ImageContentSourcePolicy** object that can configure nodes to translate between the image references stored in Operator manifests and the mirrored registry.



## NOTE

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

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



## IMPORTANT

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

### 3.9.4. Post-installation requirements

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

#### Additional resources

- [Populating OperatorHub from mirrored Operator catalogs](#)

## 3.10. NEXT STEPS

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

## 3.11. ADDITIONAL RESOURCES

- See [Gathering data about specific features](#) for more information about using must-gather.

## CHAPTER 4. INSTALLING ON AWS

### 4.1. PREPARING TO INSTALL ON AWS

#### 4.1.1. Prerequisites

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

#### 4.1.2. Requirements for installing OpenShift Container Platform on AWS

Before installing OpenShift Container Platform on Amazon Web Services (AWS), you must create an AWS account. See [Configuring an AWS account](#) for details about configuring an account, account limits, account permissions, IAM user setup, and supported AWS regions.

If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, see [Manually creating IAM for AWS](#) for other options, including [configuring the Cloud Credential Operator \(CCO\) to use the Amazon Web Services Security Token Service \(AWS STS\)](#).

#### 4.1.3. Choosing a method to install OpenShift Container Platform on AWS

You can install OpenShift Container Platform on installer-provisioned or user-provisioned infrastructure. The default installation type uses installer-provisioned infrastructure, where the installation program provisions the underlying infrastructure for the cluster. You can also install OpenShift Container Platform on infrastructure that you provision. If you do not use infrastructure that the installation program provisions, you must manage and maintain the cluster resources yourself.

See [Installation process](#) for more information about installer-provisioned and user-provisioned installation processes.

##### 4.1.3.1. Installing a cluster on installer-provisioned infrastructure

You can install a cluster on AWS infrastructure that is provisioned by the OpenShift Container Platform installation program, by using one of the following methods:

- [Installing a cluster quickly on AWS](#) You can install OpenShift Container Platform on AWS infrastructure that is provisioned by the OpenShift Container Platform installation program. You can install a cluster quickly by using the default configuration options.
- [Installing a customized cluster on AWS](#) You can install a customized cluster on AWS infrastructure that the installation program provisions. The installation program allows for some customization to be applied at the installation stage. Many other customization options are available [post-installation](#).
- [Installing a cluster on AWS with network customizations](#) You can customize your OpenShift Container Platform network configuration during installation, so that your cluster can coexist with your existing IP address allocations and adhere to your network requirements.
- [Installing a cluster on AWS in a restricted network](#) You can install OpenShift Container Platform on AWS on installer-provisioned infrastructure by using an internal mirror of the

installation release content. You can use this method to install a cluster that does not require an active internet connection to obtain the software components.

- **Installing a cluster on an existing Virtual Private Cloud** You can install OpenShift Container Platform on an existing AWS Virtual Private Cloud (VPC). You can use this installation method if you have constraints set by the guidelines of your company, such as limits when creating new accounts or infrastructure.
- **Installing a private cluster on an existing VPC** You can install a private cluster on an existing AWS VPC. You can use this method to deploy OpenShift Container Platform on an internal network that is not visible to the internet.
- **Installing a cluster on AWS into a government or secret region** OpenShift Container Platform can be deployed into AWS regions that are specifically designed for US government agencies at the federal, state, and local level, as well as contractors, educational institutions, and other US customers that must run sensitive workloads in the cloud.

#### 4.1.3.2. Installing a cluster on user-provisioned infrastructure

You can install a cluster on AWS infrastructure that you provision, by using one of the following methods:

- **Installing a cluster on AWS infrastructure that you provide** You can install OpenShift Container Platform on AWS infrastructure that you provide. You can use the provided CloudFormation templates to create stacks of AWS resources that represent each of the components required for an OpenShift Container Platform installation.
- **Installing a cluster on AWS in a restricted network with user-provisioned infrastructure** You can install OpenShift Container Platform on AWS infrastructure that you provide by using an internal mirror of the installation release content. You can use this method to install a cluster that does not require an active internet connection to obtain the software components. You can also use this installation method to ensure that your clusters only use container images that satisfy your organizational controls on external content. While you can install OpenShift Container Platform by using the mirrored content, your cluster still requires internet access to use the AWS APIs.

#### 4.1.4. Next steps

- [Configuring an AWS account](#)

## 4.2. CONFIGURING AN AWS ACCOUNT

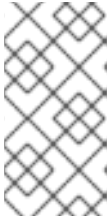
Before you can install OpenShift Container Platform, you must configure an Amazon Web Services (AWS) account.

### 4.2.1. Configuring Route 53

To install OpenShift Container Platform, the Amazon Web Services (AWS) account you use must have a dedicated public hosted zone in your Route 53 service. This zone must be authoritative for the domain. The Route 53 service provides cluster DNS resolution and name lookup for external connections to the cluster.

#### Procedure

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

**NOTE**

If you purchase a new domain through AWS, it takes time for the relevant DNS changes to propagate. For more information about purchasing domains through AWS, see [Registering Domain Names Using Amazon Route 53](#) in the AWS documentation.

2. If you are using an existing domain and registrar, migrate its DNS to AWS. See [Making Amazon Route 53 the DNS Service for an Existing Domain](#) in the AWS documentation.
3. Create a public hosted zone for your domain or subdomain. See [Creating a Public Hosted Zone](#) in the AWS documentation.  
Use an appropriate root domain, such as **openshiftcorp.com**, or subdomain, such as **clusters.openshiftcorp.com**.
4. Extract the new authoritative name servers from the hosted zone records. See [Getting the Name Servers for a Public Hosted Zone](#) in the AWS documentation.
5. Update the registrar records for the AWS Route 53 name servers that your domain uses. For example, if you registered your domain to a Route 53 service in a different accounts, see the following topic in the AWS documentation: [Adding or Changing Name Servers or Glue Records](#).
6. If you are using a subdomain, add its delegation records to the parent domain. This gives Amazon Route 53 responsibility for the subdomain. Follow the delegation procedure outlined by the DNS provider of the parent domain. See [Creating a subdomain that uses Amazon Route 53 as the DNS service without migrating the parent domain](#) in the AWS documentation for an example high level procedure.

#### 4.2.1.1. Ingress Operator endpoint configuration for AWS Route 53

If you install in either Amazon Web Services (AWS) GovCloud (US) US-West or US-East region, the Ingress Operator uses **us-gov-west-1** region for Route53 and tagging API clients.

The Ingress Operator uses <https://tagging.us-gov-west-1.amazonaws.com> as the tagging API endpoint if a tagging custom endpoint is configured that includes the string 'us-gov-east-1'.

For more information on AWS GovCloud (US) endpoints, see the [Service Endpoints](#) in the AWS documentation about GovCloud (US).

**IMPORTANT**

Private, disconnected installations are not supported for AWS GovCloud when you install in the **us-gov-east-1** region.

#### Example Route 53 configuration

```
platform:
  aws:
    region: us-gov-west-1
    serviceEndpoints:
      - name: ec2
        url: https://ec2.us-gov-west-1.amazonaws.com
      - name: elasticloadbalancing
        url: https://elasticloadbalancing.us-gov-west-1.amazonaws.com
      - name: route53
```

```
url: https://route53.us-gov.amazonaws.com 1
- name: tagging
url: https://tagging.us-gov-west-1.amazonaws.com 2
```

- 1** Route 53 defaults to <https://route53.us-gov.amazonaws.com> for both AWS GovCloud (US) regions.
- 2** Only the US-West region has endpoints for tagging. Omit this parameter if your cluster is in another region.


## 4.2.2. AWS account limits

The OpenShift Container Platform cluster uses a number of Amazon Web Services (AWS) components, and the default [Service Limits](#) affect your ability to install OpenShift Container Platform clusters. If you use certain cluster configurations, deploy your cluster in certain AWS regions, or run multiple clusters from your account, you might need to request additional resources for your AWS account.

The following table summarizes the AWS components whose limits can impact your ability to install and run OpenShift Container Platform clusters.

Component	Number of clusters available by default	Default AWS limit	Description
Instance Limits	Varies	Varies	<p>By default, each cluster creates the following instances:</p> <ul style="list-style-type: none"> <li>● One bootstrap machine, which is removed after installation</li> <li>● Three control plane nodes</li> <li>● Three worker nodes</li> </ul> <p>These instance type counts are within a new account's default limit. To deploy more worker nodes, enable autoscaling, deploy large workloads, or use a different instance type, review your account limits to ensure that your cluster can deploy the machines that you need.</p> <p>In most regions, the bootstrap and worker machines uses an <b>m4.large</b> machines and the control plane machines use <b>m4.xlarge</b> instances. In some regions, including all regions that do not support these instance types, <b>m5.large</b> and <b>m5.xlarge</b> instances are used instead.</p>



Component	Number of clusters available by default	Default AWS limit	Description
Elastic IPs (EIPs)	0 to 1	5 EIPs per account	<p>To provision the cluster in a highly available configuration, the installation program creates a public and private subnet for each <a href="#">availability zone within a region</a>. Each private subnet requires a <a href="#">NAT Gateway</a>, and each NAT gateway requires a separate <a href="#">elastic IP</a>. Review the <a href="#">AWS region map</a> to determine how many availability zones are in each region. To take advantage of the default high availability, install the cluster in a region with at least three availability zones. To install a cluster in a region with more than five availability zones, you must increase the EIP limit.</p> <div style="display: flex; align-items: flex-start; margin-top: 20px;">  <div> <p><b>IMPORTANT</b></p> <p>To use the <b>us-east-1</b> region, you must increase the EIP limit for your account.</p> </div> </div>
Virtual Private Clouds (VPCs)	5	5 VPCs per region	Each cluster creates its own VPC.
Elastic Load Balancing (ELB/NLB)	3	20 per region	By default, each cluster creates internal and external network load balancers for the master API server and a single classic elastic load balancer for the router. Deploying more Kubernetes <b>Service</b> objects with type <b>LoadBalancer</b> will create additional <a href="#">load balancers</a> .
NAT Gateways	5	5 per availability zone	The cluster deploys one NAT gateway in each availability zone.
Elastic Network Interfaces (ENIs)	At least 12	350 per region	<p>The default installation creates 21 ENIs and an ENI for each availability zone in your region. For example, the <b>us-east-1</b> region contains six availability zones, so a cluster that is deployed in that zone uses 27 ENIs. Review the <a href="#">AWS region map</a> to determine how many availability zones are in each region.</p> <p>Additional ENIs are created for additional machines and elastic load balancers that are created by cluster usage and deployed workloads.</p>

Component	Number of clusters available by default	Default AWS limit	Description
VPC Gateway	20	20 per account	Each cluster creates a single VPC Gateway for S3 access.
S3 buckets	99	100 buckets per account	Because the installation process creates a temporary bucket and the registry component in each cluster creates a bucket, you can create only 99 OpenShift Container Platform clusters per AWS account.
Security Groups	250	2,500 per account	Each cluster creates 10 distinct security groups.

### 4.2.3. Required AWS permissions for the IAM user



#### NOTE

Your IAM user must have the permission **tag:GetResources** in the region **us-east-1** to delete the base cluster resources. As part of the AWS API requirement, the OpenShift Container Platform installation program performs various actions in this region.

When you attach the **AdministratorAccess** policy to the IAM user that you create in Amazon Web Services (AWS), you grant that user all of the required permissions. To deploy all components of an OpenShift Container Platform cluster, the IAM user requires the following permissions:

#### Example 4.1. Required EC2 permissions for installation

- **ec2:AuthorizeSecurityGroupEgress**
- **ec2:AuthorizeSecurityGroupIngress**
- **ec2:CopyImage**
- **ec2:CreateNetworkInterface**
- **ec2:AttachNetworkInterface**
- **ec2:CreateSecurityGroup**
- **ec2:CreateTags**
- **ec2:CreateVolume**
- **ec2>DeleteSecurityGroup**
- **ec2>DeleteSnapshot**
- **ec2>DeleteTags**

- **ec2:DeregisterImage**
- **ec2:DescribeAccountAttributes**
- **ec2:DescribeAddresses**
- **ec2:DescribeAvailabilityZones**
- **ec2:DescribeDhcpOptions**
- **ec2:DescribeImages**
- **ec2:DescribeInstanceAttribute**
- **ec2:DescribeInstanceCreditSpecifications**
- **ec2:DescribeInstances**
- **ec2:DescribeInstanceTypes**
- **ec2:DescribeInternetGateways**
- **ec2:DescribeKeyPairs**
- **ec2:DescribeNatGateways**
- **ec2:DescribeNetworkAcls**
- **ec2:DescribeNetworkInterfaces**
- **ec2:DescribePrefixLists**
- **ec2:DescribeRegions**
- **ec2:DescribeRouteTables**
- **ec2:DescribeSecurityGroups**
- **ec2:DescribeSubnets**
- **ec2:DescribeTags**
- **ec2:DescribeVolumes**
- **ec2:DescribeVpcAttribute**
- **ec2:DescribeVpcClassicLink**
- **ec2:DescribeVpcClassicLinkDnsSupport**
- **ec2:DescribeVpcEndpoints**
- **ec2:DescribeVpcs**
- **ec2:GetEbsDefaultKmsKeyId**
- **ec2:ModifyInstanceAttribute**

- **ec2:ModifyNetworkInterfaceAttribute**
- **ec2:RevokeSecurityGroupEgress**
- **ec2:RevokeSecurityGroupIngress**
- **ec2:RunInstances**
- **ec2:TerminateInstances**

Example 4.2. Required permissions for creating network resources during installation

- **ec2:AllocateAddress**
- **ec2:AssociateAddress**
- **ec2:AssociateDhcpOptions**
- **ec2:AssociateRouteTable**
- **ec2:AttachInternetGateway**
- **ec2:CreateDhcpOptions**
- **ec2:CreateInternetGateway**
- **ec2:CreateNatGateway**
- **ec2:CreateRoute**
- **ec2:CreateRouteTable**
- **ec2:CreateSubnet**
- **ec2:CreateVpc**
- **ec2:CreateVpcEndpoint**
- **ec2:ModifySubnetAttribute**
- **ec2:ModifyVpcAttribute**



**NOTE**

If you use an existing VPC, your account does not require these permissions for creating network resources.

Example 4.3. Required Elastic Load Balancing permissions (ELB) for installation

- **elasticloadbalancing:AddTags**
- **elasticloadbalancing:ApplySecurityGroupsToLoadBalancer**
- **elasticloadbalancing:AttachLoadBalancerToSubnets**

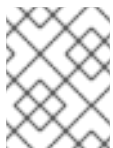
- **elasticloadbalancing:ConfigureHealthCheck**
- **elasticloadbalancing>CreateLoadBalancer**
- **elasticloadbalancing>CreateLoadBalancerListeners**
- **elasticloadbalancing>DeleteLoadBalancer**
- **elasticloadbalancing:DeregisterInstancesFromLoadBalancer**
- **elasticloadbalancing:DescribeInstanceHealth**
- **elasticloadbalancing:DescribeLoadBalancerAttributes**
- **elasticloadbalancing:DescribeLoadBalancers**
- **elasticloadbalancing:DescribeTags**
- **elasticloadbalancing:ModifyLoadBalancerAttributes**
- **elasticloadbalancing:RegisterInstancesWithLoadBalancer**
- **elasticloadbalancing:SetLoadBalancerPoliciesOfListener**

Example 4.4. Required Elastic Load Balancing permissions (ELBv2) for installation

- **elasticloadbalancing:AddTags**
- **elasticloadbalancing>CreateListener**
- **elasticloadbalancing>CreateLoadBalancer**
- **elasticloadbalancing>CreateTargetGroup**
- **elasticloadbalancing>DeleteLoadBalancer**
- **elasticloadbalancing:DeregisterTargets**
- **elasticloadbalancing:DescribeListeners**
- **elasticloadbalancing:DescribeLoadBalancerAttributes**
- **elasticloadbalancing:DescribeLoadBalancers**
- **elasticloadbalancing:DescribeTargetGroupAttributes**
- **elasticloadbalancing:DescribeTargetHealth**
- **elasticloadbalancing:ModifyLoadBalancerAttributes**
- **elasticloadbalancing:ModifyTargetGroup**
- **elasticloadbalancing:ModifyTargetGroupAttributes**
- **elasticloadbalancing:RegisterTargets**

#### Example 4.5. Required IAM permissions for installation

- **iam:AddRoleToInstanceProfile**
- **iam:CreateInstanceProfile**
- **iam:CreateRole**
- **iam:DeleteInstanceProfile**
- **iam>DeleteRole**
- **iam>DeleteRolePolicy**
- **iam:GetInstanceProfile**
- **iam:GetRole**
- **iam:GetRolePolicy**
- **iam:GetUser**
- **iam:ListInstanceProfilesForRole**
- **iam:ListRoles**
- **iam:ListUsers**
- **iam:PassRole**
- **iam:PutRolePolicy**
- **iam:RemoveRoleFromInstanceProfile**
- **iam:SimulatePrincipalPolicy**
- **iam:TagRole**



#### NOTE

If you have not created an elastic load balancer (ELB) in your AWS account, the IAM user also requires the **iam:CreateServiceLinkedRole** permission.

#### Example 4.6. Required Route 53 permissions for installation

- **route53:ChangeResourceRecordSets**
- **route53:ChangeTagsForResource**
- **route53:CreateHostedZone**
- **route53>DeleteHostedZone**
- **route53:GetChange**

- **route53:GetHostedZone**
- **route53:ListHostedZones**
- **route53:ListHostedZonesByName**
- **route53:ListResourceRecordSets**
- **route53:ListTagsForResource**
- **route53:UpdateHostedZoneComment**

Example 4.7. Required S3 permissions for installation

- **s3:CreateBucket**
- **s3>DeleteBucket**
- **s3:GetAccelerateConfiguration**
- **s3:GetBucketAcl**
- **s3:GetBucketCors**
- **s3:GetBucketLocation**
- **s3:GetBucketLogging**
- **s3:GetBucketObjectLockConfiguration**
- **s3:GetBucketReplication**
- **s3:GetBucketRequestPayment**
- **s3:GetBucketTagging**
- **s3:GetBucketVersioning**
- **s3:GetBucketWebsite**
- **s3:GetEncryptionConfiguration**
- **s3:GetLifecycleConfiguration**
- **s3:GetReplicationConfiguration**
- **s3:ListBucket**
- **s3:PutBucketAcl**
- **s3:PutBucketTagging**
- **s3:PutEncryptionConfiguration**

Example 4.8. S3 permissions that cluster Operators require

- **s3:DeleteObject**
- **s3:GetObject**
- **s3:GetObjectAcl**
- **s3:GetObjectTagging**
- **s3:GetObjectVersion**
- **s3:PutObject**
- **s3:PutObjectAcl**
- **s3:PutObjectTagging**

Example 4.9. Required permissions to delete base cluster resources

- **autoscaling:DescribeAutoScalingGroups**
- **ec2:DeleteNetworkInterface**
- **ec2:DeleteVolume**
- **elasticloadbalancing:DeleteTargetGroup**
- **elasticloadbalancing:DescribeTargetGroups**
- **iam:DeleteAccessKey**
- **iam:DeleteUser**
- **iam>ListAttachedRolePolicies**
- **iam>ListInstanceProfiles**
- **iam>ListRolePolicies**
- **iam>ListUserPolicies**
- **s3:DeleteObject**
- **s3>ListBucketVersions**
- **tag:GetResources**

Example 4.10. Required permissions to delete network resources

- **ec2:DeleteDhcpOptions**
- **ec2:DeleteInternetGateway**
- **ec2:DeleteNatGateway**
- **ec2:DeleteRoute**



- **ec2:DeleteRouteTable**
- **ec2:DeleteSubnet**
- **ec2:DeleteVpc**
- **ec2:DeleteVpcEndpoints**
- **ec2:DetachInternetGateway**
- **ec2:DisassociateRouteTable**
- **ec2:ReleaseAddress**
- **ec2:ReplaceRouteTableAssociation**



#### NOTE

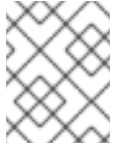
If you use an existing VPC, your account does not require these permissions to delete network resources. Instead, your account only requires the **tag:UntagResources** permission to delete network resources.

#### Example 4.11. Required permissions to delete a cluster with shared instance roles

- **iam:UntagRole**

#### Example 4.12. Additional IAM and S3 permissions that are required to create manifests

- **iam>DeleteAccessKey**
- **iam>DeleteUser**
- **iam>DeleteUserPolicy**
- **iam:GetUserPolicy**
- **iam>ListAccessKeys**
- **iam:PutUserPolicy**
- **iam:TagUser**
- **s3:PutBucketPublicAccessBlock**
- **s3:GetBucketPublicAccessBlock**
- **s3:PutLifecycleConfiguration**
- **s3:HeadBucket**
- **s3>ListBucketMultipartUploads**
- **s3:AbortMultipartUpload**

**NOTE**

If you are managing your cloud provider credentials with mint mode, the IAM user also requires the **iam:CreateAccessKey** and **iam:CreateUser** permissions.

**Example 4.13. Optional permissions for instance and quota checks for installation**

- **ec2:DescribeInstanceTypeOfferings**
- **servicequotas:ListAWSDefaultServiceQuotas**

**4.2.4. Creating an IAM user**

Each Amazon Web Services (AWS) account contains a root user account that is based on the email address you used to create the account. This is a highly-privileged account, and it is recommended to use it for only initial account and billing configuration, creating an initial set of users, and securing the account.

Before you install OpenShift Container Platform, create a secondary IAM administrative user. As you complete the [Creating an IAM User in Your AWS Account](#) procedure in the AWS documentation, set the following options:

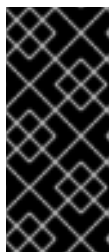
**Procedure**

1. Specify the IAM user name and select **Programmatic access**.
2. Attach the **AdministratorAccess** policy to ensure that the account has sufficient permission to create the cluster. This policy provides the cluster with the ability to grant credentials to each OpenShift Container Platform component. The cluster grants the components only the credentials that they require.

**NOTE**

While it is possible to create a policy that grants the all of the required AWS permissions and attach it to the user, this is not the preferred option. The cluster will not have the ability to grant additional credentials to individual components, so the same credentials are used by all components.

3. Optional: Add metadata to the user by attaching tags.
4. Confirm that the user name that you specified is granted the **AdministratorAccess** policy.
5. Record the access key ID and secret access key values. You must use these values when you configure your local machine to run the installation program.

**IMPORTANT**

You cannot use a temporary session token that you generated while using a multi-factor authentication device to authenticate to AWS when you deploy a cluster. The cluster continues to use your current AWS credentials to create AWS resources for the entire life of the cluster, so you must use key-based, long-lived credentials.

## Additional resources

- See [Manually creating IAM for AWS](#) for steps to set the Cloud Credential Operator (CCO) to manual mode prior to installation. Use this mode in environments where the cloud identity and access management (IAM) APIs are not reachable, or if you prefer not to store an administrator-level credential secret in the cluster **kube-system** project.

### 4.2.5. IAM Policies and AWS authentication

By default, the installation program creates instance profiles for the bootstrap, control plane, and compute instances with the necessary permissions for the cluster to operate.

However, you can create your own IAM roles and specify them as part of the installation process. You might need to specify your own roles to deploy the cluster or to manage the cluster after installation. For example:

- Your organization's security policies require that you use a more restrictive set of permissions to install the cluster.
- After the installation, the cluster is configured with an Operator that requires access to additional services.

If you choose to specify your own IAM roles, you can take the following steps:

- Begin with the default policies and adapt as required. For more information, see "Default permissions for IAM instance profiles".
- Use the AWS Identity and Access Management Access Analyzer (IAM Access Analyzer) to create a policy template that is based on the cluster's activity. For more information see, "Using AWS IAM Analyzer to create policy templates".

#### 4.2.5.1. Default permissions for IAM instance profiles

By default, the installation program creates IAM instance profiles for the bootstrap, control plane and worker instances with the necessary permissions for the cluster to operate.

The following lists specify the default permissions for control plane and compute machines:

##### Example 4.14. Default IAM role permissions for control plane instance profiles

- **ec2:AttachVolume**
- **ec2:AuthorizeSecurityGroupIngress**
- **ec2:CreateSecurityGroup**
- **ec2:CreateTags**
- **ec2:CreateVolume**
- **ec2>DeleteSecurityGroup**
- **ec2>DeleteVolume**
- **ec2:Describe\***
- **ec2:DetachVolume**

- **ec2:ModifyInstanceAttribute**
- **ec2:ModifyVolume**
- **ec2:RevokeSecurityGroupIngress**
- **elasticloadbalancing:AddTags**
- **elasticloadbalancing:AttachLoadBalancerToSubnets**
- **elasticloadbalancing:ApplySecurityGroupsToLoadBalancer**
- **elasticloadbalancing:CreateListener**
- **elasticloadbalancing:CreateLoadBalancer**
- **elasticloadbalancing:CreateLoadBalancerPolicy**
- **elasticloadbalancing:CreateLoadBalancerListeners**
- **elasticloadbalancing:CreateTargetGroup**
- **elasticloadbalancing:ConfigureHealthCheck**
- **elasticloadbalancing>DeleteListener**
- **elasticloadbalancing>DeleteLoadBalancer**
- **elasticloadbalancing>DeleteLoadBalancerListeners**
- **elasticloadbalancing>DeleteTargetGroup**
- **elasticloadbalancing:DeregisterInstancesFromLoadBalancer**
- **elasticloadbalancing:DeregisterTargets**
- **elasticloadbalancing:Describe\***
- **elasticloadbalancing:DetachLoadBalancerFromSubnets**
- **elasticloadbalancing:ModifyListener**
- **elasticloadbalancing:ModifyLoadBalancerAttributes**
- **elasticloadbalancing:ModifyTargetGroup**
- **elasticloadbalancing:ModifyTargetGroupAttributes**
- **elasticloadbalancing:RegisterInstancesWithLoadBalancer**
- **elasticloadbalancing:RegisterTargets**
- **elasticloadbalancing:SetLoadBalancerPoliciesForBackendServer**
- **elasticloadbalancing:SetLoadBalancerPoliciesOfListener**
- **kms:DescribeKey**

#### Example 4.15. Default IAM role permissions for compute instance profiles

- **ec2:DescribeInstances**
- **ec2:DescribeRegions**

#### 4.2.5.2. Specifying an existing IAM role

Instead of allowing the installation program to create IAM instance profiles with the default permissions, you can use the **install-config.yaml** file to specify an existing IAM role for control plane and compute instances.

##### Prerequisites

- You have an existing **install-config.yaml** file.

##### Procedure

1. Update **compute.platform.aws.iamRole** with an existing role for the control plane machines.

##### Sample install-config.yaml file with an IAM role for compute instances

```
compute:
  - hyperthreading: Enabled
    name: worker
  platform:
    aws:
      iamRole: ExampleRole
```

2. Update **controlPlane.platform.aws.iamRole** with an existing role for the compute machines.

##### Sample install-config.yaml file with an IAM role for control plane instances

```
controlPlane:
  hyperthreading: Enabled
  name: master
  platform:
    aws:
      iamRole: ExampleRole
```

3. Save the file and reference it when installing the OpenShift Container Platform cluster.

##### Additional resources

- See [Deploying the cluster](#).

#### 4.2.5.3. Using AWS IAM Analyzer to create policy templates

The minimal set of permissions that the control plane and compute instance profiles require depends on how the cluster is configured for its daily operation.

One way to determine which permissions the cluster instances require is to use the AWS Identity and Access Management Access Analyzer (IAM Access Analyzer) to create a policy template:

- A policy template contains the permissions the cluster has used over a specified period of time.
- You can then use the template to create policies with fine-grained permissions.

## Procedure

The overall process could be:

1. Ensure that CloudTrail is enabled. CloudTrail records all of the actions and events in your AWS account, including the API calls that are required to create a policy template. For more information, see the AWS documentation for [working with CloudTrail](#).
2. Create an instance profile for control plane instances and an instance profile for compute instances. Be sure to assign each role a permissive policy, such as PowerUserAccess. For more information, see the AWS documentation for [creating instance profile roles](#).
3. Install the cluster in a development environment and configure it as required. Be sure to deploy all of applications the cluster will host in a production environment.
4. Test the cluster thoroughly. Testing the cluster ensures that all of the required API calls are logged.
5. Use the IAM Access Analyzer to create a policy template for each instance profile. For more information, see the AWS documentation for [generating policies based on the CloudTrail logs](#).
6. Create and add a fine-grained policy to each instance profile.
7. Remove the permissive policy from each instance profile.
8. Deploy a production cluster using the existing instance profiles with the new policies.



### NOTE

You can add [IAM Conditions](#) to your policy to make it more restrictive and compliant with your organization security requirements.

## 4.2.6. Supported AWS Marketplace regions

Installing an OpenShift Container Platform cluster using an AWS Marketplace image is available to customers who purchase the offer in North America.

While the offer must be purchased in North America, you can deploy the cluster to any of the following supported partitions:

- Public
- GovCloud

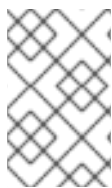


### NOTE

Deploying a OpenShift Container Platform cluster using an AWS Marketplace image is not supported for the AWS secret regions or China regions.

## 4.2.7. Supported AWS regions

You can deploy an OpenShift Container Platform cluster to the following regions.



### NOTE

Your IAM user must have the permission **tag:GetResources** in the region **us-east-1** to delete the base cluster resources. As part of the AWS API requirement, the OpenShift Container Platform installation program performs various actions in this region.

### 4.2.7.1. AWS public regions

The following AWS public regions are supported:

- **af-south-1** (Cape Town)
- **ap-east-1** (Hong Kong)
- **ap-northeast-1** (Tokyo)
- **ap-northeast-2** (Seoul)
- **ap-northeast-3** (Osaka)
- **ap-south-1** (Mumbai)
- **ap-southeast-1** (Singapore)
- **ap-southeast-2** (Sydney)
- **ca-central-1** (Central)
- **eu-central-1** (Frankfurt)
- **eu-north-1** (Stockholm)
- **eu-south-1** (Milan)
- **eu-west-1** (Ireland)
- **eu-west-2** (London)
- **eu-west-3** (Paris)
- **me-south-1** (Bahrain)
- **sa-east-1** (São Paulo)
- **us-east-1** (N. Virginia)
- **us-east-2** (Ohio)
- **us-west-1** (N. California)
- **us-west-2** (Oregon)

### 4.2.7.2. AWS GovCloud regions

The following AWS GovCloud regions are supported:

- **us-gov-west-1**
- **us-gov-east-1**

#### 4.2.7.3. AWS C2S Secret region

The **us-iso-east-1** region is supported.

#### 4.2.7.4. AWS China regions

The following AWS China regions are supported:

- **cn-north-1** (Beijing)
- **cn-northwest-1** (Ningxia)

### 4.2.8. Next steps

- Install an OpenShift Container Platform cluster:
  - [Quickly install a cluster](#) with default options on installer-provisioned infrastructure
  - [Install a cluster with cloud customizations on installer-provisioned infrastructure](#)
  - [Install a cluster with network customizations on installer-provisioned infrastructure](#)
  - [Installing a cluster on user-provisioned infrastructure in AWS by using CloudFormation templates](#)

## 4.3. MANUALLY CREATING IAM FOR AWS

In environments where the cloud identity and access management (IAM) APIs are not reachable, or the administrator prefers not to store an administrator-level credential secret in the cluster **kube-system** namespace, you can put the Cloud Credential Operator (CCO) into manual mode before you install the cluster.

### 4.3.1. Alternatives to storing administrator-level secrets in the kube-system project

The Cloud Credential Operator (CCO) manages cloud provider credentials as Kubernetes custom resource definitions (CRDs). You can configure the CCO to suit the security requirements of your organization by setting different values for the **credentialsMode** parameter in the **install-config.yaml** file.

If you prefer not to store an administrator-level credential secret in the cluster **kube-system** project, you can choose one of the following options when installing OpenShift Container Platform:

- **Use the Amazon Web Services Security Token Service**  
You can use the CCO utility (**ccoctl**) to configure the cluster to use the Amazon Web Services Security Token Service (AWS STS). When the CCO utility is used to configure the cluster for STS, it assigns IAM roles that provide short-term, limited-privilege security credentials to components.



**NOTE**

This credentials strategy is supported for only new OpenShift Container Platform clusters and must be configured during installation. You cannot reconfigure an existing cluster that uses a different credentials strategy to use this feature.

- **Manage cloud credentials manually.**

You can set the **credentialsMode** parameter for the CCO to **Manual** to manage cloud credentials manually. Using manual mode allows each cluster component to have only the permissions it requires, without storing an administrator-level credential in the cluster. You can also use this mode if your environment does not have connectivity to the cloud provider public IAM endpoint. However, you must manually reconcile permissions with new release images for every upgrade. You must also manually supply credentials for every component that requests them.

- **Remove the administrator-level credential secret after installing OpenShift Container Platform with mint mode:**

If you are using the CCO with the **credentialsMode** parameter set to **Mint**, you can remove or rotate the administrator-level credential after installing OpenShift Container Platform. Mint mode is the default configuration for the CCO. This option requires the presence of the administrator-level credential during an installation. The administrator-level credential is used during the installation to mint other credentials with some permissions granted. The original credential secret is not stored in the cluster permanently.

**NOTE**

Prior to a non z-stream upgrade, you must reinstate the credential secret with the administrator-level credential. If the credential is not present, the upgrade might be blocked.

**Additional resources**

- To learn how to use the CCO utility (**ccoctl**) to configure the CCO to use the AWS STS, see [Using manual mode with STS](#).
- To learn how to rotate or remove the administrator-level credential secret after installing OpenShift Container Platform, see [Rotating or removing cloud provider credentials](#).
- For a detailed description of all available CCO credential modes and their supported platforms, see [About the Cloud Credential Operator](#).

**4.3.2. Manually create IAM**

The Cloud Credential Operator (CCO) can be put into manual mode prior to installation in environments where the cloud identity and access management (IAM) APIs are not reachable, or the administrator prefers not to store an administrator-level credential secret in the cluster **kube-system** namespace.

**Procedure**

1. Change to the directory that contains the installation program and create the **install-config.yaml** file by running the following command:

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

where **<installation\_directory>** is the directory in which the installation program creates files.

2. Edit the **install-config.yaml** configuration file so that it contains the **credentialsMode** parameter set to **Manual**.

### Example install-config.yaml configuration file

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

- 1** This line is added to set the **credentialsMode** parameter to **Manual**.

3. To generate the manifests, run the following command from the directory that contains the installation program:

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

where **<installation\_directory>** is the directory in which the installation program creates files.

4. From the directory that contains the installation program, obtain details of the OpenShift Container Platform release image that your **openshift-install** binary is built to use by running the following command:

```
$ openshift-install version
```

### Example output

```
release image quay.io/openshift-release-dev/ocp-release:4.y.z-x86_64
```

5. Locate all **CredentialsRequest** objects in this release image that target the cloud you are deploying on by running the following command:

```
$ oc adm release extract quay.io/openshift-release-dev/ocp-release:4.y.z-x86_64 \
  --credentials-requests \
  --cloud=aws
```

This command creates a YAML file for each **CredentialsRequest** object.

### Sample CredentialsRequest object

```
apiVersion: cloudcredential.openshift.io/v1
kind: CredentialsRequest
metadata:
  name: <component-credentials-request>
  namespace: openshift-cloud-credential-operator
...
spec:
  providerSpec:
```

```

apiVersion: cloudcredential.openshift.io/v1
kind: AWSProviderSpec
statementEntries:
- effect: Allow
  action:
  - iam:GetUser
  - iam:GetUserPolicy
  - iam:ListAccessKeys
  resource: "*"
...

```

6. Create YAML files for secrets in the **openshift-install** manifests directory that you generated previously. The secrets must be stored using the namespace and secret name defined in the **spec.secretRef** for each **CredentialsRequest** object.

### Sample CredentialsRequest object with secrets

```

apiVersion: cloudcredential.openshift.io/v1
kind: CredentialsRequest
metadata:
  name: <component-credentials-request>
  namespace: openshift-cloud-credential-operator
...
spec:
  providerSpec:
    apiVersion: cloudcredential.openshift.io/v1
    kind: AWSProviderSpec
    statementEntries:
    - effect: Allow
      action:
      - s3:CreateBucket
      - s3>DeleteBucket
      resource: "*"
    ...
  secretRef:
    name: <component-secret>
    namespace: <component-namespace>
...

```

### Sample Secret object

```

apiVersion: v1
kind: Secret
metadata:
  name: <component-secret>
  namespace: <component-namespace>
data:
  aws_access_key_id: <base64_encoded_aws_access_key_id>
  aws_secret_access_key: <base64_encoded_aws_secret_access_key>

```



## IMPORTANT

Before upgrading a cluster that uses manually maintained credentials, you must ensure that the CCO is in an upgradeable state. For details, see the "Upgrading clusters with manually maintained credentials" section of the installation content for your cloud provider.

### 4.3.3. Upgrading clusters with manually maintained credentials

The Cloud Credential Operator (CCO) **Upgradable** status for a cluster with manually maintained credentials is **False** by default.

- For minor releases, for example, from 4.8 to 4.9, this status prevents you from upgrading until you have addressed any updated permissions and annotated the **CloudCredential** resource to indicate that the permissions are updated as needed for the next version. This annotation changes the **Upgradable** status to **True**.
- For z-stream releases, for example, from 4.9.0 to 4.9.1, no permissions are added or changed, so the upgrade is not blocked.

Before upgrading a cluster with manually maintained credentials, you must create any new credentials for the release image that you are upgrading to. Additionally, you must review the required permissions for existing credentials and accommodate any new permissions requirements in the new release for those components.

#### Procedure

1. Extract and examine the **CredentialsRequest** custom resource for the new release. The "Manually creating IAM" section of the installation content for your cloud provider explains how to obtain and use the credentials required for your cloud.
2. Update the manually maintained credentials on your cluster:
  - Create new secrets for any **CredentialsRequest** custom resources that are added by the new release image.
  - If the **CredentialsRequest** custom resources for any existing credentials that are stored in secrets have changed their permissions requirements, update the permissions as required.
3. When all of the secrets are correct for the new release, indicate that the cluster is ready to upgrade:
  - a. Log in to the OpenShift Container Platform CLI as a user with the **cluster-admin** role.
  - b. Edit the **CloudCredential** resource to add an **upgradeable-to** annotation within the **metadata** field:

```
$ oc edit cloudcredential cluster
```

#### Text to add

```
...
metadata:
  annotations:
    cloudcredential.openshift.io/upgradeable-to: <version_number>
...
```

-

Where **<version\_number>** is the version you are upgrading to, in the format **x.y.z**. For example, **4.8.2** for OpenShift Container Platform 4.8.2.

It may take several minutes after adding the annotation for the upgradeable status to change.

4. Verify that the CCO is upgradeable:
  - a. In the **Administrator** perspective of the web console, navigate to **Administration → Cluster Settings**.
  - b. To view the CCO status details, click **cloud-credential** in the **Cluster Operators** list.
  - c. If the **Upgradeable** status in the **Conditions** section is **False**, verify that the **upgradeable-to** annotation is free of typographical errors.

When the **Upgradeable** status in the **Conditions** section is **True**, you can begin the OpenShift Container Platform upgrade.

:\_content-type: CONCEPT

#### 4.3.4. Mint mode

Mint mode is the default Cloud Credential Operator (CCO) credentials mode for OpenShift Container Platform. In this mode, the CCO uses the provided administrator-level cloud credential to run the cluster. Mint mode is supported for AWS and GCP.

In mint mode, the **admin** credential is stored in the **kube-system** namespace and then used by the CCO to process the **CredentialsRequest** objects in the cluster and create users for each with specific permissions.

The benefits of mint mode include:

- Each cluster component has only the permissions it requires
- Automatic, on-going reconciliation for cloud credentials, including additional credentials or permissions that might be required for upgrades

One drawback is that mint mode requires **admin** credential storage in a cluster **kube-system** secret.

#### 4.3.5. Mint mode with removal or rotation of the administrator-level credential

Currently, this mode is only supported on AWS and GCP.

In this mode, a user installs OpenShift Container Platform with an administrator-level credential just like the normal mint mode. However, this process removes the administrator-level credential secret from the cluster post-installation.

The administrator can have the Cloud Credential Operator make its own request for a read-only credential that allows it to verify if all **CredentialsRequest** objects have their required permissions, thus the administrator-level credential is not required unless something needs to be changed. After the associated credential is removed, it can be deleted or deactivated on the underlying cloud, if desired.

**NOTE**

Prior to a non z-stream upgrade, you must reinstate the credential secret with the administrator-level credential. If the credential is not present, the upgrade might be blocked.

The administrator-level credential is not stored in the cluster permanently.

Following these steps still requires the administrator-level credential in the cluster for brief periods of time. It also requires manually re-instating the secret with administrator-level credentials for each upgrade.

**4.3.6. Next steps**

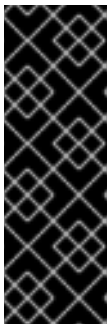
- Install an OpenShift Container Platform cluster:
  - [Installing a cluster quickly on AWS](#) with default options on installer-provisioned infrastructure
  - [Install a cluster with cloud customizations on installer-provisioned infrastructure](#)
  - [Install a cluster with network customizations on installer-provisioned infrastructure](#)
  - [Installing a cluster on user-provisioned infrastructure in AWS by using CloudFormation templates](#)

**4.4. INSTALLING A CLUSTER QUICKLY ON AWS**

In OpenShift Container Platform version 4.9, you can install a cluster on Amazon Web Services (AWS) that uses the default configuration options.

**4.4.1. Prerequisites**

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You [configured an AWS account](#) to host the cluster.

**IMPORTANT**

If you have an AWS profile stored on your computer, it must not use a temporary session token that you generated while using a multi-factor authentication device. The cluster continues to use your current AWS credentials to create AWS resources for the entire life of the cluster, so you must use key-based, long-lived credentials. To generate appropriate keys, see [Managing Access Keys for IAM Users](#) in the AWS documentation. You can supply the keys when you run the installation program.

- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment,

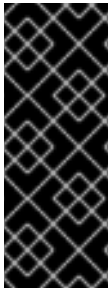
or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can [manually create and maintain IAM credentials](#). Manual mode can also be used in environments where the cloud IAM APIs are not reachable.

#### 4.4.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

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



#### IMPORTANT

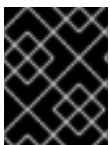
If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation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

#### 4.4.3. Generating a key pair for cluster node SSH access

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

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

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



#### IMPORTANT

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



#### NOTE

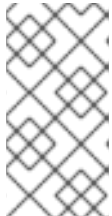
You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

#### Procedure

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

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

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



#### NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

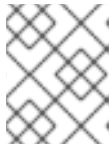
2. View the public SSH key:

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

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

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

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



#### NOTE

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

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

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

#### Example output

```
Agent pid 31874
```



#### NOTE

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

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

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



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

### Example output

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

### Next steps

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

## 4.4.4. Obtaining the installation program

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

### Prerequisites

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

### Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



#### IMPORTANT

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



#### IMPORTANT

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

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

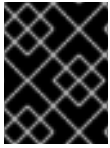
```
$ tar -xvf openshift-install-linux.tar.gz
```

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

components.

#### 4.4.5. Deploying the cluster

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



#### IMPORTANT

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

#### Prerequisites

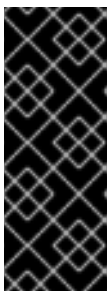
- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

#### Procedure

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

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

- 1** For **<installation\_directory>**, specify the directory name to store the files that the installation program creates.
- 2** To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.



#### IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

Provide values at the prompts:

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



#### NOTE

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

- b. Select **aws** as the platform to target.

- c. If you do not have an Amazon Web Services (AWS) profile stored on your computer, enter the AWS access key ID and secret access key for the user that you configured to run the installation program.

**NOTE**

The AWS access key ID and secret access key are stored in `~/.aws/credentials` in the home directory of the current user on the installation host. You are prompted for the credentials by the installation program if the credentials for the exported profile are not present in the file. Any credentials that you provide to the installation program are stored in the file.

- d. Select the AWS region to deploy the cluster to.
- e. Select the base domain for the Route 53 service that you configured for your cluster.
- f. Enter a descriptive name for your cluster.
- g. Paste the [pull secret from the Red Hat OpenShift Cluster Manager](#) .

**NOTE**

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

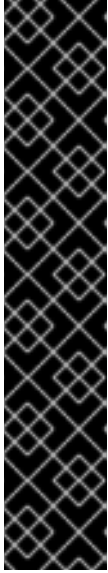
When the cluster deployment completes, directions for accessing your cluster, including a link to its web console and credentials for the **kubeadmin** user, display in your terminal.

**Example output**

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Ee6gm-ymBZj-
Wt5AL"
INFO Time elapsed: 36m22s
```

**NOTE**

The cluster access and credential information also outputs to `<installation_directory>/openshift_install.log` when an installation succeeds.

**IMPORTANT**

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

**IMPORTANT**

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

2. Optional: Remove or disable the **AdministratorAccess** policy from the IAM account that you used to install the cluster.

**NOTE**

The elevated permissions provided by the **AdministratorAccess** policy are required only during installation.

**Additional resources**

- See [Configuration and credential file settings](#) in the AWS documentation for more information about AWS profile and credential configuration.

**4.4.6. Installing the OpenShift CLI by downloading the binary**

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

**IMPORTANT**

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

**Installing the OpenShift CLI on Linux**

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

**Procedure**

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.

3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

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

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

```
$ echo $PATH
```

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

```
$ oc <command>
```

### Installing the OpenShift CLI on Windows

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

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

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

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

### Installing the OpenShift CLI on macOS

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

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your **PATH**.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

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

```
$ oc <command>
```

#### 4.4.7. Logging in to the cluster by using the CLI

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

##### Prerequisites

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

##### Procedure

1. Export the **kubeadmin** credentials:

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

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

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

```
$ oc whoami
```

##### Example output

```
system:admin
```

#### 4.4.8. Logging in to the cluster by using the web console

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

##### Prerequisites

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

##### Procedure

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

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

**NOTE**

Alternatively, you can obtain the **kubeadmin** password from the **<installation\_directory>/openshift\_install.log** log file on the installation host.

- List the OpenShift Container Platform web console route:

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

**NOTE**

Alternatively, you can obtain the OpenShift Container Platform route from the **<installation\_directory>/openshift\_install.log** log file on the installation host.

**Example output**

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

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

**Additional resources**

- See [Accessing the web console](#) for more details about accessing and understanding the OpenShift Container Platform web console.

**4.4.9. Telemetry access for OpenShift Container Platform**

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

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

**Additional resources**

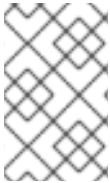
- See [About remote health monitoring](#) for more information about the Telemetry service

**4.4.10. Next steps**

- [Validating an installation.](#)
- [Customize your cluster.](#)
- If necessary, you can [opt out of remote health reporting](#).
- If necessary, you can [remove cloud provider credentials](#).

## 4.5. INSTALLING A CLUSTER ON AWS WITH CUSTOMIZATIONS

In OpenShift Container Platform version 4.9, you can install a customized cluster on infrastructure that the installation program provisions on Amazon Web Services (AWS). To customize the installation, you modify parameters in the **install-config.yaml** file before you install the cluster.

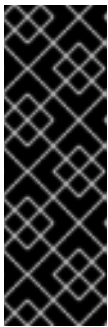


### NOTE

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

### 4.5.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You [configured an AWS account](#) to host the cluster.



### IMPORTANT

If you have an AWS profile stored on your computer, it must not use a temporary session token that you generated while using a multi-factor authentication device. The cluster continues to use your current AWS credentials to create AWS resources for the entire life of the cluster, so you must use long-lived credentials. To generate appropriate keys, see [Managing Access Keys for IAM Users](#) in the AWS documentation. You can supply the keys when you run the installation program.

- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can [manually create and maintain IAM credentials](#).

### 4.5.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

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





## IMPORTANT

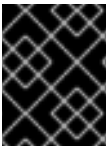
If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation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

### 4.5.3. Generating a key pair for cluster node SSH access

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

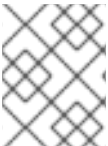
After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

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



## IMPORTANT

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



## NOTE

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

## Procedure

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

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

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



## NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

- View the public SSH key:

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

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

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

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



#### NOTE

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

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

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

#### Example output

```
Agent pid 31874
```



#### NOTE

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

- Add your SSH private key to the `ssh-agent`:

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

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

#### Example output

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

#### Next steps

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

#### 4.5.4. Obtaining an AWS Marketplace image

If you are deploying an OpenShift Container Platform cluster using an AWS Marketplace image, you must first subscribe through AWS. Subscribing to the offer provides you with the AMI ID that the installation program uses to deploy worker nodes.



## NOTE

Deploying an OpenShift Container Platform cluster using an AWS Marketplace image is not supported in the secret regions or China regions.

## Prerequisites

- You have an AWS account to purchase the offer. This account does not have to be the same account that is used to install the cluster.

## Procedure

1. Complete the OpenShift Container Platform subscription from the [AWS Marketplace](#).
2. Record the AMI ID for your specific region. As part of the installation process, you must update the **install-config.yaml** file with this value before deploying the cluster.

## Sample install-config.yaml file with AWS Marketplace worker nodes

```
apiVersion: v1
baseDomain: example.com
compute:
- hyperthreading: Enabled
  name: worker
  platform:
    aws:
      amiID: ami-06c4d345f7c207239 1
      type: m5.4xlarge
    replicas: 3
  metadata:
    name: test-cluster
  platform:
    aws:
      region: us-east-2 2
  sshKey: ssh-ed25519 AAAA...
  pullSecret: '{"auths": ...}'
```

- 1** The AMI ID from your AWS Marketplace subscription.
- 2** Your AMI ID is associated with a specific AWS region. When creating the installation configuration file, ensure that you select the same AWS region that you specified when configuring your subscription.

### 4.5.5. Obtaining the installation program

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

## Prerequisites

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

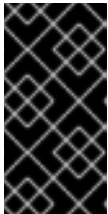
## Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



### IMPORTANT

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



### IMPORTANT

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

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

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

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

## 4.5.6. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Amazon Web Services (AWS).

### Prerequisites

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

### Procedure

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

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

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

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



### IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

- b. At the prompts, provide the configuration details for your cloud:
- i. Optional: Select an SSH key to use to access your cluster machines.



### NOTE

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

- ii. Select **AWS** as the platform to target.
  - iii. If you do not have an Amazon Web Services (AWS) profile stored on your computer, enter the AWS access key ID and secret access key for the user that you configured to run the installation program.
  - iv. Select the AWS region to deploy the cluster to.
  - v. Select the base domain for the Route 53 service that you configured for your cluster.
  - vi. Enter a descriptive name for your cluster.
  - vii. Paste the [pull secret from the Red Hat OpenShift Cluster Manager](#) .
2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.
  3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



### IMPORTANT

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

#### 4.5.6.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.



#### NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.



#### IMPORTANT

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

#### 4.5.6.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 4.1. Required parameters

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;</b> . <b>&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object

Parameter	Description	Values
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}.{{.baseDomain}}</b> .	String of lowercase letters, hyphens (-), and periods (.), such as <b>dev</b> .
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws, baremetal, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } }</pre>


#### 4.5.6.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.


Only IPv4 addresses are supported.

**Table 4.2. Network parameters**

Parameter	Description	Values
-----------	-------------	--------

Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	Object  <b>NOTE</b> You cannot modify parameters specified by the <b>networking</b> object after installation.
<b>networking.networkType</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .
<b>networking.clusterNetwork</b>	The IP address blocks for pods.  The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b> .  If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example:  <pre>networking:   clusterNetwork:     - cidr: 10.128.0.0/14       hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	Required if you use <b>networking.clusterNetwork</b> . An IP address block.  An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b> .
<b>networking.clusterNetwork.hostPrefix</b>	The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b> . A <b>hostPrefix</b> value of <b>23</b> provides 510 ( $2^{(32 - 23)} - 2$ ) pod IP addresses.	A subnet prefix.  The default value is <b>23</b> .




Parameter	Description	Values
<b>networking.serviceNetwork</b>	<p>The IP address block for services. The default value is <b>172.30.0.0/16</b>.</p> <p>The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.</p>	<p>An array with an IP address block in CIDR format. For example:</p> <pre>networking:   serviceNetwork:     - 172.30.0.0/16</pre>
<b>networking.machineNetwork</b>	<p>The IP address blocks for machines.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   machineNetwork:     - cidr: 10.0.0.0/16</pre>
<b>networking.machineNetwork.cidr</b>	<p>Required if you use <b>networking.machineNetwork</b>. An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b>.</p>	<p>An IP network block in CIDR notation.</p> <p>For example, <b>10.0.0.0/16</b>.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p> </div> </div>


#### 4.5.6.1.3. Optional configuration parameters



Optional installation configuration parameters are described in the following table:

Table 4.3. Optional parameters


Parameter	Description	Values
<b>additionalTrustBundle</b>	<p>A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.</p>	String
<b>compute</b>	<p>The configuration for the machines that comprise the compute nodes.</p>	Array of <b>MachinePool</b> objects.

Parameter	Description	Values
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String
<b>compute.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b>
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String

Parameter	Description	Values
<b>controlPlane.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platform</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>controlPlane.replicas</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.

Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.</p> <div data-bbox="485 512 595 864" style="border: 1px solid black; padding: 5px; margin-bottom: 10px;">  </div> <p><b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators reference content</i>.</p> <div data-bbox="485 909 595 1261" style="border: 1px solid black; padding: 5px;">  </div> <p><b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p>	<b>Mint, Passthrough, Manual</b> or an empty string ("").

Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start;"> <div style="width: 40px; height: 40px; background-color: black; margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 40px; height: 40px; background-color: black; margin-right: 10px;"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<b>Internal</b> or <b>External</b> . To deploy a private cluster, which cannot be accessed from the internet, set <b>publish</b> to <b>Internal</b> . The default value is <b>External</b> .

Parameter	Description	Values
<b>sshKey</b>	<p>The SSH key or keys to authenticate access your cluster machines.</p>  <p><b>NOTE</b></p> <p>For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.</p>	<p>One or more keys. For example:</p> <pre>sshKey:   &lt;key1&gt;   &lt;key2&gt;   &lt;key3&gt;</pre>

#### 4.5.6.1.4. Optional AWS configuration parameters

Optional AWS configuration parameters are described in the following table:

Table 4.4. Optional AWS parameters

Parameter	Description	Values
<b>compute.platform.aws.amiID</b>	The AWS AMI used to boot compute machines for the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region.
<b>compute.platform.aws.iamRole</b>	A pre-existing AWS IAM role applied to the compute machine pool instance profiles. You can use these fields to match naming schemes and include predefined permissions boundaries for your IAM roles. If undefined, the installation program creates a new IAM role.	The name of a valid AWS IAM role.
<b>compute.platform.aws.rootVolume.iops</b>	The Input/Output Operations Per Second (IOPS) that is reserved for the root volume.	Integer, for example <b>4000</b> .

Parameter	Description	Values
<b>compute.platform.aws.rootVolume.size</b>	The size in GiB of the root volume.	Integer, for example <b>500</b> .
<b>compute.platform.aws.rootVolume.type</b>	The type of the root volume.	Valid <a href="#">AWS EBS volume type</a> , such as <b>io1</b> .
<b>compute.platform.aws.rootVolume.kmsKeyARN</b>	The Amazon Resource Name (key ARN) of a KMS key. This is required to encrypt OS volumes of worker nodes with a specific KMS key.	Valid <a href="#">key ID</a> or the <a href="#">key ARN</a>
<b>compute.platform.aws.type</b>	The EC2 instance type for the compute machines.	Valid AWS instance type, such as <b>m4.2xlarge</b> . See the <b>Instance types for machines</b> table that follows.
<b>compute.platform.aws.zones</b>	The availability zones where the installation program creates machines for the compute machine pool. If you provide your own VPC, you must provide a subnet in that availability zone.	A list of valid AWS availability zones, such as <b>us-east-1c</b> , in a <a href="#">YAML sequence</a> .
<b>compute.aws.region</b>	The AWS region that the installation program creates compute resources in.	Any valid <a href="#">AWS region</a> , such as <b>us-east-1</b> .
<b>controlPlane.platform.aws.amiID</b>	The AWS AMI used to boot control plane machines for the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region.
<b>controlPlane.platform.aws.iamRole</b>	A pre-existing AWS IAM role applied to the control plane machine pool instance profiles. You can use these fields to match naming schemes and include predefined permissions boundaries for your IAM roles. If undefined, the installation program creates a new IAM role.	The name of a valid AWS IAM role.

Parameter	Description	Values
<b>controlPlane.platform.aws.rootVolume.kmsKeyARN</b>	The Amazon Resource Name (key ARN) of a KMS key. This is required to encrypt OS volumes of control plane nodes with a specific KMS key.	Valid <a href="#">key ID</a> and the <a href="#">key ARN</a>
<b>controlPlane.platform.aws.type</b>	The EC2 instance type for the control plane machines.	Valid AWS instance type, such as <b>m5.xlarge</b> . See the <b>Instance types for machines</b> table that follows.
<b>controlPlane.platform.aws.zones</b>	The availability zones where the installation program creates machines for the control plane machine pool.	A list of valid AWS availability zones, such as <b>us-east-1c</b> , in a <a href="#">YAML sequence</a> .
<b>controlPlane.aws.region</b>	The AWS region that the installation program creates control plane resources in.	Valid <a href="#">AWS region</a> , such as <b>us-east-1</b> .
<b>platform.aws.amiID</b>	The AWS AMI used to boot all machines for the cluster. If set, the AMI must belong to the same region as the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region.
<b>platform.aws.hostedZone</b>	An existing Route 53 private hosted zone for the cluster. You can only use a pre-existing hosted zone when also supplying your own VPC. The hosted zone must already be associated with the user-provided VPC before installation. Also, the domain of the hosted zone must be the cluster domain or a parent of the cluster domain. If undefined, the installation program creates a new hosted zone.	String, for example <b>Z3URY6TWQ91KVV</b> .



Parameter	Description	Values
<b>platform.aws.serviceEndpoints.name</b>	The AWS service endpoint name. Custom endpoints are only required for cases where alternative AWS endpoints, like FIPS, must be used. Custom API endpoints can be specified for EC2, S3, IAM, Elastic Load Balancing, Tagging, Route 53, and STS AWS services.	Valid <a href="#">AWS service endpoint</a> name.
<b>platform.aws.serviceEndpoints.url</b>	The AWS service endpoint URL. The URL must use the <b>https</b> protocol and the host must trust the certificate.	Valid <a href="#">AWS service endpoint</a> URL.
<b>platform.aws.userTags</b>	A map of keys and values that the installation program adds as tags to all resources that it creates.	Any valid YAML map, such as key value pairs in the <b>&lt;key&gt;: &lt;value&gt;</b> format. For more information about AWS tags, see <a href="#">Tagging Your Amazon EC2 Resources</a> in the AWS documentation.
<b>platform.aws.subnets</b>	If you provide the VPC instead of allowing the installation program to create the VPC for you, specify the subnet for the cluster to use. The subnet must be part of the same <b>machineNetwork[].cidr</b> ranges that you specify. For a standard cluster, specify a public and a private subnet for each availability zone. For a private cluster, specify a private subnet for each availability zone.	Valid subnet IDs.

#### 4.5.6.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

**Table 4.5. Minimum resource requirements**

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 7.9, or RHEL 8.4 [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.

#### 4.5.6.3. Supported AWS machine types

The following Amazon Web Services (AWS) instance types are supported with OpenShift Container Platform.

##### Example 4.16. Instance types for machines

Instance type	Bootstrap	Control plane	Compute
<b>i3.large</b>	x		
<b>m4.large</b>			x
<b>m4.xlarge</b>		x	x
<b>m4.2xlarge</b>		x	x
<b>m4.4xlarge</b>		x	x
<b>m4.10xlarge</b>		x	x
<b>m4.16xlarge</b>		x	x
<b>m5.large</b>			x

Instance type	Bootstrap	Control plane	Compute
m5.xlarge		x	x
m5.2xlarge		x	x
m5.4xlarge		x	x
m5.8xlarge		x	x
m5.12xlarge		x	x
m5.16xlarge		x	x
m5a.large			x
m5a.xlarge		x	x
m5a.2xlarge		x	x
m5a.4xlarge		x	x
m5a.8xlarge		x	x
m5a.12xlarge		x	x
m5a.16xlarge		x	x
m6i.xlarge		x	x
m6i.2xlarge		x	x
m6i.4xlarge		x	x
m6i.8xlarge		x	x
m6i.16xlarge		x	x
c4.2xlarge		x	x
c4.4xlarge		x	x
c4.8xlarge		x	x
c5.xlarge			x
c5.2xlarge		x	x

Instance type	Bootstrap	Control plane	Compute
<b>c5.4xlarge</b>		x	x
<b>c5.9xlarge</b>		x	x
<b>c5.12xlarge</b>		x	x
<b>c5.18xlarge</b>		x	x
<b>c5.24xlarge</b>		x	x
<b>c5a.xlarge</b>			x
<b>c5a.2xlarge</b>		x	x
<b>c5a.4xlarge</b>		x	x
<b>c5a.8xlarge</b>		x	x
<b>c5a.12xlarge</b>		x	x
<b>c5a.16xlarge</b>		x	x
<b>c5a.24xlarge</b>		x	x
<b>r4.large</b>			x
<b>r4.xlarge</b>		x	x
<b>r4.2xlarge</b>		x	x
<b>r4.4xlarge</b>		x	x
<b>r4.8xlarge</b>		x	x
<b>r4.16xlarge</b>		x	x
<b>r5.large</b>			x
<b>r5.xlarge</b>		x	x
<b>r5.2xlarge</b>		x	x
<b>r5.4xlarge</b>		x	x
<b>r5.8xlarge</b>		x	x

Instance type	Bootstrap	Control plane	Compute
r5.12xlarge		x	x
r5.16xlarge		x	x
r5.24xlarge		x	x
r5a.large			x
r5a.xlarge		x	x
r5a.2xlarge		x	x
r5a.4xlarge		x	x
r5a.8xlarge		x	x
r5a.12xlarge		x	x
r5a.16xlarge		x	x
r5a.24xlarge		x	x
t3.large			x
t3.xlarge			x
t3.2xlarge			x
t3a.large			x
t3a.xlarge			x
t3a.2xlarge			x

#### 4.5.6.4. Sample customized install-config.yaml file for AWS

You can customize the installation configuration file (**install-config.yaml**) to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.



#### IMPORTANT

This sample YAML file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program and modify it.

```
apiVersion: v1
baseDomain: example.com 1
credentialsMode: Mint 2
controlPlane: 3 4
  hyperthreading: Enabled 5
  name: master
  platform:
    aws:
      zones:
        - us-west-2a
        - us-west-2b
      rootVolume:
        iops: 4000
        size: 500
        type: io1 6
      type: m5.xlarge
    replicas: 3
compute: 7
- hyperthreading: Enabled 8
  name: worker
  platform:
    aws:
      rootVolume:
        iops: 2000
        size: 500
        type: io1 9
      type: c5.4xlarge
      zones:
        - us-west-2c
    replicas: 3
metadata:
  name: test-cluster 10
networking:
  clusterNetwork:
    - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
    - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
    - 172.30.0.0/16
platform:
  aws:
    region: us-west-2 11
    userTags:
      adminContact: jdoe
      costCenter: 7536
    amiID: ami-96c6f8f7 12
    serviceEndpoints: 13
      - name: ec2
        url: https://vpce-id.ec2.us-west-2.vpce.amazonaws.com
  fips: false 14
sshKey: ssh-ed25519 AAAA... 15
pullSecret: '{"auths": ...}' 16
```

- 
- 1 10 11 16 Required. The installation program prompts you for this value.
- 2 Optional: Add this parameter to force the Cloud Credential Operator (CCO) to use the specified mode, instead of having the CCO dynamically try to determine the capabilities of the credentials. For details about CCO modes, see the *Cloud Credential Operator* entry in the *Platform Operators reference* content.
- 3 7 If you do not provide these parameters and values, the installation program provides the default value.
- 4 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. Only one control plane pool is used.
- 5 8 Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.



### IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger instance types, such as **m4.2xlarge** or **m5.2xlarge**, for your machines if you disable simultaneous multithreading.

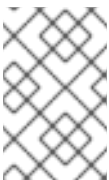
- 6 9 To configure faster storage for etcd, especially for larger clusters, set the storage type as **io1** and set **iopts** to **2000**.
- 12 The ID of the AMI used to boot machines for the cluster. If set, the AMI must belong to the same region as the cluster.
- 13 The AWS service endpoints. Custom endpoints are required when installing to an unknown AWS region. The endpoint URL must use the **https** protocol and the host must trust the certificate.
- 14 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.



### IMPORTANT

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

- 15 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.



### NOTE

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

### 4.5.6.5. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

#### Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



#### NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

- You have added the **ec2.<region>.amazonaws.com**, **elasticloadbalancing.<region>.amazonaws.com**, and **s3.<region>.amazonaws.com** endpoints to your VPC endpoint. These endpoints are required to complete requests from the nodes to the AWS EC2 API. Because the proxy works on the container level, not the node level, you must route these requests to the AWS EC2 API through the AWS private network. Adding the public IP address of the EC2 API to your allowlist in your proxy server is not sufficient.

#### Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
  additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
  ...
```

**1** A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.

**2** A proxy URL to use for creating HTTPS connections outside the cluster.



- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with `.` to match subdomains only. For
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

**NOTE**

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

**NOTE**

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

### 4.5.7. Deploying the cluster

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

**IMPORTANT**

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

#### Prerequisites

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

#### Procedure

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

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

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

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



### NOTE

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

When the cluster deployment completes, directions for accessing your cluster, including a link to its web console and credentials for the **kubeadmin** user, display in your terminal.

### Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Ee6gm-ymBZj-
Wt5AL"
INFO Time elapsed: 36m22s
```



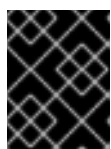
### NOTE

The cluster access and credential information also outputs to **<installation\_directory>/openshift\_install.log** when an installation succeeds.



### IMPORTANT

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



### IMPORTANT

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

- Optional: Remove or disable the **AdministratorAccess** policy from the IAM account that you used to install the cluster.

**NOTE**

The elevated permissions provided by the **AdministratorAccess** policy are required only during installation.

#### 4.5.8. Installing the OpenShift CLI by downloading the binary

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

**IMPORTANT**

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

##### Installing the OpenShift CLI on Linux

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

##### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

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

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

```
$ echo $PATH
```

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

```
$ oc <command>
```

##### Installing the OpenShift CLI on Windows

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

##### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.

5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

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

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

### Installing the OpenShift CLI on macOS

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

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

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

```
$ oc <command>
```

### 4.5.9. Logging in to the cluster by using the CLI

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

#### Prerequisites

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

#### Procedure

1. Export the **kubeadmin** credentials:

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

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

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

```
$ oc whoami
```

#### Example output

```
system:admin
```

### 4.5.10. Logging in to the cluster by using the web console

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

#### Prerequisites

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

#### Procedure

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

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



#### NOTE

Alternatively, you can obtain the **kubeadmin** password from the **<installation\_directory>/openshift\_install.log** log file on the installation host.

2. List the OpenShift Container Platform web console route:

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



#### NOTE

Alternatively, you can obtain the OpenShift Container Platform route from the **<installation\_directory>/openshift\_install.log** log file on the installation host.

#### Example output

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

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

#### Additional resources

- See [Accessing the web console](#) for more details about accessing and understanding the OpenShift Container Platform web console.

#### 4.5.11. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

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

##### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service.

#### 4.5.12. Next steps

- [Validating an installation](#).
- [Customize your cluster](#).
- If necessary, you can [opt out of remote health reporting](#) .
- If necessary, you can [remove cloud provider credentials](#).

## 4.6. INSTALLING A CLUSTER ON AWS WITH NETWORK CUSTOMIZATIONS

In OpenShift Container Platform version 4.9, you can install a cluster on Amazon Web Services (AWS) with customized network configuration options. By customizing your network configuration, your cluster can coexist with existing IP address allocations in your environment and integrate with existing MTU and VXLAN configurations.

You must set most of the network configuration parameters during installation, and you can modify only **kubeProxy** configuration parameters in a running cluster.

### 4.6.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You [configured an AWS account](#) to host the cluster.



## IMPORTANT

If you have an AWS profile stored on your computer, it must not use a temporary session token that you generated while using a multi-factor authentication device. The cluster continues to use your current AWS credentials to create AWS resources for the entire life of the cluster, so you must use key-based, long-lived credentials. To generate appropriate keys, see [Managing Access Keys for IAM Users](#) in the AWS documentation. You can supply the keys when you run the installation program.

- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can [manually create and maintain IAM credentials](#).

### 4.6.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

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



## IMPORTANT

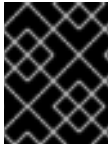
If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation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

### 4.6.3. Generating a key pair for cluster node SSH access

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

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

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

**IMPORTANT**

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

**NOTE**

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

**Procedure**

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

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

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

**NOTE**

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

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

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

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

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

**NOTE**

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

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

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

**Example output**



Agent pid 31874



#### NOTE

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

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

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

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

#### Example output

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

#### Next steps

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

### 4.6.4. Obtaining the installation program

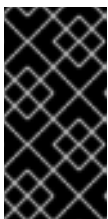
Before you install OpenShift Container Platform, download the installation file on a local computer.

#### Prerequisites

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

#### Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



#### IMPORTANT

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



## IMPORTANT

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

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

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

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

### 4.6.5. Network configuration phases

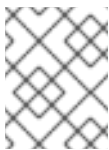
There are two phases prior to OpenShift Container Platform installation where you can customize the network configuration.

#### Phase 1

You can customize the following network-related fields in the **install-config.yaml** file before you create the manifest files:

- **networking.networkType**
- **networking.clusterNetwork**
- **networking.serviceNetwork**
- **networking.machineNetwork**

For more information on these fields, refer to *Installation configuration parameters*.



## NOTE

Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

#### Phase 2

After creating the manifest files by running **openshift-install create manifests**, you can define a customized Cluster Network Operator manifest with only the fields you want to modify. You can use the manifest to specify advanced network configuration.

You cannot override the values specified in phase 1 in the **install-config.yaml** file during phase 2. However, you can further customize the cluster network provider during phase 2.

### 4.6.6. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Amazon Web Services (AWS).

#### Prerequisites

## Prerequisites

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

## Procedure

1. Create the **install-config.yaml** file.
  - a. Change to the directory that contains the installation program and run the following command:

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

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



### IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

- b. At the prompts, provide the configuration details for your cloud:
  - i. Optional: Select an SSH key to use to access your cluster machines.



### NOTE

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

- ii. Select **AWS** as the platform to target.
  - iii. If you do not have an Amazon Web Services (AWS) profile stored on your computer, enter the AWS access key ID and secret access key for the user that you configured to run the installation program.
  - iv. Select the AWS region to deploy the cluster to.
  - v. Select the base domain for the Route 53 service that you configured for your cluster.
  - vi. Enter a descriptive name for your cluster.
  - vii. Paste the [pull secret from the Red Hat OpenShift Cluster Manager](#) .
2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.

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



### IMPORTANT

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

#### 4.6.6.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.



### NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.



### IMPORTANT

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

##### 4.6.6.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 4.6. Required parameters

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;</b> . <b>&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .

Parameter	Description	Values
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}</b> . <b>{{.baseDomain}}</b> .	String of lowercase letters, hyphens (-), and periods (.), such as <b>dev</b> .
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws</b> , <b>baremetal</b> , <b>azure</b> , <b>gcp</b> , <b>openstack</b> , <b>ovirt</b> , <b>vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } }</pre>


#### 4.6.6.1.2. Network configuration parameters

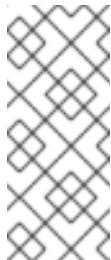
You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

**Table 4.7. Network parameters**

Parameter	Description	Values
-----------	-------------	--------

Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	Object   <b>NOTE</b> You cannot modify parameters specified by the <b>networking</b> object after installation.
<b>networking.networkType</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .
<b>networking.clusterNetwork</b>	The IP address blocks for pods.  The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b> .  If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example:  <pre>networking:   clusterNetwork:   - cidr: 10.128.0.0/14     hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	Required if you use <b>networking.clusterNetwork</b> . An IP address block.  An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b> .
<b>networking.clusterNetwork.hostPrefix</b>	The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b> . A <b>hostPrefix</b> value of <b>23</b> provides 510 ( $2^{(32 - 23)} - 2$ ) pod IP addresses.	A subnet prefix.  The default value is <b>23</b> .
<b>networking.serviceNetwork</b>	The IP address block for services. The default value is <b>172.30.0.0/16</b> .  The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example:  <pre>networking:   serviceNetwork:   - 172.30.0.0/16</pre>


Parameter	Description	Values
<b>networking.machineNetwork</b>	The IP address blocks for machines.  If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example:  <pre>networking:   machineNetwork:     - cidr: 10.0.0.0/16</pre>
<b>networking.machineNetwork.cidr</b>	Required if you use <b>networking.machineNetwork</b> . An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b> .	An IP network block in CIDR notation.  For example, <b>10.0.0.0/16</b> .   <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p>

#### 4.6.6.1.3. Optional configuration parameters


Optional installation configuration parameters are described in the following table:



Table 4.8. Optional parameters

Parameter	Description	Values
<b>additionalTrustBundle</b>	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
<b>compute</b>	The configuration for the machines that comprise the compute nodes.	Array of <b>MachinePool</b> objects.
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String


Parameter	Description	Values
<b>compute.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p>  <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p>	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b>
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String



Parameter	Description	Values
<b>controlPlane.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platform</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>controlPlane.replicas</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.

Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.</p> <p> <b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators reference content</i>.</p> <p> <b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p>	<b>Mint, Passthrough, Manual</b> or an empty string ("").

Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start;"> <div style="width: 40px; height: 40px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 40px; height: 40px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<b>Internal</b> or <b>External</b> . To deploy a private cluster, which cannot be accessed from the internet, set <b>publish</b> to <b>Internal</b> . The default value is <b>External</b> .

Parameter	Description	Values
<b>sshKey</b>	<p>The SSH key or keys to authenticate access your cluster machines.</p>  <p><b>NOTE</b></p> <p>For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.</p>	<p>One or more keys. For example:</p> <pre>sshKey:   &lt;key1&gt;   &lt;key2&gt;   &lt;key3&gt;</pre>

#### 4.6.6.1.4. Optional AWS configuration parameters

Optional AWS configuration parameters are described in the following table:

Table 4.9. Optional AWS parameters

Parameter	Description	Values
<b>compute.platform.aws.amiID</b>	The AWS AMI used to boot compute machines for the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region.
<b>compute.platform.aws.iamRole</b>	A pre-existing AWS IAM role applied to the compute machine pool instance profiles. You can use these fields to match naming schemes and include predefined permissions boundaries for your IAM roles. If undefined, the installation program creates a new IAM role.	The name of a valid AWS IAM role.
<b>compute.platform.aws.rootVolume.iops</b>	The Input/Output Operations Per Second (IOPS) that is reserved for the root volume.	Integer, for example <b>4000</b> .
<b>compute.platform.aws.rootVolume.size</b>	The size in GiB of the root volume.	Integer, for example <b>500</b> .

Parameter	Description	Values
<code>compute.platform.aws.rootVolume.type</code>	The type of the root volume.	Valid <a href="#">AWS EBS volume type</a> , such as <b>io1</b> .
<code>compute.platform.aws.rootVolume.kmsKeyARN</code>	The Amazon Resource Name (key ARN) of a KMS key. This is required to encrypt OS volumes of worker nodes with a specific KMS key.	Valid <a href="#">key ID or the key ARN</a>
<code>compute.platform.aws.type</code>	The EC2 instance type for the compute machines.	Valid AWS instance type, such as <b>m4.2xlarge</b> . See the <b>Instance types for machines</b> table that follows.
<code>compute.platform.aws.zones</code>	The availability zones where the installation program creates machines for the compute machine pool. If you provide your own VPC, you must provide a subnet in that availability zone.	A list of valid AWS availability zones, such as <b>us-east-1c</b> , in a <a href="#">YAML sequence</a> .
<code>compute.aws.region</code>	The AWS region that the installation program creates compute resources in.	Any valid <a href="#">AWS region</a> , such as <b>us-east-1</b> .
<code>controlPlane.platform.aws.amiID</code>	The AWS AMI used to boot control plane machines for the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region.
<code>controlPlane.platform.aws.iamRole</code>	A pre-existing AWS IAM role applied to the control plane machine pool instance profiles. You can use these fields to match naming schemes and include predefined permissions boundaries for your IAM roles. If undefined, the installation program creates a new IAM role.	The name of a valid AWS IAM role.
<code>controlPlane.platform.aws.rootVolume.kmsKeyARN</code>	The Amazon Resource Name (key ARN) of a KMS key. This is required to encrypt OS volumes of control plane nodes with a specific KMS key.	Valid <a href="#">key ID and the key ARN</a>

Parameter	Description	Values
<b>controlPlane.platform.aws.type</b>	The EC2 instance type for the control plane machines.	Valid AWS instance type, such as <b>m5.xlarge</b> . See the <b>Instance types for machines</b> table that follows.
<b>controlPlane.platform.aws.zones</b>	The availability zones where the installation program creates machines for the control plane machine pool.	A list of valid AWS availability zones, such as <b>us-east-1c</b> , in a <a href="#">YAML sequence</a> .
<b>controlPlane.aws.region</b>	The AWS region that the installation program creates control plane resources in.	Valid <a href="#">AWS region</a> , such as <b>us-east-1</b> .
<b>platform.aws.amiID</b>	The AWS AMI used to boot all machines for the cluster. If set, the AMI must belong to the same region as the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region.
<b>platform.aws.hostedZone</b>	An existing Route 53 private hosted zone for the cluster. You can only use a pre-existing hosted zone when also supplying your own VPC. The hosted zone must already be associated with the user-provided VPC before installation. Also, the domain of the hosted zone must be the cluster domain or a parent of the cluster domain. If undefined, the installation program creates a new hosted zone.	String, for example <b>Z3URY6TWQ91KVV</b> .
<b>platform.aws.serviceEndpoints.name</b>	The AWS service endpoint name. Custom endpoints are only required for cases where alternative AWS endpoints, like FIPS, must be used. Custom API endpoints can be specified for EC2, S3, IAM, Elastic Load Balancing, Tagging, Route 53, and STS AWS services.	Valid <a href="#">AWS service endpoint</a> name.

Parameter	Description	Values
<b>platform.aws.serviceEndpoints.url</b>	The AWS service endpoint URL. The URL must use the <b>https</b> protocol and the host must trust the certificate.	Valid <a href="#">AWS service endpoint</a> URL.
<b>platform.aws.userTags</b>	A map of keys and values that the installation program adds as tags to all resources that it creates.	Any valid YAML map, such as key value pairs in the <b>&lt;key&gt;: &lt;value&gt;</b> format. For more information about AWS tags, see <a href="#">Tagging Your Amazon EC2 Resources</a> in the AWS documentation.
<b>platform.aws.subnets</b>	If you provide the VPC instead of allowing the installation program to create the VPC for you, specify the subnet for the cluster to use. The subnet must be part of the same <b>machineNetwork[].cidr</b> ranges that you specify. For a standard cluster, specify a public and a private subnet for each availability zone. For a private cluster, specify a private subnet for each availability zone.	Valid subnet IDs.

#### 4.6.6.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 4.10. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 7.9, or RHEL 8.4 [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio:  $(\text{threads per core} \times \text{cores}) \times \text{sockets} = \text{vCPUs}$ .

2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.

#### 4.6.6.3. Supported AWS machine types

The following Amazon Web Services (AWS) instance types are supported with OpenShift Container Platform.

Example 4.17. Instance types for machines

Instance type	Bootstrap	Control plane	Compute
<b>i3.large</b>	x		
<b>m4.large</b>			x
<b>m4.xlarge</b>		x	x
<b>m4.2xlarge</b>		x	x
<b>m4.4xlarge</b>		x	x
<b>m4.10xlarge</b>		x	x
<b>m4.16xlarge</b>		x	x
<b>m5.large</b>			x
<b>m5.xlarge</b>		x	x
<b>m5.2xlarge</b>		x	x
<b>m5.4xlarge</b>		x	x
<b>m5.8xlarge</b>		x	x
<b>m5.12xlarge</b>		x	x
<b>m5.16xlarge</b>		x	x
<b>m5a.large</b>			x



Instance type	Bootstrap	Control plane	Compute
<b>m5a.xlarge</b>		x	x
<b>m5a.2xlarge</b>		x	x
<b>m5a.4xlarge</b>		x	x
<b>m5a.8xlarge</b>		x	x
<b>m5a.12xlarge</b>		x	x
<b>m5a.16xlarge</b>		x	x
<b>m6i.xlarge</b>		x	x
<b>m6i.2xlarge</b>		x	x
<b>m6i.4xlarge</b>		x	x
<b>m6i.8xlarge</b>		x	x
<b>m6i.16xlarge</b>		x	x
<b>c4.2xlarge</b>		x	x
<b>c4.4xlarge</b>		x	x
<b>c4.8xlarge</b>		x	x
<b>c5.xlarge</b>			x
<b>c5.2xlarge</b>		x	x
<b>c5.4xlarge</b>		x	x
<b>c5.9xlarge</b>		x	x
<b>c5.12xlarge</b>		x	x
<b>c5.18xlarge</b>		x	x
<b>c5.24xlarge</b>		x	x
<b>c5a.xlarge</b>			x

Instance type	Bootstrap	Control plane	Compute
<b>c5a.2xlarge</b>		x	x
<b>c5a.4xlarge</b>		x	x
<b>c5a.8xlarge</b>		x	x
<b>c5a.12xlarge</b>		x	x
<b>c5a.16xlarge</b>		x	x
<b>c5a.24xlarge</b>		x	x
<b>r4.large</b>			x
<b>r4.xlarge</b>		x	x
<b>r4.2xlarge</b>		x	x
<b>r4.4xlarge</b>		x	x
<b>r4.8xlarge</b>		x	x
<b>r4.16xlarge</b>		x	x
<b>r5.large</b>			x
<b>r5.xlarge</b>		x	x
<b>r5.2xlarge</b>		x	x
<b>r5.4xlarge</b>		x	x
<b>r5.8xlarge</b>		x	x
<b>r5.12xlarge</b>		x	x
<b>r5.16xlarge</b>		x	x
<b>r5.24xlarge</b>		x	x
<b>r5a.large</b>			x
<b>r5a.xlarge</b>		x	x

Instance type	Bootstrap	Control plane	Compute
<b>r5a.2xlarge</b>		x	x
<b>r5a.4xlarge</b>		x	x
<b>r5a.8xlarge</b>		x	x
<b>r5a.12xlarge</b>		x	x
<b>r5a.16xlarge</b>		x	x
<b>r5a.24xlarge</b>		x	x
<b>t3.large</b>			x
<b>t3.xlarge</b>			x
<b>t3.2xlarge</b>			x
<b>t3a.large</b>			x
<b>t3a.xlarge</b>			x
<b>t3a.2xlarge</b>			x

#### 4.6.6.4. Sample customized install-config.yaml file for AWS

You can customize the installation configuration file (**install-config.yaml**) to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.



#### IMPORTANT

This sample YAML file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program and modify it.

```

apiVersion: v1
baseDomain: example.com 1
credentialsMode: Mint 2
controlPlane: 3 4
  hyperthreading: Enabled 5
name: master
platform:
  aws:
    zones:
      - us-west-2a

```

```

- us-west-2b
rootVolume:
  iops: 4000
  size: 500
  type: io1 6
  type: m5.xlarge
replicas: 3
compute: 7
- hyperthreading: Enabled 8
name: worker
platform:
  aws:
    rootVolume:
      iops: 2000
      size: 500
      type: io1 9
      type: c5.4xlarge
    zones:
      - us-west-2c
replicas: 3
metadata:
  name: test-cluster 10
networking: 11
  clusterNetwork:
    - cidr: 10.128.0.0/14
      hostPrefix: 23
  machineNetwork:
    - cidr: 10.0.0.0/16
networkType: OpenShiftSDN
serviceNetwork:
  - 172.30.0.0/16
platform:
  aws:
    region: us-west-2 12
    userTags:
      adminContact: jdoe
      costCenter: 7536
    amiID: ami-96c6f8f7 13
    serviceEndpoints: 14
      - name: ec2
        url: https://vpce-id.ec2.us-west-2.vpce.amazonaws.com
  fips: false 15
sshKey: ssh-ed25519 AAAA... 16
pullSecret: '{"auths": ...}' 17

```

**1 10 12 17** Required. The installation program prompts you for this value.

**2** Optional: Add this parameter to force the Cloud Credential Operator (CCO) to use the specified mode, instead of having the CCO dynamically try to determine the capabilities of the credentials. For details about CCO modes, see the *Cloud Credential Operator* entry in the *Platform Operators reference* content.

**3 7 11** If you do not provide these parameters and values, the installation program provides the default value.

- 4 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section
- 5 8 Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.



### IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger instance types, such as **m4.2xlarge** or **m5.2xlarge**, for your machines if you disable simultaneous multithreading.

- 6 9 To configure faster storage for etcd, especially for larger clusters, set the storage type as **io1** and set **iops** to **2000**.
- 13 The ID of the AMI used to boot machines for the cluster. If set, the AMI must belong to the same region as the cluster.
- 14 The AWS service endpoints. Custom endpoints are required when installing to an unknown AWS region. The endpoint URL must use the **https** protocol and the host must trust the certificate.
- 15 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.



### IMPORTANT

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

- 16 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.



### NOTE

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

#### 4.6.6.5. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

#### Prerequisites

- You have an existing **install-config.yaml** file.

- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



## NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

- You have added the **ec2.<region>.amazonaws.com**, **elasticloadbalancing.<region>.amazonaws.com**, and **s3.<region>.amazonaws.com** endpoints to your VPC endpoint. These endpoints are required to complete requests from the nodes to the AWS EC2 API. Because the proxy works on the container level, not the node level, you must route these requests to the AWS EC2 API through the AWS private network. Adding the public IP address of the EC2 API to your allowlist in your proxy server is not sufficient.

## Procedure

- Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
  additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
  ...
```

- A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- A proxy URL to use for creating HTTPS connections outside the cluster.
- A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations.
- If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The

**additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.



#### NOTE

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



#### NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

### 4.6.7. Cluster Network Operator configuration

The configuration for the cluster network is specified as part of the Cluster Network Operator (CNO) configuration and stored in a custom resource (CR) object that is named **cluster**. The CR specifies the fields for the **Network** API in the **operator.openshift.io** API group.

The CNO configuration inherits the following fields during cluster installation from the **Network** API in the **Network.config.openshift.io** API group and these fields cannot be changed:

#### **clusterNetwork**

IP address pools from which pod IP addresses are allocated.

#### **serviceNetwork**

IP address pool for services.

#### **defaultNetwork.type**

Cluster network provider, such as OpenShift SDN or OVN-Kubernetes.

You can specify the cluster network provider configuration for your cluster by setting the fields for the **defaultNetwork** object in the CNO object named **cluster**.

#### 4.6.7.1. Cluster Network Operator configuration object

The fields for the Cluster Network Operator (CNO) are described in the following table:

**Table 4.11. Cluster Network Operator configuration object**

Field	Type	Description
<b>metadata.name</b>	<b>string</b>	The name of the CNO object. This name is always <b>cluster</b> .

Field	Type	Description
<b>spec.clusterNetwork</b>	<b>array</b>	<p>A list specifying the blocks of IP addresses from which pod IP addresses are allocated and the subnet prefix length assigned to each individual node in the cluster. For example:</p> <pre>spec:   clusterNetwork:   - cidr: 10.128.0.0/19     hostPrefix: 23   - cidr: 10.128.32.0/19     hostPrefix: 23</pre> <p>You can customize this field only in the <b>install-config.yaml</b> file before you create the manifests. The value is read-only in the manifest file.</p>
<b>spec.serviceNetwork</b>	<b>array</b>	<p>A block of IP addresses for services. The OpenShift SDN and OVN-Kubernetes Container Network Interface (CNI) network providers support only a single IP address block for the service network. For example:</p> <pre>spec:   serviceNetwork:   - 172.30.0.0/14</pre> <p>You can customize this field only in the <b>install-config.yaml</b> file before you create the manifests. The value is read-only in the manifest file.</p>
<b>spec.defaultNetwork</b>	<b>object</b>	Configures the Container Network Interface (CNI) cluster network provider for the cluster network.
<b>spec.kubeProxy</b> <b>Config</b>	<b>object</b>	The fields for this object specify the kube-proxy configuration. If you are using the OVN-Kubernetes cluster network provider, the kube-proxy configuration has no effect.


### defaultNetwork object configuration

The values for the **defaultNetwork** object are defined in the following table:

Table 4.12. **defaultNetwork** object

Field	Type	Description
-------	------	-------------



Field	Type	Description
<b>type</b>	<b>string</b>	<p>Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b>. The cluster network provider is selected during installation. This value cannot be changed after cluster installation.</p> <div style="display: flex; align-items: flex-start;"> <div style="flex: 1;">  </div> <div style="flex: 2;"> <p><b>NOTE</b></p> <p>OpenShift Container Platform uses the OpenShift SDN Container Network Interface (CNI) cluster network provider by default.</p> </div> </div>
<b>openshiftSDNConfig</b>	<b>object</b>	This object is only valid for the OpenShift SDN cluster network provider.
<b>ovnKubernetesConfig</b>	<b>object</b>	This object is only valid for the OVN-Kubernetes cluster network provider.

#### Configuration for the OpenShift SDN CNI cluster network provider

The following table describes the configuration fields for the OpenShift SDN Container Network Interface (CNI) cluster network provider.

Table 4.13. **openshiftSDNConfig** object

Field	Type	Description
<b>mode</b>	<b>string</b>	<p>Configures the network isolation mode for OpenShift SDN. The default value is <b>NetworkPolicy</b>.</p> <p>The values <b>Multitenant</b> and <b>Subnet</b> are available for backwards compatibility with OpenShift Container Platform 3.x but are not recommended. This value cannot be changed after cluster installation.</p>

Field	Type	Description
<b>mtu</b>	<b>integer</b>	<p>The maximum transmission unit (MTU) for the VXLAN overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU.</p> <p>If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes.</p> <p>If your cluster requires different MTU values for different nodes, you must set this value to <b>50</b> less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of <b>9001</b>, and some have an MTU of <b>1500</b>, you must set this value to <b>1450</b>.</p> <p>This value cannot be changed after cluster installation.</p>
<b>vxlanPort</b>	<b>integer</b>	<p>The port to use for all VXLAN packets. The default value is <b>4789</b>. This value cannot be changed after cluster installation.</p> <p>If you are running in a virtualized environment with existing nodes that are part of another VXLAN network, then you might be required to change this. For example, when running an OpenShift SDN overlay on top of VMware NSX-T, you must select an alternate port for the VXLAN, because both SDNs use the same default VXLAN port number.</p> <p>On Amazon Web Services (AWS), you can select an alternate port for the VXLAN between port <b>9000</b> and port <b>9999</b>.</p>

### Example OpenShift SDN configuration

```
defaultNetwork:
  type: OpenShiftSDN
  openshiftSDNConfig:
    mode: NetworkPolicy
    mtu: 1450
    vxlanPort: 4789
```

### Configuration for the OVN-Kubernetes CNI cluster network provider

The following table describes the configuration fields for the OVN-Kubernetes CNI cluster network provider.

Table 4.14. `ovnKubernetesConfig` object

Field	Type	Description
-------	------	-------------

Field	Type	Description
<b>mtu</b>	<b>integer</b>	<p>The maximum transmission unit (MTU) for the Geneve (Generic Network Virtualization Encapsulation) overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU.</p> <p>If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes.</p> <p>If your cluster requires different MTU values for different nodes, you must set this value to <b>100</b> less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of <b>9001</b>, and some have an MTU of <b>1500</b>, you must set this value to <b>1400</b>.</p> <p>This value cannot be changed after cluster installation.</p>
<b>genevePort</b>	<b>integer</b>	The port to use for all Geneve packets. The default value is <b>6081</b> . This value cannot be changed after cluster installation.
<b>ipsecConfig</b>	<b>object</b>	Specify an empty object to enable IPsec encryption. This value cannot be changed after cluster installation.
<b>policyAuditConfig</b>	<b>object</b>	Specify a configuration object for customizing network policy audit logging. If unset, the defaults audit log settings are used.

Table 4.15. **policyAuditConfig** object

Field	Type	Description
<b>rateLimit</b>	integer	The maximum number of messages to generate every second per node. The default value is <b>20</b> messages per second.
<b>maxFileSize</b>	integer	The maximum size for the audit log in bytes. The default value is <b>50000000</b> or 50 MB.

Field	Type	Description
<b>destination</b>	string	<p>One of the following additional audit log targets:</p> <p><b>libc</b> The libc <b>syslog()</b> function of the journald process on the host.</p> <p><b>udp:&lt;host&gt;:&lt;port&gt;</b> A syslog server. Replace <b>&lt;host&gt;:&lt;port&gt;</b> with the host and port of the syslog server.</p> <p><b>unix:&lt;file&gt;</b> A Unix Domain Socket file specified by <b>&lt;file&gt;</b>.</p> <p><b>null</b> Do not send the audit logs to any additional target.</p>
<b>syslogFacility</b>	string	The syslog facility, such as <b>kern</b> , as defined by RFC5424. The default value is <b>local0</b> .


### Example OVN-Kubernetes configuration

```
defaultNetwork:
  type: OVNKubernetes
  ovnKubernetesConfig:
    mtu: 1400
    genevePort: 6081
    ipsecConfig: {}
```

### kubeProxyConfig object configuration

The values for the **kubeProxyConfig** object are defined in the following table:

Table 4.16. **kubeProxyConfig** object

Field	Type	Description
<b>iptablesSyncPeriod</b>	<b>string</b>	<p>The refresh period for <b>iptables</b> rules. The default value is <b>30s</b>. Valid suffixes include <b>s</b>, <b>m</b>, and <b>h</b> and are described in the <a href="#">Go time package</a> documentation.</p> <div style="display: flex; align-items: flex-start;"> <div style="flex: 1;">  </div> <div style="flex: 2;"> <p><b>NOTE</b></p> <p>Because of performance improvements introduced in OpenShift Container Platform 4.3 and greater, adjusting the <b>iptablesSyncPeriod</b> parameter is no longer necessary.</p> </div> </div>

Field	Type	Description
<b>proxyArguments.iptables-min-sync-period</b>	<b>array</b>	<p>The minimum duration before refreshing <b>iptables</b> rules. This field ensures that the refresh does not happen too frequently. Valid suffixes include <b>s</b>, <b>m</b>, and <b>h</b> and are described in the <a href="#">Go time package</a>. The default value is:</p> <pre>kubeProxyConfig:   proxyArguments:     iptables-min-sync-period:       - 0s</pre>

#### 4.6.8. Specifying advanced network configuration

You can use advanced network configuration for your cluster network provider to integrate your cluster into your existing network environment. You can specify advanced network configuration only before you install the cluster.



#### IMPORTANT

Customizing your network configuration by modifying the OpenShift Container Platform manifest files created by the installation program is not supported. Applying a manifest file that you create, as in the following procedure, is supported.

#### Prerequisites

- You have created the **install-config.yaml** file and completed any modifications to it.

#### Procedure

- Change to the directory that contains the installation program and create the manifests:

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

- 1** **<installation\_directory>** specifies the name of the directory that contains the **install-config.yaml** file for your cluster.

- Create a stub manifest file for the advanced network configuration that is named **cluster-network-03-config.yml** in the **<installation\_directory>/manifests/** directory:

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
```

- Specify the advanced network configuration for your cluster in the **cluster-network-03-config.yml** file, such as in the following examples:

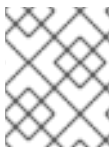
### Specify a different VXLAN port for the OpenShift SDN network provider

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    openshiftSDNConfig:
      vxlanPort: 4800
```

### Enable IPsec for the OVN-Kubernetes network provider

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    ovnKubernetesConfig:
      ipsecConfig: {}
```

- Optional: Back up the **manifests/cluster-network-03-config.yml** file. The installation program consumes the **manifests/** directory when you create the Ignition config files.



#### NOTE

For more information on using a Network Load Balancer (NLB) on AWS, see [Configuring Ingress cluster traffic on AWS using a Network Load Balancer](#).

## 4.6.9. Configuring an Ingress Controller Network Load Balancer on a new AWS cluster

You can create an Ingress Controller backed by an AWS Network Load Balancer (NLB) on a new cluster.

### Prerequisites

- Create the **install-config.yaml** file and complete any modifications to it.

### Procedure

Create an Ingress Controller backed by an AWS NLB on a new cluster.

- Change to the directory that contains the installation program and create the manifests:

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

- For **<installation\_directory>**, specify the name of the directory that contains the **install-config.yaml** file for your cluster.

2. Create a file that is named **cluster-ingress-default-ingresscontroller.yaml** in the **<installation\_directory>/manifests/** directory:

```
$ touch <installation_directory>/manifests/cluster-ingress-default-ingresscontroller.yaml 1
```

- 1 For **<installation\_directory>**, specify the directory name that contains the **manifests/** directory for your cluster.

After creating the file, several network configuration files are in the **manifests/** directory, as shown:

```
$ ls <installation_directory>/manifests/cluster-ingress-default-ingresscontroller.yaml
```

### Example output

```
cluster-ingress-default-ingresscontroller.yaml
```

3. Open the **cluster-ingress-default-ingresscontroller.yaml** file in an editor and enter a custom resource (CR) that describes the Operator configuration you want:

```
apiVersion: operator.openshift.io/v1
kind: IngressController
metadata:
  creationTimestamp: null
  name: default
  namespace: openshift-ingress-operator
spec:
  endpointPublishingStrategy:
    loadBalancer:
      scope: External
      providerParameters:
        type: AWS
      aws:
        type: NLB
    type: LoadBalancerService
```

4. Save the **cluster-ingress-default-ingresscontroller.yaml** file and quit the text editor.
5. Optional: Back up the **manifests/cluster-ingress-default-ingresscontroller.yaml** file. The installation program deletes the **manifests/** directory when creating the cluster.

#### 4.6.10. Configuring hybrid networking with OVN-Kubernetes

You can configure your cluster to use hybrid networking with OVN-Kubernetes. This allows a hybrid cluster that supports different node networking configurations. For example, this is necessary to run both Linux and Windows nodes in a cluster.



#### IMPORTANT

You must configure hybrid networking with OVN-Kubernetes during the installation of your cluster. You cannot switch to hybrid networking after the installation process.

## Prerequisites

- You defined **OVNKubernetes** for the **networking.networkType** parameter in the **install-config.yaml** file. See the installation documentation for configuring OpenShift Container Platform network customizations on your chosen cloud provider for more information.

## Procedure

- Change to the directory that contains the installation program and create the manifests:

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

where:

### <installation\_directory>

Specifies the name of the directory that contains the **install-config.yaml** file for your cluster.

- Create a stub manifest file for the advanced network configuration that is named **cluster-network-03-config.yml** in the **<installation\_directory>/manifests/** directory:

```
$ cat <<EOF > <installation_directory>/manifests/cluster-network-03-config.yml
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  EOF
```

where:

### <installation\_directory>

Specifies the directory name that contains the **manifests/** directory for your cluster.

- Open the **cluster-network-03-config.yml** file in an editor and configure OVN-Kubernetes with hybrid networking, such as in the following example:

## Specify a hybrid networking configuration

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    ovnKubernetesConfig:
      hybridOverlayConfig:
        hybridClusterNetwork: 1
        - cidr: 10.132.0.0/14
          hostPrefix: 23
        hybridOverlayVXLANPort: 9898 2
```

- Specify the CIDR configuration used for nodes on the additional overlay network. The **hybridClusterNetwork** CIDR cannot overlap with the **clusterNetwork** CIDR.



- 2 Specify a custom VXLAN port for the additional overlay network. This is required for running Windows nodes in a cluster installed on vSphere, and must not be configured for any other cloud provider. The custom port can be any open port excluding the default **4789** port. For more information on this requirement, see the Microsoft documentation on [Pod-to-pod connectivity between hosts is broken](#).



#### NOTE

Windows Server Long-Term Servicing Channel (LTSC): Windows Server 2019 is not supported on clusters with a custom **hybridOverlayVXLANPort** value because this Windows server version does not support selecting a custom VXLAN port.

4. Save the **cluster-network-03-config.yml** file and quit the text editor.
5. Optional: Back up the **manifests/cluster-network-03-config.yml** file. The installation program deletes the **manifests/** directory when creating the cluster.

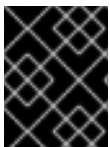


#### NOTE

For more information on using Linux and Windows nodes in the same cluster, see [Understanding Windows container workloads](#).

### 4.6.11. Deploying the cluster

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



#### IMPORTANT

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

#### Prerequisites

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

#### Procedure

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

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

- 1 For **<installation\_directory>**, specify the location of your customized **./install-config.yaml** file.
- 2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

**NOTE**

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

When the cluster deployment completes, directions for accessing your cluster, including a link to its web console and credentials for the **kubeadmin** user, display in your terminal.

**Example output**

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Ee6gm-ymBZj-
Wt5AL"
INFO Time elapsed: 36m22s
```

**NOTE**

The cluster access and credential information also outputs to **<installation\_directory>/openshift\_install.log** when an installation succeeds.

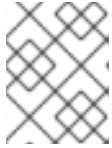
**IMPORTANT**

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

**IMPORTANT**

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

2. Optional: Remove or disable the **AdministratorAccess** policy from the IAM account that you used to install the cluster.

**NOTE**

The elevated permissions provided by the **AdministratorAccess** policy are required only during installation.

**4.6.12. Installing the OpenShift CLI by downloading the binary**

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

**IMPORTANT**

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

**Installing the OpenShift CLI on Linux**

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

**Procedure**

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

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

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

```
$ echo $PATH
```

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

```
$ oc <command>
```

**Installing the OpenShift CLI on Windows**

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

**Procedure**

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.

5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

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

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

### Installing the OpenShift CLI on macOS

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

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

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

```
$ oc <command>
```

### 4.6.13. Logging in to the cluster by using the CLI

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

#### Prerequisites

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

#### Procedure

1. Export the **kubeadmin** credentials:

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

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

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

```
$ oc whoami
```

#### Example output

```
system:admin
```

### 4.6.14. Logging in to the cluster by using the web console

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

#### Prerequisites

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

#### Procedure

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

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



#### NOTE

Alternatively, you can obtain the **kubeadmin** password from the **<installation\_directory>/openshift\_install.log** log file on the installation host.

2. List the OpenShift Container Platform web console route:

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



#### NOTE

Alternatively, you can obtain the OpenShift Container Platform route from the **<installation\_directory>/openshift\_install.log** log file on the installation host.

#### Example output

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

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

#### Additional resources

- See [Accessing the web console](#) for more details about accessing and understanding the OpenShift Container Platform web console.

#### 4.6.15. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

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

##### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service.

#### 4.6.16. Next steps

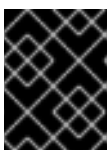
- [Validating an installation.](#)
- [Customize your cluster.](#)
- If necessary, you can [opt out of remote health reporting](#) .
- If necessary, you can [remove cloud provider credentials](#).

## 4.7. INSTALLING A CLUSTER ON AWS IN A RESTRICTED NETWORK

In OpenShift Container Platform version 4.9, you can install a cluster on Amazon Web Services (AWS) in a restricted network by creating an internal mirror of the installation release content on an existing Amazon Virtual Private Cloud (VPC).

### 4.7.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You [mirrored the images for a disconnected installation](#) to your registry and obtained the **imageContentSources** data for your version of OpenShift Container Platform.



#### IMPORTANT

Because the installation media is on the mirror host, you can use that computer to complete all installation steps.

- You have an existing VPC in AWS. When installing to a restricted network using installer-provisioned infrastructure, you cannot use the installer-provisioned VPC. You must use a user-provisioned VPC that satisfies one of the following requirements:
  - Contains the mirror registry

- Has firewall rules or a peering connection to access the mirror registry hosted elsewhere
- You [configured an AWS account](#) to host the cluster.



### IMPORTANT

If you have an AWS profile stored on your computer, it must not use a temporary session token that you generated while using a multi-factor authentication device. The cluster continues to use your current AWS credentials to create AWS resources for the entire life of the cluster, so you must use key-based, long-lived credentials. To generate appropriate keys, see [Managing Access Keys for IAM Users](#) in the AWS documentation. You can supply the keys when you run the installation program.

- You downloaded the AWS CLI and installed it on your computer. See [Install the AWS CLI Using the Bundled Installer \(Linux, macOS, or Unix\)](#) in the AWS documentation.
- If you use a firewall and plan to use the Telemetry service, you [configured the firewall to allow the sites](#) that your cluster requires access to.



### NOTE

If you are configuring a proxy, be sure to also review this site list.

- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can [manually create and maintain IAM credentials](#).

## 4.7.2. About installations in restricted networks

In OpenShift Container Platform 4.9, you can perform an installation that does not require an active connection to the internet to obtain software components. Restricted network installations can be completed using installer-provisioned infrastructure or user-provisioned infrastructure, depending on the cloud platform to which you are installing the cluster.

If you choose to perform a restricted network installation on a cloud platform, you still require access to its cloud APIs. Some cloud functions, like Amazon Web Service's Route 53 DNS and IAM services, require internet access. Depending on your network, you might require less internet access for an installation on bare metal hardware or on VMware vSphere.

To complete a restricted network installation, you must create a registry that mirrors the contents of the OpenShift Container Platform registry and contains the installation media. You can create this registry on a mirror host, which can access both the internet and your closed network, or by using other methods that meet your restrictions.

### 4.7.2.1. Additional limits

Clusters in restricted networks have the following additional limitations and restrictions:

- The **ClusterVersion** status includes an **Unable to retrieve available updates** error.
- By default, you cannot use the contents of the Developer Catalog because you cannot access the required image stream tags.

### 4.7.3. About using a custom VPC

In OpenShift Container Platform 4.9, you can deploy a cluster into existing subnets in an existing Amazon Virtual Private Cloud (VPC) in Amazon Web Services (AWS). By deploying OpenShift Container Platform into an existing AWS VPC, you might be able to avoid limit constraints in new accounts or more easily abide by the operational constraints that your company's guidelines set. If you cannot obtain the infrastructure creation permissions that are required to create the VPC yourself, use this installation option.

Because the installation program cannot know what other components are also in your existing subnets, it cannot choose subnet CIDRs and so forth on your behalf. You must configure networking for the subnets that you install your cluster to yourself.

#### 4.7.3.1. Requirements for using your VPC

The installation program no longer creates the following components:

- Internet gateways
- NAT gateways
- Subnets
- Route tables
- VPCs
- VPC DHCP options
- VPC endpoints



#### NOTE

The installation program requires that you use the cloud-provided DNS server. Using a custom DNS server is not supported and causes the installation to fail.

If you use a custom VPC, you must correctly configure it and its subnets for the installation program and the cluster to use. See [Amazon VPC console wizard configurations](#) and [Work with VPCs and subnets](#) in the AWS documentation for more information on creating and managing an AWS VPC.

The installation program cannot:

- Subdivide network ranges for the cluster to use.
- Set route tables for the subnets.
- Set VPC options like DHCP.

You must complete these tasks before you install the cluster. See [VPC networking components](#) and [Route tables for your VPC](#) for more information on configuring networking in an AWS VPC.

Your VPC must meet the following characteristics:

- The VPC must not use the **kubernetes.io/cluster/.\*: owned** tag. The installation program modifies your subnets to add the **kubernetes.io/cluster/.\*: shared** tag, so your subnets must have at least one free tag slot available for it. See [Tag Restrictions](#) in



the AWS documentation to confirm that the installation program can add a tag to each subnet that you specify.

- You must enable the **enableDnsSupport** and **enableDnsHostnames** attributes in your VPC, so that the cluster can use the Route 53 zones that are attached to the VPC to resolve cluster's internal DNS records. See [DNS Support in Your VPC](#) in the AWS documentation. If you prefer to use your own Route 53 hosted private zone, you must associate the existing hosted zone with your VPC prior to installing a cluster. You can define your hosted zone using the **platform.aws.hostedZone** field in the **install-config.yaml** file.
- If you use a cluster with public access, you must create a public and a private subnet for each availability zone that your cluster uses. Each availability zone can contain no more than one public and one private subnet.

If you are working in a disconnected environment, you are unable to reach the public IP addresses for EC2 and ELB endpoints. To resolve this, you must create a VPC endpoint and attach it to the subnet that the clusters are using. The endpoints should be named as follows:

### Government regions

- **ec2.<region>.amazonaws.com**
- **elasticloadbalancing.<region>.amazonaws.com**
- **s3.<region>.amazonaws.com**

### Top secret region

- **ec2.<region>.c2s.ic.gov**
- **elasticloadbalancing.<region>.c2s.ic.gov**
- **s3.<region>.c2s.ic.gov**

### Required VPC components

You must provide a suitable VPC and subnets that allow communication to your machines.

Component	AWS type	Description
VPC	<ul style="list-style-type: none"> <li>• <b>AWS::EC2::VPC</b></li> <li>• <b>AWS::EC2::VPCEndpoint</b></li> </ul>	You must provide a public VPC for the cluster to use. The VPC uses an endpoint that references the route tables for each subnet to improve communication with the registry that is hosted in S3.
Public subnets	<ul style="list-style-type: none"> <li>• <b>AWS::EC2::Subnet</b></li> <li>• <b>AWS::EC2::SubnetNetworkAclAssociation</b></li> </ul>	Your VPC must have public subnets for between 1 and 3 availability zones and associate them with appropriate Ingress rules.

Component	AWS type	Description												
Internet gateway	<ul style="list-style-type: none"> <li>● <b>AWS::EC2::InternetGateway</b></li> <li>● <b>AWS::EC2::VPCGatewayAttachment</b></li> <li>● <b>AWS::EC2::RouteTable</b></li> <li>● <b>AWS::EC2::Route</b></li> <li>● <b>AWS::EC2::SubnetRouteTableAssociation</b></li> <li>● <b>AWS::EC2::NatGateway</b></li> <li>● <b>AWS::EC2::EIP</b></li> </ul>	<p>You must have a public internet gateway, with public routes, attached to the VPC. In the provided templates, each public subnet has a NAT gateway with an EIP address. These NAT gateways allow cluster resources, like private subnet instances, to reach the internet and are not required for some restricted network or proxy scenarios.</p>												
Network access control	<ul style="list-style-type: none"> <li>● <b>AWS::EC2::NetworkAcl</b></li> <li>● <b>AWS::EC2::NetworkAclEntry</b></li> </ul>	<p>You must allow the VPC to access the following ports:</p> <table border="1"> <thead> <tr> <th>Port</th> <th>Reason</th> </tr> </thead> <tbody> <tr> <td><b>80</b></td> <td>Inbound HTTP traffic</td> </tr> <tr> <td><b>443</b></td> <td>Inbound HTTPS traffic</td> </tr> <tr> <td><b>22</b></td> <td>Inbound SSH traffic</td> </tr> <tr> <td><b>1024 - 65535</b></td> <td>Inbound ephemeral traffic</td> </tr> <tr> <td><b>0 - 65535</b></td> <td>Outbound ephemeral traffic</td> </tr> </tbody> </table>	Port	Reason	<b>80</b>	Inbound HTTP traffic	<b>443</b>	Inbound HTTPS traffic	<b>22</b>	Inbound SSH traffic	<b>1024 - 65535</b>	Inbound ephemeral traffic	<b>0 - 65535</b>	Outbound ephemeral traffic
Port	Reason													
<b>80</b>	Inbound HTTP traffic													
<b>443</b>	Inbound HTTPS traffic													
<b>22</b>	Inbound SSH traffic													
<b>1024 - 65535</b>	Inbound ephemeral traffic													
<b>0 - 65535</b>	Outbound ephemeral traffic													
Private subnets	<ul style="list-style-type: none"> <li>● <b>AWS::EC2::Subnet</b></li> <li>● <b>AWS::EC2::RouteTable</b></li> <li>● <b>AWS::EC2::SubnetRouteTableAssociation</b></li> </ul>	<p>Your VPC can have private subnets. The provided CloudFormation templates can create private subnets for between 1 and 3 availability zones. If you use private subnets, you must provide appropriate routes and tables for them.</p>												

#### 4.7.3.2. VPC validation

To ensure that the subnets that you provide are suitable, the installation program confirms the following data:

- All the subnets that you specify exist.
- You provide private subnets.
- The subnet CIDRs belong to the machine CIDR that you specified.
- You provide subnets for each availability zone. Each availability zone contains no more than one public and one private subnet. If you use a private cluster, provide only a private subnet for each availability zone. Otherwise, provide exactly one public and private subnet for each availability zone.
- You provide a public subnet for each private subnet availability zone. Machines are not provisioned in availability zones that you do not provide private subnets for.

If you destroy a cluster that uses an existing VPC, the VPC is not deleted. When you remove the OpenShift Container Platform cluster from a VPC, the **kubernetes.io/cluster/.\*: shared** tag is removed from the subnets that it used.

#### 4.7.3.3. Division of permissions

Starting with OpenShift Container Platform 4.3, you do not need all of the permissions that are required for an installation program-provisioned infrastructure cluster to deploy a cluster. This change mimics the division of permissions that you might have at your company: some individuals can create different resource in your clouds than others. For example, you might be able to create application-specific items, like instances, buckets, and load balancers, but not networking-related components such as VPCs, subnets, or ingress rules.

The AWS credentials that you use when you create your cluster do not need the networking permissions that are required to make VPCs and core networking components within the VPC, such as subnets, routing tables, internet gateways, NAT, and VPN. You still need permission to make the application resources that the machines within the cluster require, such as ELBs, security groups, S3 buckets, and nodes.

#### 4.7.3.4. Isolation between clusters

If you deploy OpenShift Container Platform to an existing network, the isolation of cluster services is reduced in the following ways:

- You can install multiple OpenShift Container Platform clusters in the same VPC.
- ICMP ingress is allowed from the entire network.
- TCP 22 ingress (SSH) is allowed to the entire network.
- Control plane TCP 6443 ingress (Kubernetes API) is allowed to the entire network.
- Control plane TCP 22623 ingress (MCS) is allowed to the entire network.

#### 4.7.4. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to obtain the images that are necessary to install your cluster.

You must have internet access to:

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



### IMPORTANT

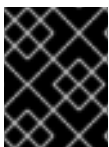
If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation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

#### 4.7.5. Generating a key pair for cluster node SSH access

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

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

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



### IMPORTANT

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



### NOTE

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

#### Procedure

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

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

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

**NOTE**

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

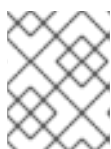
2. View the public SSH key:

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

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

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

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

**NOTE**

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

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

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

**Example output**

```
Agent pid 31874
```

**NOTE**

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

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

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

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

**Example output**

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

**Next steps**

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

#### 4.7.6. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Amazon Web Services (AWS).

##### Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster. For a restricted network installation, these files are on your mirror host.
- Have the **imageContentSources** values that were generated during mirror registry creation.
- Obtain the contents of the certificate for your mirror registry.
- Obtain service principal permissions at the subscription level.

##### Procedure

1. Create the **install-config.yaml** file.
  - a. Change to the directory that contains the installation program and run the following command:

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

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



##### IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

- b. At the prompts, provide the configuration details for your cloud:
  - i. Optional: Select an SSH key to use to access your cluster machines.



##### NOTE

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

- ii. Select **AWS** as the platform to target.

- iii. If you do not have an Amazon Web Services (AWS) profile stored on your computer, enter the AWS access key ID and secret access key for the user that you configured to run the installation program.
  - iv. Select the AWS region to deploy the cluster to.
  - v. Select the base domain for the Route 53 service that you configured for your cluster.
  - vi. Enter a descriptive name for your cluster.
  - vii. Paste the [pull secret from the Red Hat OpenShift Cluster Manager](#) .
2. Edit the **install-config.yaml** file to provide the additional information that is required for an installation in a restricted network.
- a. Update the **pullSecret** value to contain the authentication information for your registry:

```
pullSecret: '{"auths":{"<mirror_host_name>:5000": {"auth": "<credentials>","email":
"you@example.com"}}}'
```

For **<mirror\_host\_name>**, specify the registry domain name that you specified in the certificate for your mirror registry, and for **<credentials>**, specify the base64-encoded user name and password for your mirror registry.

- b. Add the **additionalTrustBundle** parameter and value.

```
additionalTrustBundle: |
  -----BEGIN CERTIFICATE-----
  ////////////////////////////////////////////////////////////////////
  -----END CERTIFICATE-----
```

The value must be the contents of the certificate file that you used for your mirror registry, which can be an existing, trusted certificate authority or the self-signed certificate that you generated for the mirror registry.

- c. Define the subnets for the VPC to install the cluster in:

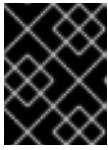
```
subnets:
- subnet-1
- subnet-2
- subnet-3
```

- d. Add the image content resources, which look like this excerpt:

```
imageContentSources:
- mirrors:
  - <mirror_host_name>:5000/<repo_name>/release
  source: quay.io/openshift-release-dev/ocp-release
- mirrors:
  - <mirror_host_name>:5000/<repo_name>/release
  source: registry.redhat.io/ocp/release
```

To complete these values, use the **imageContentSources** that you recorded during mirror registry creation.

3. Make any other modifications to the **install-config.yaml** file that you require. You can find more information about the available parameters in the **Installation configuration parameters** section.
4. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

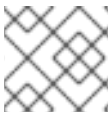


### IMPORTANT

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

#### 4.7.6.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.



### NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.



### IMPORTANT

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

##### 4.7.6.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 4.17. Required parameters

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String



Parameter	Description	Values
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;</b> . <b>&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}</b> . <b>{{.baseDomain}}</b> .	String of lowercase letters, hyphens (-), and periods (.), such as <b>dev</b> .
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws, baremetal, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } }</pre>


#### 4.7.6.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

Table 4.18. Network parameters

Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	Object   <b>NOTE</b> You cannot modify parameters specified by the <b>networking</b> object after installation.
<b>networking.network Type</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .
<b>networking.clusterNetwork</b>	The IP address blocks for pods.  The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b> .  If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example:  <pre>networking:   clusterNetwork:     - cidr: 10.128.0.0/14       hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	Required if you use <b>networking.clusterNetwork</b> . An IP address block.  An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b> .
<b>networking.clusterNetwork.hostPrefix</b>	The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b> . A <b>hostPrefix</b> value of <b>23</b> provides 510 ( $2^{(32 - 23)} - 2$ ) pod IP addresses.	A subnet prefix.  The default value is <b>23</b> .


Parameter	Description	Values
<b>networking.serviceNetwork</b>	<p>The IP address block for services. The default value is <b>172.30.0.0/16</b>.</p> <p>The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.</p>	<p>An array with an IP address block in CIDR format. For example:</p> <pre>networking:   serviceNetwork:     - 172.30.0.0/16</pre>
<b>networking.machineNetwork</b>	<p>The IP address blocks for machines.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   machineNetwork:     - cidr: 10.0.0.0/16</pre>
<b>networking.machineNetwork.cidr</b>	<p>Required if you use <b>networking.machineNetwork</b>. An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b>.</p>	<p>An IP network block in CIDR notation.</p> <p>For example, <b>10.0.0.0/16</b>.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p> </div> </div>


#### 4.7.6.1.3. Optional configuration parameters



Optional installation configuration parameters are described in the following table:

Table 4.19. Optional parameters


Parameter	Description	Values
<b>additionalTrustBundle</b>	<p>A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.</p>	String
<b>compute</b>	<p>The configuration for the machines that comprise the compute nodes.</p>	Array of <b>MachinePool</b> objects.

Parameter	Description	Values
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String
<b>compute.hyperthreading</b>	Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b> , on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.   <b>IMPORTANT</b> If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b>
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String

Parameter	Description	Values
<b>controlPlane.hypert hreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platfor m</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>controlPlane.replica s</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.

Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.</p> <p> <b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators reference content</i>.</p> <p> <b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p>	<b>Mint, Passthrough, Manual</b> or an empty string ("").

Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start; gap: 10px;"> <div style="width: 60px; height: 150px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px);"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; gap: 10px; margin-top: 10px;"> <div style="width: 60px; height: 80px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px);"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<b>Internal</b> or <b>External</b> . To deploy a private cluster, which cannot be accessed from the internet, set <b>publish</b> to <b>Internal</b> . The default value is <b>External</b> .

Parameter	Description	Values
<b>sshKey</b>	<p>The SSH key or keys to authenticate access your cluster machines.</p>  <p><b>NOTE</b></p> <p>For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.</p>	<p>One or more keys. For example:</p> <pre>sshKey:   &lt;key1&gt;   &lt;key2&gt;   &lt;key3&gt;</pre>

#### 4.7.6.1.4. Optional AWS configuration parameters

Optional AWS configuration parameters are described in the following table:

Table 4.20. Optional AWS parameters

Parameter	Description	Values
<b>compute.platform.aws.amiID</b>	The AWS AMI used to boot compute machines for the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region.
<b>compute.platform.aws.iamRole</b>	A pre-existing AWS IAM role applied to the compute machine pool instance profiles. You can use these fields to match naming schemes and include predefined permissions boundaries for your IAM roles. If undefined, the installation program creates a new IAM role.	The name of a valid AWS IAM role.
<b>compute.platform.aws.rootVolume.iops</b>	The Input/Output Operations Per Second (IOPS) that is reserved for the root volume.	Integer, for example <b>4000</b> .



Parameter	Description	Values
<b>compute.platform.aws.rootVolume.size</b>	The size in GiB of the root volume.	Integer, for example <b>500</b> .
<b>compute.platform.aws.rootVolume.type</b>	The type of the root volume.	Valid <a href="#">AWS EBS volume type</a> , such as <b>io1</b> .
<b>compute.platform.aws.rootVolume.kmsKeyARN</b>	The Amazon Resource Name (key ARN) of a KMS key. This is required to encrypt OS volumes of worker nodes with a specific KMS key.	Valid <a href="#">key ID</a> or the <a href="#">key ARN</a>
<b>compute.platform.aws.type</b>	The EC2 instance type for the compute machines.	Valid AWS instance type, such as <b>m4.2xlarge</b> . See the <b>Instance types for machines</b> table that follows.
<b>compute.platform.aws.zones</b>	The availability zones where the installation program creates machines for the compute machine pool. If you provide your own VPC, you must provide a subnet in that availability zone.	A list of valid AWS availability zones, such as <b>us-east-1c</b> , in a <a href="#">YAML sequence</a> .
<b>compute.aws.region</b>	The AWS region that the installation program creates compute resources in.	Any valid <a href="#">AWS region</a> , such as <b>us-east-1</b> .
<b>controlPlane.platform.aws.amiID</b>	The AWS AMI used to boot control plane machines for the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region.
<b>controlPlane.platform.aws.iamRole</b>	A pre-existing AWS IAM role applied to the control plane machine pool instance profiles. You can use these fields to match naming schemes and include predefined permissions boundaries for your IAM roles. If undefined, the installation program creates a new IAM role.	The name of a valid AWS IAM role.

Parameter	Description	Values
<b>controlPlane.platform.aws.rootVolume.kmsKeyARN</b>	The Amazon Resource Name (key ARN) of a KMS key. This is required to encrypt OS volumes of control plane nodes with a specific KMS key.	Valid <a href="#">key ID</a> and the <a href="#">key ARN</a>
<b>controlPlane.platform.aws.type</b>	The EC2 instance type for the control plane machines.	Valid AWS instance type, such as <b>m5.xlarge</b> . See the <b>Instance types for machines</b> table that follows.
<b>controlPlane.platform.aws.zones</b>	The availability zones where the installation program creates machines for the control plane machine pool.	A list of valid AWS availability zones, such as <b>us-east-1c</b> , in a <a href="#">YAML sequence</a> .
<b>controlPlane.aws.region</b>	The AWS region that the installation program creates control plane resources in.	Valid <a href="#">AWS region</a> , such as <b>us-east-1</b> .
<b>platform.aws.amiID</b>	The AWS AMI used to boot all machines for the cluster. If set, the AMI must belong to the same region as the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region.
<b>platform.aws.hostedZone</b>	An existing Route 53 private hosted zone for the cluster. You can only use a pre-existing hosted zone when also supplying your own VPC. The hosted zone must already be associated with the user-provided VPC before installation. Also, the domain of the hosted zone must be the cluster domain or a parent of the cluster domain. If undefined, the installation program creates a new hosted zone.	String, for example <b>Z3URY6TWQ91KVV</b> .

Parameter	Description	Values
<b>platform.aws.serviceEndpoints.name</b>	The AWS service endpoint name. Custom endpoints are only required for cases where alternative AWS endpoints, like FIPS, must be used. Custom API endpoints can be specified for EC2, S3, IAM, Elastic Load Balancing, Tagging, Route 53, and STS AWS services.	Valid <a href="#">AWS service endpoint</a> name.
<b>platform.aws.serviceEndpoints.url</b>	The AWS service endpoint URL. The URL must use the <b>https</b> protocol and the host must trust the certificate.	Valid <a href="#">AWS service endpoint</a> URL.
<b>platform.aws.userTags</b>	A map of keys and values that the installation program adds as tags to all resources that it creates.	Any valid YAML map, such as key value pairs in the <b>&lt;key&gt;: &lt;value&gt;</b> format. For more information about AWS tags, see <a href="#">Tagging Your Amazon EC2 Resources</a> in the AWS documentation.
<b>platform.aws.subnets</b>	If you provide the VPC instead of allowing the installation program to create the VPC for you, specify the subnet for the cluster to use. The subnet must be part of the same <b>machineNetwork[].cidr</b> ranges that you specify. For a standard cluster, specify a public and a private subnet for each availability zone. For a private cluster, specify a private subnet for each availability zone.	Valid subnet IDs.

#### 4.7.6.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

**Table 4.21. Minimum resource requirements**

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 7.9, or RHEL 8.4 [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.

#### 4.7.6.3. Sample customized install-config.yaml file for AWS

You can customize the installation configuration file (**install-config.yaml**) to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.



#### IMPORTANT

This sample YAML file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program and modify it.

```

apiVersion: v1
baseDomain: example.com 1
credentialsMode: Mint 2
controlPlane: 3 4
hyperthreading: Enabled 5
name: master
platform:
  aws:
    zones:
      - us-west-2a
      - us-west-2b
    rootVolume:
      iops: 4000
      size: 500
      type: io1 6
      type: m5.xlarge
    replicas: 3
  compute: 7

```

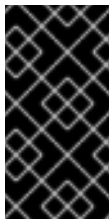
```

- hyperthreading: Enabled 8
  name: worker
  platform:
    aws:
      rootVolume:
        iops: 2000
        size: 500
        type: io1 9
      type: c5.4xlarge
      zones:
        - us-west-2c
    replicas: 3
  metadata:
    name: test-cluster 10
  networking:
    clusterNetwork:
      - cidr: 10.128.0.0/14
      hostPrefix: 23
    machineNetwork:
      - cidr: 10.0.0.0/16
    networkType: OpenShiftSDN
    serviceNetwork:
      - 172.30.0.0/16
  platform:
    aws:
      region: us-west-2 11
      userTags:
        adminContact: jdoe
        costCenter: 7536
      subnets: 12
      - subnet-1
      - subnet-2
      - subnet-3
      amiID: ami-96c6f8f7 13
      serviceEndpoints: 14
      - name: ec2
        url: https://vpce-id.ec2.us-west-2.vpce.amazonaws.com
      hostedZone: Z3URY6TWQ91KVV 15
    fips: false 16
    sshKey: ssh-ed25519 AAAA... 17
    pullSecret: '{"auths":{"<local_registry>":{"auth": "<credentials>","email": "you@example.com"}}}' 18
    additionalTrustBundle: | 19
      -----BEGIN CERTIFICATE-----
      <MY_TRUSTED_CA_CERT>
      -----END CERTIFICATE-----
    imageContentSources: 20
    - mirrors:
      - <local_registry>/<local_repository_name>/release
      source: quay.io/openshift-release-dev/ocp-release
    - mirrors:
      - <local_registry>/<local_repository_name>/release
      source: quay.io/openshift-release-dev/ocp-v4.0-art-dev

```

**1** **10** **11** Required. The installation program prompts you for this value.

- 2 Optional: Add this parameter to force the Cloud Credential Operator (CCO) to use the specified mode, instead of having the CCO dynamically try to determine the capabilities of the credentials.
- 3 7 If you do not provide these parameters and values, the installation program provides the default value.
- 4 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. Only one control plane pool is used.
- 5 8 Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.



### IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger instance types, such as **m4.2xlarge** or **m5.2xlarge**, for your machines if you disable simultaneous multithreading.

- 6 9 To configure faster storage for etcd, especially for larger clusters, set the storage type as **io1** and set **iops** to **2000**.
- 12 If you provide your own VPC, specify subnets for each availability zone that your cluster uses.
- 13 The ID of the AMI used to boot machines for the cluster. If set, the AMI must belong to the same region as the cluster.
- 14 The AWS service endpoints. Custom endpoints are required when installing to an unknown AWS region. The endpoint URL must use the **https** protocol and the host must trust the certificate.
- 15 The ID of your existing Route 53 private hosted zone. Providing an existing hosted zone requires that you supply your own VPC and the hosted zone is already associated with the VPC prior to installing your cluster. If undefined, the installation program creates a new hosted zone.
- 16 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.



### IMPORTANT

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

- 17 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.

**NOTE**

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

- 18 For **<local\_registry>**, specify the registry domain name, and optionally the port, that your mirror registry uses to serve content. For example **registry.example.com** or **registry.example.com:5000**. For **<credentials>**, specify the base64-encoded user name and password for your mirror registry.
- 19 Provide the contents of the certificate file that you used for your mirror registry.
- 20 Provide the **imageContentSources** section from the output of the command to mirror the repository.

#### 4.7.6.4. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

##### Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

**NOTE**

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

- You have added the **ec2.<region>.amazonaws.com**, **elasticloadbalancing.<region>.amazonaws.com**, and **s3.<region>.amazonaws.com** endpoints to your VPC endpoint. These endpoints are required to complete requests from the nodes to the AWS EC2 API. Because the proxy works on the container level, not the node level, you must route these requests to the AWS EC2 API through the AWS private network. Adding the public IP address of the EC2 API to your allowlist in your proxy server is not sufficient.

##### Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

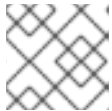
```
apiVersion: v1
```

```

baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
  -----BEGIN CERTIFICATE-----
  <MY_TRUSTED_CA_CERT>
  -----END CERTIFICATE-----
...

```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations.
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.



#### NOTE

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



#### NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

### 4.7.7. Deploying the cluster

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



#### IMPORTANT

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



## Prerequisites

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

## Procedure

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

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

- 1 For **<installation\_directory>**, specify the location of your customized **./install-config.yaml** file.
- 2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.



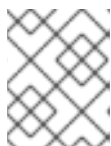
### NOTE

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

When the cluster deployment completes, directions for accessing your cluster, including a link to its web console and credentials for the **kubeadmin** user, display in your terminal.

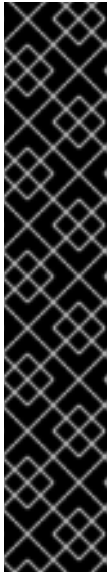
## Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Ee6gm-ymBZj-
Wt5AL"
INFO Time elapsed: 36m22s
```



### NOTE

The cluster access and credential information also outputs to **<installation\_directory>/./openshift\_install.log** when an installation succeeds.

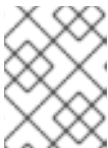
**IMPORTANT**

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

**IMPORTANT**

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

2. Optional: Remove or disable the **AdministratorAccess** policy from the IAM account that you used to install the cluster.

**NOTE**

The elevated permissions provided by the **AdministratorAccess** policy are required only during installation.

#### 4.7.8. Installing the OpenShift CLI by downloading the binary

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

**IMPORTANT**

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

##### Installing the OpenShift CLI on Linux

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

##### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

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

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

```
$ echo $PATH
```

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

```
$ oc <command>
```

### Installing the OpenShift CLI on Windows

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

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**. To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

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

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

### Installing the OpenShift CLI on macOS

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

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your **PATH**. To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

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

```
$ oc <command>
```

### 4.7.9. Logging in to the cluster by using the CLI

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

#### Prerequisites

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

#### Procedure

1. Export the **kubeadmin** credentials:

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

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

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

```
$ oc whoami
```

#### Example output

```
system:admin
```

### 4.7.10. Disabling the default OperatorHub sources

Operator catalogs that source content provided by Red Hat and community projects are configured for OperatorHub by default during an OpenShift Container Platform installation. In a restricted network environment, you must disable the default catalogs as a cluster administrator.

#### Procedure

- Disable the sources for the default catalogs by adding **disableAllDefaultSources: true** to the **OperatorHub** object:

```
$ oc patch OperatorHub cluster --type json \  
-p '[{"op": "add", "path": "/spec/disableAllDefaultSources", "value": true}]'
```

## TIP

Alternatively, you can use the web console to manage catalog sources. From the **Administration** → **Cluster Settings** → **Configuration** → **OperatorHub** page, click the **Sources** tab, where you can create, delete, disable, and enable individual sources.

### 4.7.11. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

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

#### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

### 4.7.12. Next steps

- [Validate an installation](#).
- [Customize your cluster](#).
- [Configure image streams](#) for the Cluster Samples Operator and the **must-gather** tool.
- Learn how to [use Operator Lifecycle Manager \(OLM\) on restricted networks](#).
- If the mirror registry that you used to install your cluster has a trusted CA, add it to the cluster by [configuring additional trust stores](#).
- If necessary, you can [opt out of remote health reporting](#).

## 4.8. INSTALLING A CLUSTER ON AWS INTO AN EXISTING VPC

In OpenShift Container Platform version 4.9, you can install a cluster into an existing Amazon Virtual Private Cloud (VPC) on Amazon Web Services (AWS). The installation program provisions the rest of the required infrastructure, which you can further customize. To customize the installation, you modify parameters in the **install-config.yaml** file before you install the cluster.

### 4.8.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You [configured an AWS account](#) to host the cluster.



## IMPORTANT

If you have an AWS profile stored on your computer, it must not use a temporary session token that you generated while using a multi-factor authentication device. The cluster continues to use your current AWS credentials to create AWS resources for the entire life of the cluster, so you must use long-lived credentials. To generate appropriate keys, see [Managing Access Keys for IAM Users](#) in the AWS documentation. You can supply the keys when you run the installation program.

- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can [manually create and maintain IAM credentials](#).

### 4.8.2. About using a custom VPC

In OpenShift Container Platform 4.9, you can deploy a cluster into existing subnets in an existing Amazon Virtual Private Cloud (VPC) in Amazon Web Services (AWS). By deploying OpenShift Container Platform into an existing AWS VPC, you might be able to avoid limit constraints in new accounts or more easily abide by the operational constraints that your company's guidelines set. If you cannot obtain the infrastructure creation permissions that are required to create the VPC yourself, use this installation option.

Because the installation program cannot know what other components are also in your existing subnets, it cannot choose subnet CIDRs and so forth on your behalf. You must configure networking for the subnets that you install your cluster to yourself.

#### 4.8.2.1. Requirements for using your VPC

The installation program no longer creates the following components:

- Internet gateways
- NAT gateways
- Subnets
- Route tables
- VPCs
- VPC DHCP options
- VPC endpoints



## NOTE

The installation program requires that you use the cloud-provided DNS server. Using a custom DNS server is not supported and causes the installation to fail.

If you use a custom VPC, you must correctly configure it and its subnets for the installation program and the cluster to use. See [Amazon VPC console wizard configurations](#) and [Work with VPCs and subnets](#) in the AWS documentation for more information on creating and managing an AWS VPC.

The installation program cannot:

- Subdivide network ranges for the cluster to use.
- Set route tables for the subnets.
- Set VPC options like DHCP.

You must complete these tasks before you install the cluster. See [VPC networking components](#) and [Route tables for your VPC](#) for more information on configuring networking in an AWS VPC.

Your VPC must meet the following characteristics:

- Create a public and private subnet for each availability zone that your cluster uses. Each availability zone can contain no more than one public and one private subnet. For an example of this type of configuration, see [VPC with public and private subnets \(NAT\)](#) in the AWS documentation.  
Record each subnet ID. Completing the installation requires that you enter these values in the **platform** section of the **install-config.yaml** file. See [Finding a subnet ID](#) in the AWS documentation.
- The VPC's CIDR block must contain the **Networking.MachineCIDR** range, which is the IP address pool for cluster machines. The subnet CIDR blocks must belong to the machine CIDR that you specify.
- The VPC must have a public internet gateway attached to it. For each availability zone:
  - The public subnet requires a route to the internet gateway.
  - The public subnet requires a NAT gateway with an EIP address.
  - The private subnet requires a route to the NAT gateway in public subnet.
- The VPC must not use the **kubernetes.io/cluster/.\*: owned** tag.  
The installation program modifies your subnets to add the **kubernetes.io/cluster/.\*: shared** tag, so your subnets must have at least one free tag slot available for it. See [Tag Restrictions](#) in the AWS documentation to confirm that the installation program can add a tag to each subnet that you specify.
- You must enable the **enableDnsSupport** and **enableDnsHostnames** attributes in your VPC, so that the cluster can use the Route 53 zones that are attached to the VPC to resolve cluster's internal DNS records. See [DNS Support in Your VPC](#) in the AWS documentation.  
If you prefer to use your own Route 53 hosted private zone, you must associate the existing hosted zone with your VPC prior to installing a cluster. You can define your hosted zone using the **platform.aws.hostedZone** field in the **install-config.yaml** file.

If you are working in a disconnected environment, you are unable to reach the public IP addresses for EC2 and ELB endpoints. To resolve this, you must create a VPC endpoint and attach it to the subnet that the clusters are using. The endpoints should be named as follows:

#### Government regions

- **ec2.<region>.amazonaws.com**
- **elasticloadbalancing.<region>.amazonaws.com**
- **s3.<region>.amazonaws.com**

## Top secret region

- **ec2.<region>.c2s.ic.gov**
- **elasticloadbalancing.<region>.c2s.ic.gov**
- **s3.<region>.c2s.ic.gov**

## Required VPC components

You must provide a suitable VPC and subnets that allow communication to your machines.

Component	AWS type	Description						
VPC	<ul style="list-style-type: none"> <li>• <b>AWS::EC2::VPC</b></li> <li>• <b>AWS::EC2::VPCEndpoint</b></li> </ul>	You must provide a public VPC for the cluster to use. The VPC uses an endpoint that references the route tables for each subnet to improve communication with the registry that is hosted in S3.						
Public subnets	<ul style="list-style-type: none"> <li>• <b>AWS::EC2::Subnet</b></li> <li>• <b>AWS::EC2::SubnetNetworkACLAssociation</b></li> </ul>	Your VPC must have public subnets for between 1 and 3 availability zones and associate them with appropriate Ingress rules.						
Internet gateway	<ul style="list-style-type: none"> <li>• <b>AWS::EC2::InternetGateway</b></li> <li>• <b>AWS::EC2::VPCGatewayAttachment</b></li> <li>• <b>AWS::EC2::RouteTable</b></li> <li>• <b>AWS::EC2::Route</b></li> <li>• <b>AWS::EC2::SubnetRouteTableAssociation</b></li> <li>• <b>AWS::EC2::NatGateway</b></li> <li>• <b>AWS::EC2::EIP</b></li> </ul>	You must have a public internet gateway, with public routes, attached to the VPC. In the provided templates, each public subnet has a NAT gateway with an EIP address. These NAT gateways allow cluster resources, like private subnet instances, to reach the internet and are not required for some restricted network or proxy scenarios.						
Network access control	<ul style="list-style-type: none"> <li>• <b>AWS::EC2::NetworkACL</b></li> <li>• <b>AWS::EC2::NetworkACLEntry</b></li> </ul>	<p>You must allow the VPC to access the following ports:</p> <table border="1"> <thead> <tr> <th>Port</th> <th>Reason</th> </tr> </thead> <tbody> <tr> <td><b>80</b></td> <td>Inbound HTTP traffic</td> </tr> <tr> <td><b>443</b></td> <td>Inbound HTTPS traffic</td> </tr> </tbody> </table>	Port	Reason	<b>80</b>	Inbound HTTP traffic	<b>443</b>	Inbound HTTPS traffic
Port	Reason							
<b>80</b>	Inbound HTTP traffic							
<b>443</b>	Inbound HTTPS traffic							



Component	AWS type	Description	
		<b>22</b>	Inbound SSH traffic
		<b>1024 - 65535</b>	Inbound ephemeral traffic
		<b>0 - 65535</b>	Outbound ephemeral traffic
Private subnets	<ul style="list-style-type: none"> <li>● <b>AWS::EC2::Subnet</b></li> <li>● <b>AWS::EC2::RouteTable</b></li> <li>● <b>AWS::EC2::SubnetRouteTableAssociation</b></li> </ul>	Your VPC can have private subnets. The provided CloudFormation templates can create private subnets for between 1 and 3 availability zones. If you use private subnets, you must provide appropriate routes and tables for them.	

#### 4.8.2.2. VPC validation

To ensure that the subnets that you provide are suitable, the installation program confirms the following data:

- All the subnets that you specify exist.
- You provide private subnets.
- The subnet CIDRs belong to the machine CIDR that you specified.
- You provide subnets for each availability zone. Each availability zone contains no more than one public and one private subnet. If you use a private cluster, provide only a private subnet for each availability zone. Otherwise, provide exactly one public and private subnet for each availability zone.
- You provide a public subnet for each private subnet availability zone. Machines are not provisioned in availability zones that you do not provide private subnets for.

If you destroy a cluster that uses an existing VPC, the VPC is not deleted. When you remove the OpenShift Container Platform cluster from a VPC, the **kubernetes.io/cluster/.\*: shared** tag is removed from the subnets that it used.

#### 4.8.2.3. Division of permissions

Starting with OpenShift Container Platform 4.3, you do not need all of the permissions that are required for an installation program-provisioned infrastructure cluster to deploy a cluster. This change mimics the division of permissions that you might have at your company: some individuals can create different resource in your clouds than others. For example, you might be able to create application-specific items, like instances, buckets, and load balancers, but not networking-related components such as VPCs, subnets, or ingress rules.

The AWS credentials that you use when you create your cluster do not need the networking permissions

that are required to make VPCs and core networking components within the VPC, such as subnets, routing tables, internet gateways, NAT, and VPN. You still need permission to make the application resources that the machines within the cluster require, such as ELBs, security groups, S3 buckets, and nodes.

#### 4.8.2.4. Isolation between clusters

If you deploy OpenShift Container Platform to an existing network, the isolation of cluster services is reduced in the following ways:

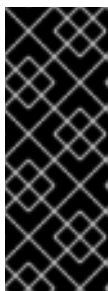
- You can install multiple OpenShift Container Platform clusters in the same VPC.
- ICMP ingress is allowed from the entire network.
- TCP 22 ingress (SSH) is allowed to the entire network.
- Control plane TCP 6443 ingress (Kubernetes API) is allowed to the entire network.
- Control plane TCP 22623 ingress (MCS) is allowed to the entire network.

#### 4.8.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

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



#### IMPORTANT

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

#### 4.8.4. Generating a key pair for cluster node SSH access

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

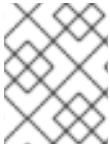
After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

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



### IMPORTANT

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



### NOTE

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

## Procedure

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

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

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



### NOTE

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

2. View the public SSH key:

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

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

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

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



### NOTE

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

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

■

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

### Example output

```
Agent pid 31874
```



### NOTE

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

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

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

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

### Example output

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

### Next steps

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

## 4.8.5. Obtaining the installation program

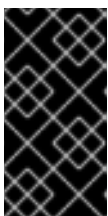
Before you install OpenShift Container Platform, download the installation file on a local computer.

### Prerequisites

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

### Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



### IMPORTANT

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



## IMPORTANT

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

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

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

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

### 4.8.6. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Amazon Web Services (AWS).

#### Prerequisites

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

#### Procedure

1. Create the **install-config.yaml** file.
  - a. Change to the directory that contains the installation program and run the following command:

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

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



## IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

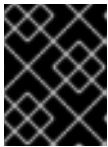
- b. At the prompts, provide the configuration details for your cloud:

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

**NOTE**

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

- ii. Select **AWS** as the platform to target.
  - iii. If you do not have an Amazon Web Services (AWS) profile stored on your computer, enter the AWS access key ID and secret access key for the user that you configured to run the installation program.
  - iv. Select the AWS region to deploy the cluster to.
  - v. Select the base domain for the Route 53 service that you configured for your cluster.
  - vi. Enter a descriptive name for your cluster.
  - vii. Paste the [pull secret from the Red Hat OpenShift Cluster Manager](#) .
2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.
  3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

**IMPORTANT**

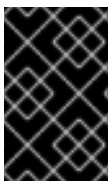
The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

#### 4.8.6.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.

**NOTE**

After installation, you cannot modify these parameters in the **install-config.yaml** file.

**IMPORTANT**

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

##### 4.8.6.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 4.22. Required parameters

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;</b> . <b>&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}</b> . <b>{{.baseDomain}}</b> .	String of lowercase letters, hyphens (-), and periods (.), such as <b>dev</b> .
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws</b> , <b>baremetal</b> , <b>azure</b> , <b>gcp</b> , <b>openstack</b> , <b>ovirt</b> , <b>vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object


Parameter	Description	Values
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } }</pre>

#### 4.8.6.1.2. Network configuration parameters


You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

Table 4.23. Network parameters

Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	Object <div style="display: flex; align-items: center; margin-top: 10px;">  <div> <p><b>NOTE</b></p> <p>You cannot modify parameters specified by the <b>networking</b> object after installation.</p> </div> </div>
<b>networking.networkType</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .





Parameter	Description	Values
<b>networking.clusterNetwork</b>	<p>The IP address blocks for pods.</p> <p>The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b>.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   clusterNetwork:     - cidr: 10.128.0.0/14       hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	<p>Required if you use <b>networking.clusterNetwork</b>. An IP address block.</p> <p>An IPv4 network.</p>	<p>An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b>.</p>
<b>networking.clusterNetwork.hostPrefix</b>	<p>The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b>. A <b>hostPrefix</b> value of <b>23</b> provides 510 (<math>2^{(32 - 23)} - 2</math>) pod IP addresses.</p>	<p>A subnet prefix.</p> <p>The default value is <b>23</b>.</p>
<b>networking.serviceNetwork</b>	<p>The IP address block for services. The default value is <b>172.30.0.0/16</b>.</p> <p>The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.</p>	<p>An array with an IP address block in CIDR format. For example:</p> <pre>networking:   serviceNetwork:     - 172.30.0.0/16</pre>
<b>networking.machineNetwork</b>	<p>The IP address blocks for machines.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   machineNetwork:     - cidr: 10.0.0.0/16</pre>
<b>networking.machineNetwork.cidr</b>	<p>Required if you use <b>networking.machineNetwork</b>. An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b>.</p>	<p>An IP network block in CIDR notation.</p> <p>For example, <b>10.0.0.0/16</b>.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p> </div> </div>



#### 4.8.6.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:


**Table 4.24. Optional parameters**

Parameter	Description	Values
<b>additionalTrustBundle</b>	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
<b>compute</b>	The configuration for the machines that comprise the compute nodes.	Array of <b>MachinePool</b> objects.
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String
<b>compute.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>

Parameter	Description	Values
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String
<b>controlPlane.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: flex-start;"> <div style="background-color: black; width: 60px; height: 100px; margin-right: 10px;">  </div> <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platform</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b>
<b>controlPlane.replicas</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.

Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.</p> <div data-bbox="485 510 595 862" style="border: 1px solid black; padding: 5px; margin-bottom: 10px;">  </div> <p><b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators reference content</i>.</p> <div data-bbox="485 907 595 1258" style="border: 1px solid black; padding: 5px;">  </div> <p><b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p>	<b>Mint, Passthrough, Manual</b> or an empty string ("").

Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start;"> <div style="width: 40px; height: 40px; background-color: black; margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 40px; height: 40px; background-color: black; margin-right: 10px;"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<b>Internal</b> or <b>External</b> . To deploy a private cluster, which cannot be accessed from the internet, set <b>publish</b> to <b>Internal</b> . The default value is <b>External</b> .

Parameter	Description	Values
<b>sshKey</b>	<p>The SSH key or keys to authenticate access your cluster machines.</p>  <p><b>NOTE</b></p> <p>For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.</p>	<p>One or more keys. For example:</p> <pre>sshKey: &lt;key1&gt; &lt;key2&gt; &lt;key3&gt;</pre>

#### 4.8.6.1.4. Optional AWS configuration parameters

Optional AWS configuration parameters are described in the following table:

Table 4.25. Optional AWS parameters

Parameter	Description	Values
<b>compute.platform.aws.amiID</b>	The AWS AMI used to boot compute machines for the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region.
<b>compute.platform.aws.iamRole</b>	A pre-existing AWS IAM role applied to the compute machine pool instance profiles. You can use these fields to match naming schemes and include predefined permissions boundaries for your IAM roles. If undefined, the installation program creates a new IAM role.	The name of a valid AWS IAM role.
<b>compute.platform.aws.rootVolume.iops</b>	The Input/Output Operations Per Second (IOPS) that is reserved for the root volume.	Integer, for example <b>4000</b> .
<b>compute.platform.aws.rootVolume.size</b>	The size in GiB of the root volume.	Integer, for example <b>500</b> .

Parameter	Description	Values
<b>compute.platform.aws.rootVolume.type</b>	The type of the root volume.	Valid <a href="#">AWS EBS volume type</a> , such as <b>io1</b> .
<b>compute.platform.aws.rootVolume.kmsKeyARN</b>	The Amazon Resource Name (key ARN) of a KMS key. This is required to encrypt OS volumes of worker nodes with a specific KMS key.	Valid <a href="#">key ID</a> or the <a href="#">key ARN</a>
<b>compute.platform.aws.type</b>	The EC2 instance type for the compute machines.	Valid AWS instance type, such as <b>m4.2xlarge</b> . See the <b>Instance types for machines</b> table that follows.
<b>compute.platform.aws.zones</b>	The availability zones where the installation program creates machines for the compute machine pool. If you provide your own VPC, you must provide a subnet in that availability zone.	A list of valid AWS availability zones, such as <b>us-east-1c</b> , in a <a href="#">YAML sequence</a> .
<b>compute.aws.region</b>	The AWS region that the installation program creates compute resources in.	Any valid <a href="#">AWS region</a> , such as <b>us-east-1</b> .
<b>controlPlane.platform.aws.amiID</b>	The AWS AMI used to boot control plane machines for the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region.
<b>controlPlane.platform.aws.iamRole</b>	A pre-existing AWS IAM role applied to the control plane machine pool instance profiles. You can use these fields to match naming schemes and include predefined permissions boundaries for your IAM roles. If undefined, the installation program creates a new IAM role.	The name of a valid AWS IAM role.
<b>controlPlane.platform.aws.rootVolume.kmsKeyARN</b>	The Amazon Resource Name (key ARN) of a KMS key. This is required to encrypt OS volumes of control plane nodes with a specific KMS key.	Valid <a href="#">key ID</a> and the <a href="#">key ARN</a>

Parameter	Description	Values
<b>controlPlane.platform.aws.type</b>	The EC2 instance type for the control plane machines.	Valid AWS instance type, such as <b>m5.xlarge</b> . See the <b>Instance types for machines</b> table that follows.
<b>controlPlane.platform.aws.zones</b>	The availability zones where the installation program creates machines for the control plane machine pool.	A list of valid AWS availability zones, such as <b>us-east-1c</b> , in a <a href="#">YAML sequence</a> .
<b>controlPlane.aws.region</b>	The AWS region that the installation program creates control plane resources in.	Valid <a href="#">AWS region</a> , such as <b>us-east-1</b> .
<b>platform.aws.amiID</b>	The AWS AMI used to boot all machines for the cluster. If set, the AMI must belong to the same region as the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region.
<b>platform.aws.hostedZone</b>	An existing Route 53 private hosted zone for the cluster. You can only use a pre-existing hosted zone when also supplying your own VPC. The hosted zone must already be associated with the user-provided VPC before installation. Also, the domain of the hosted zone must be the cluster domain or a parent of the cluster domain. If undefined, the installation program creates a new hosted zone.	String, for example <b>Z3URY6TWQ91KVV</b> .
<b>platform.aws.serviceEndpoints.name</b>	The AWS service endpoint name. Custom endpoints are only required for cases where alternative AWS endpoints, like FIPS, must be used. Custom API endpoints can be specified for EC2, S3, IAM, Elastic Load Balancing, Tagging, Route 53, and STS AWS services.	Valid <a href="#">AWS service endpoint</a> name.



Parameter	Description	Values
<b>platform.aws.serviceEndpoints.url</b>	The AWS service endpoint URL. The URL must use the <b>https</b> protocol and the host must trust the certificate.	Valid <a href="#">AWS service endpoint</a> URL.
<b>platform.aws.userTags</b>	A map of keys and values that the installation program adds as tags to all resources that it creates.	Any valid YAML map, such as key value pairs in the <b>&lt;key&gt;: &lt;value&gt;</b> format. For more information about AWS tags, see <a href="#">Tagging Your Amazon EC2 Resources</a> in the AWS documentation.
<b>platform.aws.subnets</b>	If you provide the VPC instead of allowing the installation program to create the VPC for you, specify the subnet for the cluster to use. The subnet must be part of the same <b>machineNetwork[].cidr</b> ranges that you specify. For a standard cluster, specify a public and a private subnet for each availability zone. For a private cluster, specify a private subnet for each availability zone.	Valid subnet IDs.

#### 4.8.6.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

**Table 4.26. Minimum resource requirements**

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 7.9, or RHEL 8.4 [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio:  $(\text{threads per core} \times \text{cores}) \times \text{sockets} = \text{vCPUs}$ .

2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.

#### 4.8.6.3. Supported AWS machine types

The following Amazon Web Services (AWS) instance types are supported with OpenShift Container Platform.

Example 4.18. Instance types for machines

Instance type	Bootstrap	Control plane	Compute
<b>i3.large</b>	x		
<b>m4.large</b>			x
<b>m4.xlarge</b>		x	x
<b>m4.2xlarge</b>		x	x
<b>m4.4xlarge</b>		x	x
<b>m4.10xlarge</b>		x	x
<b>m4.16xlarge</b>		x	x
<b>m5.large</b>			x
<b>m5.xlarge</b>		x	x
<b>m5.2xlarge</b>		x	x
<b>m5.4xlarge</b>		x	x
<b>m5.8xlarge</b>		x	x
<b>m5.12xlarge</b>		x	x
<b>m5.16xlarge</b>		x	x
<b>m5a.large</b>			x

Instance type	Bootstrap	Control plane	Compute
<b>m5a.xlarge</b>		x	x
<b>m5a.2xlarge</b>		x	x
<b>m5a.4xlarge</b>		x	x
<b>m5a.8xlarge</b>		x	x
<b>m5a.12xlarge</b>		x	x
<b>m5a.16xlarge</b>		x	x
<b>m6i.xlarge</b>		x	x
<b>m6i.2xlarge</b>		x	x
<b>m6i.4xlarge</b>		x	x
<b>m6i.8xlarge</b>		x	x
<b>m6i.16xlarge</b>		x	x
<b>c4.2xlarge</b>		x	x
<b>c4.4xlarge</b>		x	x
<b>c4.8xlarge</b>		x	x
<b>c5.xlarge</b>			x
<b>c5.2xlarge</b>		x	x
<b>c5.4xlarge</b>		x	x
<b>c5.9xlarge</b>		x	x
<b>c5.12xlarge</b>		x	x
<b>c5.18xlarge</b>		x	x
<b>c5.24xlarge</b>		x	x
<b>c5a.xlarge</b>			x

Instance type	Bootstrap	Control plane	Compute
<b>c5a.2xlarge</b>		x	x
<b>c5a.4xlarge</b>		x	x
<b>c5a.8xlarge</b>		x	x
<b>c5a.12xlarge</b>		x	x
<b>c5a.16xlarge</b>		x	x
<b>c5a.24xlarge</b>		x	x
<b>r4.large</b>			x
<b>r4.xlarge</b>		x	x
<b>r4.2xlarge</b>		x	x
<b>r4.4xlarge</b>		x	x
<b>r4.8xlarge</b>		x	x
<b>r4.16xlarge</b>		x	x
<b>r5.large</b>			x
<b>r5.xlarge</b>		x	x
<b>r5.2xlarge</b>		x	x
<b>r5.4xlarge</b>		x	x
<b>r5.8xlarge</b>		x	x
<b>r5.12xlarge</b>		x	x
<b>r5.16xlarge</b>		x	x
<b>r5.24xlarge</b>		x	x
<b>r5a.large</b>			x
<b>r5a.xlarge</b>		x	x

Instance type	Bootstrap	Control plane	Compute
<b>r5a.2xlarge</b>		x	x
<b>r5a.4xlarge</b>		x	x
<b>r5a.8xlarge</b>		x	x
<b>r5a.12xlarge</b>		x	x
<b>r5a.16xlarge</b>		x	x
<b>r5a.24xlarge</b>		x	x
<b>t3.large</b>			x
<b>t3.xlarge</b>			x
<b>t3.2xlarge</b>			x
<b>t3a.large</b>			x
<b>t3a.xlarge</b>			x
<b>t3a.2xlarge</b>			x

#### 4.8.6.4. Sample customized install-config.yaml file for AWS

You can customize the installation configuration file (**install-config.yaml**) to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.



#### IMPORTANT

This sample YAML file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program and modify it.

```

apiVersion: v1
baseDomain: example.com 1
credentialsMode: Mint 2
controlPlane: 3 4
  hyperthreading: Enabled 5
name: master
platform:
  aws:
    zones:
      - us-west-2a

```

```

- us-west-2b
rootVolume:
  iops: 4000
  size: 500
  type: io1 6
  type: m5.xlarge
replicas: 3
compute: 7
- hyperthreading: Enabled 8
name: worker
platform:
  aws:
    rootVolume:
      iops: 2000
      size: 500
      type: io1 9
      type: c5.4xlarge
    zones:
      - us-west-2c
replicas: 3
metadata:
  name: test-cluster 10
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
networkType: OpenShiftSDN
serviceNetwork:
  - 172.30.0.0/16
platform:
  aws:
    region: us-west-2 11
    userTags:
      adminContact: jdoe
      costCenter: 7536
    subnets: 12
    - subnet-1
    - subnet-2
    - subnet-3
    amiID: ami-96c6f8f7 13
    serviceEndpoints: 14
    - name: ec2
      url: https://vpce-id.ec2.us-west-2.vpce.amazonaws.com
    hostedZone: Z3URY6TWQ91KVV 15
  fips: false 16
  sshKey: ssh-ed25519 AAAA... 17
  pullSecret: '{"auths": ...}' 18

```

**1** **10** **11** **18** Required. The installation program prompts you for this value.

**2** Optional: Add this parameter to force the Cloud Credential Operator (CCO) to use the specified mode, instead of having the CCO dynamically try to determine the capabilities of the credentials. For details about CCO modes, see the *Cloud Credential Operator* entry in the *Platform Operators*

For details about OCP images, see the [Cloud Credential Operator](#) entry in the [Platform Operators reference content](#).

- 3 7 If you do not provide these parameters and values, the installation program provides the default value.
- 4 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. Only one control plane pool is used.
- 5 8 Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.



### IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger instance types, such as **m4.2xlarge** or **m5.2xlarge**, for your machines if you disable simultaneous multithreading.

- 6 9 To configure faster storage for etcd, especially for larger clusters, set the storage type as **io1** and set **iops** to **2000**.
- 12 If you provide your own VPC, specify subnets for each availability zone that your cluster uses.
- 13 The ID of the AMI used to boot machines for the cluster. If set, the AMI must belong to the same region as the cluster.
- 14 The AWS service endpoints. Custom endpoints are required when installing to an unknown AWS region. The endpoint URL must use the **https** protocol and the host must trust the certificate.
- 15 The ID of your existing Route 53 private hosted zone. Providing an existing hosted zone requires that you supply your own VPC and the hosted zone is already associated with the VPC prior to installing your cluster. If undefined, the installation program creates a new hosted zone.
- 16 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.



### IMPORTANT

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

- 17 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.



### NOTE

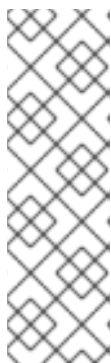
For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

### 4.8.6.5. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

#### Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



#### NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

- You have added the **ec2.<region>.amazonaws.com**, **elasticloadbalancing.<region>.amazonaws.com**, and **s3.<region>.amazonaws.com** endpoints to your VPC endpoint. These endpoints are required to complete requests from the nodes to the AWS EC2 API. Because the proxy works on the container level, not the node level, you must route these requests to the AWS EC2 API through the AWS private network. Adding the public IP address of the EC2 API to your allowlist in your proxy server is not sufficient.

#### Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

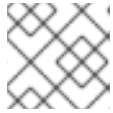
```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
  additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
  ...
```

**1** A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.

**2** A proxy URL to use for creating HTTPS connections outside the cluster.



- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with `.` to match subdomains only. For
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

**NOTE**

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

**NOTE**

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

### 4.8.7. Deploying the cluster

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

**IMPORTANT**

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

#### Prerequisites

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

#### Procedure

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

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

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

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



### NOTE

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

When the cluster deployment completes, directions for accessing your cluster, including a link to its web console and credentials for the **kubeadmin** user, display in your terminal.

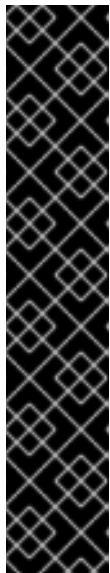
### Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Ee6gm-ymBZj-
Wt5AL"
INFO Time elapsed: 36m22s
```



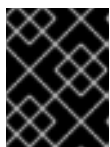
### NOTE

The cluster access and credential information also outputs to **<installation\_directory>/openshift\_install.log** when an installation succeeds.



### IMPORTANT

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



### IMPORTANT

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

2. Optional: Remove or disable the **AdministratorAccess** policy from the IAM account that you used to install the cluster.

**NOTE**

The elevated permissions provided by the **AdministratorAccess** policy are required only during installation.

**4.8.8. Installing the OpenShift CLI by downloading the binary**

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

**IMPORTANT**

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

**Installing the OpenShift CLI on Linux**

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

**Procedure**

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

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

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

```
$ echo $PATH
```

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

```
$ oc <command>
```

**Installing the OpenShift CLI on Windows**

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

**Procedure**

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.

5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

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

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

### Installing the OpenShift CLI on macOS

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

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your **PATH**.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

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

```
$ oc <command>
```

### 4.8.9. Logging in to the cluster by using the CLI

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

#### Prerequisites

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

#### Procedure

1. Export the **kubeadmin** credentials:

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

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

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

```
$ oc whoami
```

#### Example output

```
system:admin
```

### 4.8.10. Logging in to the cluster by using the web console

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

#### Prerequisites

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

#### Procedure

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

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



#### NOTE

Alternatively, you can obtain the **kubeadmin** password from the **<installation\_directory>/openshift\_install.log** log file on the installation host.

2. List the OpenShift Container Platform web console route:

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



#### NOTE

Alternatively, you can obtain the OpenShift Container Platform route from the **<installation\_directory>/openshift\_install.log** log file on the installation host.

#### Example output

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

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

#### Additional resources

- See [Accessing the web console](#) for more details about accessing and understanding the OpenShift Container Platform web console.

### 4.8.11. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

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

#### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service.

### 4.8.12. Next steps

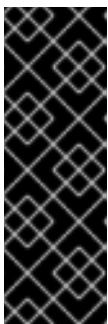
- [Validating an installation.](#)
- [Customize your cluster.](#)
- If necessary, you can [opt out of remote health reporting](#) .
- If necessary, you can [remove cloud provider credentials](#).

## 4.9. INSTALLING A PRIVATE CLUSTER ON AWS

In OpenShift Container Platform version 4.9, you can install a private cluster into an existing VPC on Amazon Web Services (AWS). The installation program provisions the rest of the required infrastructure, which you can further customize. To customize the installation, you modify parameters in the **install-config.yaml** file before you install the cluster.

### 4.9.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You [configured an AWS account](#) to host the cluster.



#### IMPORTANT

If you have an AWS profile stored on your computer, it must not use a temporary session token that you generated while using a multi-factor authentication device. The cluster continues to use your current AWS credentials to create AWS resources for the entire life of the cluster, so you must use long-lived credentials. To generate appropriate keys, see [Managing Access Keys for IAM Users](#) in the AWS documentation. You can supply the keys when you run the installation program.

- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can [manually create and maintain IAM credentials](#).

## 4.9.2. Private clusters

You can deploy a private OpenShift Container Platform cluster that does not expose external endpoints. Private clusters are accessible from only an internal network and are not visible to the internet.

By default, OpenShift Container Platform is provisioned to use publicly-accessible DNS and endpoints. A private cluster sets the DNS, Ingress Controller, and API server to private when you deploy your cluster. This means that the cluster resources are only accessible from your internal network and are not visible to the internet.



### IMPORTANT

If the cluster has any public subnets, load balancer services created by administrators might be publicly accessible. To ensure cluster security, verify that these services are explicitly annotated as private.

To deploy a private cluster, you must:

- Use existing networking that meets your requirements. Your cluster resources might be shared between other clusters on the network.
- Deploy from a machine that has access to:
  - The API services for the cloud to which you provision.
  - The hosts on the network that you provision.
  - The internet to obtain installation media.

You can use any machine that meets these access requirements and follows your company's guidelines. For example, this machine can be a bastion host on your cloud network or a machine that has access to the network through a VPN.

### 4.9.2.1. Private clusters in AWS

To create a private cluster on Amazon Web Services (AWS), you must provide an existing private VPC and subnets to host the cluster. The installation program must also be able to resolve the DNS records that the cluster requires. The installation program configures the Ingress Operator and API server for access from only the private network.

The cluster still requires access to internet to access the AWS APIs.

The following items are not required or created when you install a private cluster:

- Public subnets
- Public load balancers, which support public ingress
- A public Route 53 zone that matches the **baseDomain** for the cluster

The installation program does use the **baseDomain** that you specify to create a private Route 53 zone and the required records for the cluster. The cluster is configured so that the Operators do not create public records for the cluster and all cluster machines are placed in the private subnets that you specify.

#### 4.9.2.1.1. Limitations

The ability to add public functionality to a private cluster is limited.

- You cannot make the Kubernetes API endpoints public after installation without taking additional actions, including creating public subnets in the VPC for each availability zone in use, creating a public load balancer, and configuring the control plane security groups to allow traffic from the internet on 6443 (Kubernetes API port).
- If you use a public Service type load balancer, you must tag a public subnet in each availability zone with **kubernetes.io/cluster/<cluster-infra-id>: shared** so that AWS can use them to create public load balancers.

### 4.9.3. About using a custom VPC

In OpenShift Container Platform 4.9, you can deploy a cluster into existing subnets in an existing Amazon Virtual Private Cloud (VPC) in Amazon Web Services (AWS). By deploying OpenShift Container Platform into an existing AWS VPC, you might be able to avoid limit constraints in new accounts or more easily abide by the operational constraints that your company's guidelines set. If you cannot obtain the infrastructure creation permissions that are required to create the VPC yourself, use this installation option.

Because the installation program cannot know what other components are also in your existing subnets, it cannot choose subnet CIDRs and so forth on your behalf. You must configure networking for the subnets that you install your cluster to yourself.

#### 4.9.3.1. Requirements for using your VPC

The installation program no longer creates the following components:

- Internet gateways
- NAT gateways
- Subnets
- Route tables
- VPCs
- VPC DHCP options
- VPC endpoints



#### NOTE

The installation program requires that you use the cloud-provided DNS server. Using a custom DNS server is not supported and causes the installation to fail.



If you use a custom VPC, you must correctly configure it and its subnets for the installation program and the cluster to use. See [Amazon VPC console wizard configurations](#) and [Work with VPCs and subnets](#) in the AWS documentation for more information on creating and managing an AWS VPC.

The installation program cannot:

- Subdivide network ranges for the cluster to use.
- Set route tables for the subnets.
- Set VPC options like DHCP.

You must complete these tasks before you install the cluster. See [VPC networking components](#) and [Route tables for your VPC](#) for more information on configuring networking in an AWS VPC.

Your VPC must meet the following characteristics:

- The VPC must not use the **kubernetes.io/cluster/.\*: owned** tag. The installation program modifies your subnets to add the **kubernetes.io/cluster/.\*: shared** tag, so your subnets must have at least one free tag slot available for it. See [Tag Restrictions](#) in the AWS documentation to confirm that the installation program can add a tag to each subnet that you specify.
- You must enable the **enableDnsSupport** and **enableDnsHostnames** attributes in your VPC, so that the cluster can use the Route 53 zones that are attached to the VPC to resolve cluster's internal DNS records. See [DNS Support in Your VPC](#) in the AWS documentation. If you prefer to use your own Route 53 hosted private zone, you must associate the existing hosted zone with your VPC prior to installing a cluster. You can define your hosted zone using the **platform.aws.hostedZone** field in the **install-config.yaml** file.
- If you use a cluster with public access, you must create a public and a private subnet for each availability zone that your cluster uses. Each availability zone can contain no more than one public and one private subnet.

If you are working in a disconnected environment, you are unable to reach the public IP addresses for EC2 and ELB endpoints. To resolve this, you must create a VPC endpoint and attach it to the subnet that the clusters are using. The endpoints should be named as follows:

#### Government regions

- **ec2.<region>.amazonaws.com**
- **elasticloadbalancing.<region>.amazonaws.com**
- **s3.<region>.amazonaws.com**

#### Top secret region

- **ec2.<region>.c2s.ic.gov**
- **elasticloadbalancing.<region>.c2s.ic.gov**
- **s3.<region>.c2s.ic.gov**

#### Required VPC components

You must provide a suitable VPC and subnets that allow communication to your machines.

Component	AWS type	Description												
VPC	<ul style="list-style-type: none"> <li>● <b>AWS::EC2::VPC</b></li> <li>● <b>AWS::EC2::VPCEndpoint</b></li> </ul>	You must provide a public VPC for the cluster to use. The VPC uses an endpoint that references the route tables for each subnet to improve communication with the registry that is hosted in S3.												
Public subnets	<ul style="list-style-type: none"> <li>● <b>AWS::EC2::Subnet</b></li> <li>● <b>AWS::EC2::SubnetNetworkAclAssociation</b></li> </ul>	Your VPC must have public subnets for between 1 and 3 availability zones and associate them with appropriate Ingress rules.												
Internet gateway	<ul style="list-style-type: none"> <li>● <b>AWS::EC2::InternetGateway</b></li> <li>● <b>AWS::EC2::VPCGatewayAttachment</b></li> <li>● <b>AWS::EC2::RouteTable</b></li> <li>● <b>AWS::EC2::Route</b></li> <li>● <b>AWS::EC2::SubnetRouteTableAssociation</b></li> <li>● <b>AWS::EC2::NatGateway</b></li> <li>● <b>AWS::EC2::EIP</b></li> </ul>	You must have a public internet gateway, with public routes, attached to the VPC. In the provided templates, each public subnet has a NAT gateway with an EIP address. These NAT gateways allow cluster resources, like private subnet instances, to reach the internet and are not required for some restricted network or proxy scenarios.												
Network access control	<ul style="list-style-type: none"> <li>● <b>AWS::EC2::NetworkAcl</b></li> <li>● <b>AWS::EC2::NetworkAclEntry</b></li> </ul>	<p>You must allow the VPC to access the following ports:</p> <table border="1"> <thead> <tr> <th>Port</th> <th>Reason</th> </tr> </thead> <tbody> <tr> <td><b>80</b></td> <td>Inbound HTTP traffic</td> </tr> <tr> <td><b>443</b></td> <td>Inbound HTTPS traffic</td> </tr> <tr> <td><b>22</b></td> <td>Inbound SSH traffic</td> </tr> <tr> <td><b>1024 - 65535</b></td> <td>Inbound ephemeral traffic</td> </tr> <tr> <td><b>0 - 65535</b></td> <td>Outbound ephemeral traffic</td> </tr> </tbody> </table>	Port	Reason	<b>80</b>	Inbound HTTP traffic	<b>443</b>	Inbound HTTPS traffic	<b>22</b>	Inbound SSH traffic	<b>1024 - 65535</b>	Inbound ephemeral traffic	<b>0 - 65535</b>	Outbound ephemeral traffic
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Component	AWS type	Description
Private subnets	<ul style="list-style-type: none"> <li>● <b>AWS::EC2::Subnet</b></li> <li>● <b>AWS::EC2::RouteTable</b></li> <li>● <b>AWS::EC2::SubnetRouteTableAssociation</b></li> </ul>	Your VPC can have private subnets. The provided CloudFormation templates can create private subnets for between 1 and 3 availability zones. If you use private subnets, you must provide appropriate routes and tables for them.

#### 4.9.3.2. VPC validation

To ensure that the subnets that you provide are suitable, the installation program confirms the following data:

- All the subnets that you specify exist.
- You provide private subnets.
- The subnet CIDRs belong to the machine CIDR that you specified.
- You provide subnets for each availability zone. Each availability zone contains no more than one public and one private subnet. If you use a private cluster, provide only a private subnet for each availability zone. Otherwise, provide exactly one public and private subnet for each availability zone.
- You provide a public subnet for each private subnet availability zone. Machines are not provisioned in availability zones that you do not provide private subnets for.

If you destroy a cluster that uses an existing VPC, the VPC is not deleted. When you remove the OpenShift Container Platform cluster from a VPC, the **kubernetes.io/cluster/.\*: shared** tag is removed from the subnets that it used.

#### 4.9.3.3. Division of permissions

Starting with OpenShift Container Platform 4.3, you do not need all of the permissions that are required for an installation program-provisioned infrastructure cluster to deploy a cluster. This change mimics the division of permissions that you might have at your company: some individuals can create different resource in your clouds than others. For example, you might be able to create application-specific items, like instances, buckets, and load balancers, but not networking-related components such as VPCs, subnets, or ingress rules.

The AWS credentials that you use when you create your cluster do not need the networking permissions that are required to make VPCs and core networking components within the VPC, such as subnets, routing tables, internet gateways, NAT, and VPN. You still need permission to make the application resources that the machines within the cluster require, such as ELBs, security groups, S3 buckets, and nodes.

#### 4.9.3.4. Isolation between clusters

If you deploy OpenShift Container Platform to an existing network, the isolation of cluster services is reduced in the following ways:

- You can install multiple OpenShift Container Platform clusters in the same VPC.
- ICMP ingress is allowed from the entire network.
- TCP 22 ingress (SSH) is allowed to the entire network.
- Control plane TCP 6443 ingress (Kubernetes API) is allowed to the entire network.
- Control plane TCP 22623 ingress (MCS) is allowed to the entire network.

#### 4.9.4. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

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



#### IMPORTANT

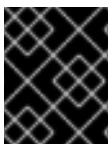
If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation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

#### 4.9.5. Generating a key pair for cluster node SSH access

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

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

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



#### IMPORTANT

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

**NOTE**

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

**Procedure**

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

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

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

**NOTE**

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

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

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

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

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

**NOTE**

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

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

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

**Example output**

```
Agent pid 31874
```

**NOTE**

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

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

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

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

**Example output**

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

**Next steps**

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

**4.9.6. Obtaining the installation program**

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

**Prerequisites**

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

**Procedure**

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.

**IMPORTANT**

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

**IMPORTANT**

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

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

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

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

### 4.9.7. Manually creating the installation configuration file

For installations of a private OpenShift Container Platform cluster that are only accessible from an internal network and are not visible to the internet, you must manually generate your installation configuration file.

#### Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

#### Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```



#### IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation\_directory>**.



#### NOTE

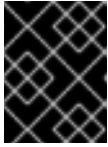
You must name this configuration file **install-config.yaml**.



#### NOTE

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation\_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

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

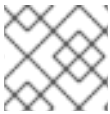


### IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

#### 4.9.7.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.



### NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.



### IMPORTANT

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

#### 4.9.7.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 4.27. Required parameters

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;</b> . <b>&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .



Parameter	Description	Values
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}</b> . <b>{{.baseDomain}}</b> .	String of lowercase letters, hyphens (-), and periods (.), such as <b>dev</b> .
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws</b> , <b>baremetal</b> , <b>azure</b> , <b>gcp</b> , <b>openstack</b> , <b>ovirt</b> , <b>vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } }</pre>


#### 4.9.7.1.2. Network configuration parameters


You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

**Table 4.28. Network parameters**

Parameter	Description	Values
-----------	-------------	--------

Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	Object  <b>NOTE</b> You cannot modify parameters specified by the <b>networking</b> object after installation.
<b>networking.networkType</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .
<b>networking.clusterNetwork</b>	The IP address blocks for pods.  The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b> .  If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example:  <pre>networking:   clusterNetwork:   - cidr: 10.128.0.0/14     hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	Required if you use <b>networking.clusterNetwork</b> . An IP address block.  An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b> .
<b>networking.clusterNetwork.hostPrefix</b>	The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b> . A <b>hostPrefix</b> value of <b>23</b> provides 510 ( $2^{(32 - 23)} - 2$ ) pod IP addresses.	A subnet prefix.  The default value is <b>23</b> .
<b>networking.serviceNetwork</b>	The IP address block for services. The default value is <b>172.30.0.0/16</b> .  The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example:  <pre>networking:   serviceNetwork:   - 172.30.0.0/16</pre>


Parameter	Description	Values
<b>networking.machineNetwork</b>	The IP address blocks for machines.  If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example:  <pre>networking:   machineNetwork:     - cidr: 10.0.0.0/16</pre>
<b>networking.machineNetwork.cidr</b>	Required if you use <b>networking.machineNetwork</b> . An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b> .	An IP network block in CIDR notation.  For example, <b>10.0.0.0/16</b> .   <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p>


#### 4.9.7.1.3. Optional configuration parameters



Optional installation configuration parameters are described in the following table:

Table 4.29. Optional parameters


Parameter	Description	Values
<b>additionalTrustBundle</b>	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
<b>compute</b>	The configuration for the machines that comprise the compute nodes.	Array of <b>MachinePool</b> objects.
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String

Parameter	Description	Values
<b>compute.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b>
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String

Parameter	Description	Values
<b>controlPlane.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platform</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>controlPlane.replicas</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.

Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.</p> <p> <b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators reference content</i>.</p> <p> <b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p>	<b>Mint, Passthrough, Manual</b> or an empty string ("").

Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 60px; height: 60px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 60px; height: 60px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<b>Internal</b> or <b>External</b> . To deploy a private cluster, which cannot be accessed from the internet, set <b>publish</b> to <b>Internal</b> . The default value is <b>External</b> .

Parameter	Description	Values
<b>sshKey</b>	<p>The SSH key or keys to authenticate access your cluster machines.</p>  <p><b>NOTE</b></p> <p>For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.</p>	<p>One or more keys. For example:</p> <pre>sshKey: &lt;key1&gt; &lt;key2&gt; &lt;key3&gt;</pre>

#### 4.9.7.1.4. Optional AWS configuration parameters

Optional AWS configuration parameters are described in the following table:

Table 4.30. Optional AWS parameters

Parameter	Description	Values
<b>compute.platform.aws.amiID</b>	The AWS AMI used to boot compute machines for the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region.
<b>compute.platform.aws.iamRole</b>	A pre-existing AWS IAM role applied to the compute machine pool instance profiles. You can use these fields to match naming schemes and include predefined permissions boundaries for your IAM roles. If undefined, the installation program creates a new IAM role.	The name of a valid AWS IAM role.
<b>compute.platform.aws.rootVolume.iops</b>	The Input/Output Operations Per Second (IOPS) that is reserved for the root volume.	Integer, for example <b>4000</b> .
<b>compute.platform.aws.rootVolume.size</b>	The size in GiB of the root volume.	Integer, for example <b>500</b> .



Parameter	Description	Values
<b>compute.platform.aws.rootVolume.type</b>	The type of the root volume.	Valid <a href="#">AWS EBS volume type</a> , such as <b>io1</b> .
<b>compute.platform.aws.rootVolume.kmsKeyARN</b>	The Amazon Resource Name (key ARN) of a KMS key. This is required to encrypt OS volumes of worker nodes with a specific KMS key.	Valid <a href="#">key ID</a> or the <a href="#">key ARN</a>
<b>compute.platform.aws.type</b>	The EC2 instance type for the compute machines.	Valid AWS instance type, such as <b>m4.2xlarge</b> . See the <b>Instance types for machines</b> table that follows.
<b>compute.platform.aws.zones</b>	The availability zones where the installation program creates machines for the compute machine pool. If you provide your own VPC, you must provide a subnet in that availability zone.	A list of valid AWS availability zones, such as <b>us-east-1c</b> , in a <a href="#">YAML sequence</a> .
<b>compute.aws.region</b>	The AWS region that the installation program creates compute resources in.	Any valid <a href="#">AWS region</a> , such as <b>us-east-1</b> .
<b>controlPlane.platform.aws.amiID</b>	The AWS AMI used to boot control plane machines for the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region.
<b>controlPlane.platform.aws.iamRole</b>	A pre-existing AWS IAM role applied to the control plane machine pool instance profiles. You can use these fields to match naming schemes and include predefined permissions boundaries for your IAM roles. If undefined, the installation program creates a new IAM role.	The name of a valid AWS IAM role.
<b>controlPlane.platform.aws.rootVolume.kmsKeyARN</b>	The Amazon Resource Name (key ARN) of a KMS key. This is required to encrypt OS volumes of control plane nodes with a specific KMS key.	Valid <a href="#">key ID</a> and the <a href="#">key ARN</a>

Parameter	Description	Values
<b>controlPlane.platform.aws.type</b>	The EC2 instance type for the control plane machines.	Valid AWS instance type, such as <b>m5.xlarge</b> . See the <b>Instance types for machines</b> table that follows.
<b>controlPlane.platform.aws.zones</b>	The availability zones where the installation program creates machines for the control plane machine pool.	A list of valid AWS availability zones, such as <b>us-east-1c</b> , in a <a href="#">YAML sequence</a> .
<b>controlPlane.aws.region</b>	The AWS region that the installation program creates control plane resources in.	Valid <a href="#">AWS region</a> , such as <b>us-east-1</b> .
<b>platform.aws.amiID</b>	The AWS AMI used to boot all machines for the cluster. If set, the AMI must belong to the same region as the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region.
<b>platform.aws.hostedZone</b>	An existing Route 53 private hosted zone for the cluster. You can only use a pre-existing hosted zone when also supplying your own VPC. The hosted zone must already be associated with the user-provided VPC before installation. Also, the domain of the hosted zone must be the cluster domain or a parent of the cluster domain. If undefined, the installation program creates a new hosted zone.	String, for example <b>Z3URY6TWQ91KVV</b> .
<b>platform.aws.serviceEndpoints.name</b>	The AWS service endpoint name. Custom endpoints are only required for cases where alternative AWS endpoints, like FIPS, must be used. Custom API endpoints can be specified for EC2, S3, IAM, Elastic Load Balancing, Tagging, Route 53, and STS AWS services.	Valid <a href="#">AWS service endpoint</a> name.

Parameter	Description	Values
<b>platform.aws.serviceEndpoints.url</b>	The AWS service endpoint URL. The URL must use the <b>https</b> protocol and the host must trust the certificate.	Valid <a href="#">AWS service endpoint</a> URL.
<b>platform.aws.userTags</b>	A map of keys and values that the installation program adds as tags to all resources that it creates.	Any valid YAML map, such as key value pairs in the <b>&lt;key&gt;: &lt;value&gt;</b> format. For more information about AWS tags, see <a href="#">Tagging Your Amazon EC2 Resources</a> in the AWS documentation.
<b>platform.aws.subnets</b>	If you provide the VPC instead of allowing the installation program to create the VPC for you, specify the subnet for the cluster to use. The subnet must be part of the same <b>machineNetwork[].cidr</b> ranges that you specify. For a standard cluster, specify a public and a private subnet for each availability zone. For a private cluster, specify a private subnet for each availability zone.	Valid subnet IDs.

#### 4.9.7.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 4.31. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 7.9, or RHEL 8.4 [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.

2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.

#### 4.9.7.3. Supported AWS machine types

The following Amazon Web Services (AWS) instance types are supported with OpenShift Container Platform.

Example 4.19. Instance types for machines

Instance type	Bootstrap	Control plane	Compute
<b>i3.large</b>	x		
<b>m4.large</b>			x
<b>m4.xlarge</b>		x	x
<b>m4.2xlarge</b>		x	x
<b>m4.4xlarge</b>		x	x
<b>m4.10xlarge</b>		x	x
<b>m4.16xlarge</b>		x	x
<b>m5.large</b>			x
<b>m5.xlarge</b>		x	x
<b>m5.2xlarge</b>		x	x
<b>m5.4xlarge</b>		x	x
<b>m5.8xlarge</b>		x	x
<b>m5.12xlarge</b>		x	x
<b>m5.16xlarge</b>		x	x
<b>m5a.large</b>			x

Instance type	Bootstrap	Control plane	Compute
<b>m5a.xlarge</b>		x	x
<b>m5a.2xlarge</b>		x	x
<b>m5a.4xlarge</b>		x	x
<b>m5a.8xlarge</b>		x	x
<b>m5a.12xlarge</b>		x	x
<b>m5a.16xlarge</b>		x	x
<b>m6i.xlarge</b>		x	x
<b>m6i.2xlarge</b>		x	x
<b>m6i.4xlarge</b>		x	x
<b>m6i.8xlarge</b>		x	x
<b>m6i.16xlarge</b>		x	x
<b>c4.2xlarge</b>		x	x
<b>c4.4xlarge</b>		x	x
<b>c4.8xlarge</b>		x	x
<b>c5.xlarge</b>			x
<b>c5.2xlarge</b>		x	x
<b>c5.4xlarge</b>		x	x
<b>c5.9xlarge</b>		x	x
<b>c5.12xlarge</b>		x	x
<b>c5.18xlarge</b>		x	x
<b>c5.24xlarge</b>		x	x
<b>c5a.xlarge</b>			x

Instance type	Bootstrap	Control plane	Compute
<b>c5a.2xlarge</b>		x	x
<b>c5a.4xlarge</b>		x	x
<b>c5a.8xlarge</b>		x	x
<b>c5a.12xlarge</b>		x	x
<b>c5a.16xlarge</b>		x	x
<b>c5a.24xlarge</b>		x	x
<b>r4.large</b>			x
<b>r4.xlarge</b>		x	x
<b>r4.2xlarge</b>		x	x
<b>r4.4xlarge</b>		x	x
<b>r4.8xlarge</b>		x	x
<b>r4.16xlarge</b>		x	x
<b>r5.large</b>			x
<b>r5.xlarge</b>		x	x
<b>r5.2xlarge</b>		x	x
<b>r5.4xlarge</b>		x	x
<b>r5.8xlarge</b>		x	x
<b>r5.12xlarge</b>		x	x
<b>r5.16xlarge</b>		x	x
<b>r5.24xlarge</b>		x	x
<b>r5a.large</b>			x
<b>r5a.xlarge</b>		x	x

Instance type	Bootstrap	Control plane	Compute
<b>r5a.2xlarge</b>		x	x
<b>r5a.4xlarge</b>		x	x
<b>r5a.8xlarge</b>		x	x
<b>r5a.12xlarge</b>		x	x
<b>r5a.16xlarge</b>		x	x
<b>r5a.24xlarge</b>		x	x
<b>t3.large</b>			x
<b>t3.xlarge</b>			x
<b>t3.2xlarge</b>			x
<b>t3a.large</b>			x
<b>t3a.xlarge</b>			x
<b>t3a.2xlarge</b>			x

#### 4.9.7.4. Sample customized install-config.yaml file for AWS

You can customize the installation configuration file (**install-config.yaml**) to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.



#### IMPORTANT

This sample YAML file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program and modify it.

```

apiVersion: v1
baseDomain: example.com 1
credentialsMode: Mint 2
controlPlane: 3 4
  hyperthreading: Enabled 5
name: master
platform:
  aws:
    zones:
      - us-west-2a

```

```

- us-west-2b
rootVolume:
  iops: 4000
  size: 500
  type: io1 6
  type: m5.xlarge
replicas: 3
compute: 7
- hyperthreading: Enabled 8
name: worker
platform:
  aws:
    rootVolume:
      iops: 2000
      size: 500
      type: io1 9
      type: c5.4xlarge
    zones:
      - us-west-2c
replicas: 3
metadata:
  name: test-cluster 10
networking:
  clusterNetwork:
    - cidr: 10.128.0.0/14
      hostPrefix: 23
  machineNetwork:
    - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
    - 172.30.0.0/16
platform:
  aws:
    region: us-west-2 11
    userTags:
      adminContact: jdoe
      costCenter: 7536
    subnets: 12
    - subnet-1
    - subnet-2
    - subnet-3
    amiID: ami-96c6f8f7 13
    serviceEndpoints: 14
    - name: ec2
      url: https://vpce-id.ec2.us-west-2.vpce.amazonaws.com
    hostedZone: Z3URY6TWQ91KVV 15
  fips: false 16
  sshKey: ssh-ed25519 AAAA... 17
  publish: Internal 18
  pullSecret: '{"auths": ...}' 19

```

**1** **10** **11** **19** Required. The installation program prompts you for this value.

**2** Optional: Add this parameter to force the Cloud Credential Operator (CCO) to use the specified



- 3 7 If you do not provide these parameters and values, the installation program provides the default value.
- 4 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. Only one control plane pool is used.
- 5 8 Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.



### IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger instance types, such as **m4.2xlarge** or **m5.2xlarge**, for your machines if you disable simultaneous multithreading.

- 6 9 To configure faster storage for etcd, especially for larger clusters, set the storage type as **io1** and set **iops** to **2000**.
- 12 If you provide your own VPC, specify subnets for each availability zone that your cluster uses.
- 13 The ID of the AMI used to boot machines for the cluster. If set, the AMI must belong to the same region as the cluster.
- 14 The AWS service endpoints. Custom endpoints are required when installing to an unknown AWS region. The endpoint URL must use the **https** protocol and the host must trust the certificate.
- 15 The ID of your existing Route 53 private hosted zone. Providing an existing hosted zone requires that you supply your own VPC and the hosted zone is already associated with the VPC prior to installing your cluster. If undefined, the installation program creates a new hosted zone.
- 16 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.



### IMPORTANT

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

- 17 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.



### NOTE

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

- 18 How to publish the user-facing endpoints of your cluster. Set **publish** to **Internal** to deploy a private cluster, which cannot be accessed from the internet. The default value is **External**.

#### 4.9.7.5. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

##### Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



##### NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

- You have added the **ec2.<region>.amazonaws.com**, **elasticloadbalancing.<region>.amazonaws.com**, and **s3.<region>.amazonaws.com** endpoints to your VPC endpoint. These endpoints are required to complete requests from the nodes to the AWS EC2 API. Because the proxy works on the container level, not the node level, you must route these requests to the AWS EC2 API through the AWS private network. Adding the public IP address of the EC2 API to your allowlist in your proxy server is not sufficient.

##### Procedure

- Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
  additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
  ...
```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations.
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

**NOTE**

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

**NOTE**

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

#### 4.9.8. Deploying the cluster

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

**IMPORTANT**

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

#### Prerequisites

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

#### Procedure

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

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

- 1 For **<installation\_directory>**, specify the
- 2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.



#### NOTE

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

When the cluster deployment completes, directions for accessing your cluster, including a link to its web console and credentials for the **kubeadmin** user, display in your terminal.

#### Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Ee6gm-ymBZj-
Wt5AL"
INFO Time elapsed: 36m22s
```



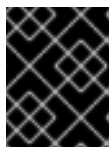
#### NOTE

The cluster access and credential information also outputs to **<installation\_directory>/openshift\_install.log** when an installation succeeds.



#### IMPORTANT

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

**IMPORTANT**

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

**4.9.9. Installing the OpenShift CLI by downloading the binary**

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

**IMPORTANT**

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

**Installing the OpenShift CLI on Linux**

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

**Procedure**

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

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

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

```
$ echo $PATH
```

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

```
$ oc <command>
```

**Installing the OpenShift CLI on Windows**

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

**Procedure**

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.

5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

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

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

### Installing the OpenShift CLI on macOS

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

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

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

```
$ oc <command>
```

### 4.9.10. Logging in to the cluster by using the CLI

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

#### Prerequisites

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

#### Procedure

1. Export the **kubeadmin** credentials:

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

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

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

```
$ oc whoami
```

#### Example output

```
system:admin
```

### 4.9.11. Logging in to the cluster by using the web console

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

#### Prerequisites

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

#### Procedure

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

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



#### NOTE

Alternatively, you can obtain the **kubeadmin** password from the **<installation\_directory>/openshift\_install.log** log file on the installation host.

2. List the OpenShift Container Platform web console route:

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



#### NOTE

Alternatively, you can obtain the OpenShift Container Platform route from the **<installation\_directory>/openshift\_install.log** log file on the installation host.

#### Example output

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

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

#### Additional resources

- See [Accessing the web console](#) for more details about accessing and understanding the OpenShift Container Platform web console.

### 4.9.12. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

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

#### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service.

### 4.9.13. Next steps

- [Validating an installation.](#)
- [Customize your cluster.](#)
- If necessary, you can [opt out of remote health reporting](#).
- If necessary, you can [remove cloud provider credentials](#).

## 4.10. INSTALLING A CLUSTER ON AWS INTO A GOVERNMENT OR SECRET REGION

In OpenShift Container Platform version 4.9, you can install a cluster on Amazon Web Services (AWS) into a government or secret region. To configure the region, modify parameters in the **install-config.yaml** file before you install the cluster.

### 4.10.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You [configured an AWS account](#) to host the cluster.



#### IMPORTANT

If you have an AWS profile stored on your computer, it must not use a temporary session token that you generated while using a multi-factor authentication device. The cluster continues to use your current AWS credentials to create AWS resources for the entire life of the cluster, so you must use long-lived credentials. To generate appropriate keys, see [Managing Access Keys for IAM Users](#) in the AWS documentation. You can supply the keys when you run the installation program.



- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can [manually create and maintain IAM credentials](#).

### 4.10.2. AWS government and secret regions

OpenShift Container Platform supports deploying a cluster to [AWS GovCloud \(US\)](#) regions and the [AWS Commercial Cloud Services \(C2S\) Top Secret Region](#). These regions are specifically designed for US government agencies at the federal, state, and local level, as well as contractors, educational institutions, and other US customers that must run sensitive workloads in the cloud.

These regions do not have published Red Hat Enterprise Linux CoreOS (RHCOS) Amazon Machine Images (AMI) to select, so you must upload a custom AMI that belongs to that region.

The following AWS GovCloud partitions are supported:

- **us-gov-west-1**
- **us-gov-east-1**

The following AWS Top Secret Region partition is supported:

- **us-iso-east-1**



#### NOTE

The maximum supported MTU in an AWS Top Secret Region is not the same as AWS commercial. For more information about configuring MTU during installation, see the *Cluster Network Operator configuration object* section in *Installing a cluster on AWS with network customizations*.

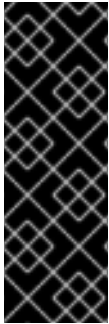
### 4.10.3. Installation requirements

Red Hat does not publish a Red Hat Enterprise Linux CoreOS (RHCOS) Amazon Machine Image for the AWS government or secret regions.

Before you can install the cluster, you must:

- Upload a custom RHCOS AMI.
- Manually create the installation configuration file (**install-config.yaml**).
- Specify the AWS region, and the accompanying custom AMI, in the installation configuration file.

You cannot use the OpenShift Container Platform installation program to create the installation configuration file. The installer does not list an AWS region without native support for an RHCOS AMI.



## IMPORTANT

If you are deploying to the C2S Top Secret Region, you must also define a custom CA certificate in the **additionalTrustBundle** field of the **install-config.yaml** file because the AWS API requires a custom CA trust bundle. To allow the installation program to access the AWS API, the CA certificates must also be defined on the machine that runs the installation program. You must add the CA bundle to the trust store on the machine, use the **AWS\_CA\_BUNDLE** environment variable, or define the CA bundle in the **ca\_bundle** field of the AWS config file.

### 4.10.4. Private clusters

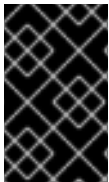
You can deploy a private OpenShift Container Platform cluster that does not expose external endpoints. Private clusters are accessible from only an internal network and are not visible to the internet.



## NOTE

Public zones are not supported in Route 53 in AWS GovCloud or Top Secret Regions. Therefore, clusters must be private if they are deployed to an AWS government or secret region.

By default, OpenShift Container Platform is provisioned to use publicly-accessible DNS and endpoints. A private cluster sets the DNS, Ingress Controller, and API server to private when you deploy your cluster. This means that the cluster resources are only accessible from your internal network and are not visible to the internet.



## IMPORTANT

If the cluster has any public subnets, load balancer services created by administrators might be publicly accessible. To ensure cluster security, verify that these services are explicitly annotated as private.

To deploy a private cluster, you must:

- Use existing networking that meets your requirements. Your cluster resources might be shared between other clusters on the network.
- Deploy from a machine that has access to:
  - The API services for the cloud to which you provision.
  - The hosts on the network that you provision.
  - The internet to obtain installation media.

You can use any machine that meets these access requirements and follows your company's guidelines. For example, this machine can be a bastion host on your cloud network or a machine that has access to the network through a VPN.

#### 4.10.4.1. Private clusters in AWS

To create a private cluster on Amazon Web Services (AWS), you must provide an existing private VPC and subnets to host the cluster. The installation program must also be able to resolve the DNS records that the cluster requires. The installation program configures the Ingress Operator and API server for

access from only the private network.

The cluster still requires access to internet to access the AWS APIs.

The following items are not required or created when you install a private cluster:

- Public subnets
- Public load balancers, which support public ingress
- A public Route 53 zone that matches the **baseDomain** for the cluster

The installation program does use the **baseDomain** that you specify to create a private Route 53 zone and the required records for the cluster. The cluster is configured so that the Operators do not create public records for the cluster and all cluster machines are placed in the private subnets that you specify.

#### 4.10.4.1.1. Limitations

The ability to add public functionality to a private cluster is limited.

- You cannot make the Kubernetes API endpoints public after installation without taking additional actions, including creating public subnets in the VPC for each availability zone in use, creating a public load balancer, and configuring the control plane security groups to allow traffic from the internet on 6443 (Kubernetes API port).
- If you use a public Service type load balancer, you must tag a public subnet in each availability zone with **kubernetes.io/cluster/<cluster-infra-id>: shared** so that AWS can use them to create public load balancers.

### 4.10.5. About using a custom VPC

In OpenShift Container Platform 4.9, you can deploy a cluster into existing subnets in an existing Amazon Virtual Private Cloud (VPC) in Amazon Web Services (AWS). By deploying OpenShift Container Platform into an existing AWS VPC, you might be able to avoid limit constraints in new accounts or more easily abide by the operational constraints that your company's guidelines set. If you cannot obtain the infrastructure creation permissions that are required to create the VPC yourself, use this installation option.

Because the installation program cannot know what other components are also in your existing subnets, it cannot choose subnet CIDRs and so forth on your behalf. You must configure networking for the subnets that you install your cluster to yourself.

#### 4.10.5.1. Requirements for using your VPC

The installation program no longer creates the following components:

- Internet gateways
- NAT gateways
- Subnets
- Route tables
- VPCs

- VPC DHCP options
- VPC endpoints



## NOTE

The installation program requires that you use the cloud-provided DNS server. Using a custom DNS server is not supported and causes the installation to fail.

If you use a custom VPC, you must correctly configure it and its subnets for the installation program and the cluster to use. See [Amazon VPC console wizard configurations](#) and [Work with VPCs and subnets](#) in the AWS documentation for more information on creating and managing an AWS VPC.

The installation program cannot:

- Subdivide network ranges for the cluster to use.
- Set route tables for the subnets.
- Set VPC options like DHCP.

You must complete these tasks before you install the cluster. See [VPC networking components](#) and [Route tables for your VPC](#) for more information on configuring networking in an AWS VPC.

Your VPC must meet the following characteristics:

- The VPC must not use the **kubernetes.io/cluster/.\*: owned** tag.  
The installation program modifies your subnets to add the **kubernetes.io/cluster/.\*: shared** tag, so your subnets must have at least one free tag slot available for it. See [Tag Restrictions](#) in the AWS documentation to confirm that the installation program can add a tag to each subnet that you specify.
- You must enable the **enableDnsSupport** and **enableDnsHostnames** attributes in your VPC, so that the cluster can use the Route 53 zones that are attached to the VPC to resolve cluster's internal DNS records. See [DNS Support in Your VPC](#) in the AWS documentation.  
If you prefer to use your own Route 53 hosted private zone, you must associate the existing hosted zone with your VPC prior to installing a cluster. You can define your hosted zone using the **platform.aws.hostedZone** field in the **install-config.yaml** file.
- If you use a cluster with public access, you must create a public and a private subnet for each availability zone that your cluster uses. Each availability zone can contain no more than one public and one private subnet.

If you are working in a disconnected environment, you are unable to reach the public IP addresses for EC2 and ELB endpoints. To resolve this, you must create a VPC endpoint and attach it to the subnet that the clusters are using. The endpoints should be named as follows:

### Government regions

- **ec2.<region>.amazonaws.com**
- **elasticloadbalancing.<region>.amazonaws.com**
- **s3.<region>.amazonaws.com**

## Top secret region

- `ec2.<region>.c2s.ic.gov`
- `elasticloadbalancing.<region>.c2s.ic.gov`
- `s3.<region>.c2s.ic.gov`

## Required VPC components

You must provide a suitable VPC and subnets that allow communication to your machines.

Component	AWS type	Description						
VPC	<ul style="list-style-type: none"> <li>• <b>AWS::EC2::VPC</b></li> <li>• <b>AWS::EC2::VPCEndpoint</b></li> </ul>	You must provide a public VPC for the cluster to use. The VPC uses an endpoint that references the route tables for each subnet to improve communication with the registry that is hosted in S3.						
Public subnets	<ul style="list-style-type: none"> <li>• <b>AWS::EC2::Subnet</b></li> <li>• <b>AWS::EC2::SubnetNetworkAclAssociation</b></li> </ul>	Your VPC must have public subnets for between 1 and 3 availability zones and associate them with appropriate Ingress rules.						
Internet gateway	<ul style="list-style-type: none"> <li>• <b>AWS::EC2::InternetGateway</b></li> <li>• <b>AWS::EC2::VPCGatewayAttachment</b></li> <li>• <b>AWS::EC2::RouteTable</b></li> <li>• <b>AWS::EC2::Route</b></li> <li>• <b>AWS::EC2::SubnetRouteTableAssociation</b></li> <li>• <b>AWS::EC2::NatGateway</b></li> <li>• <b>AWS::EC2::EIP</b></li> </ul>	You must have a public internet gateway, with public routes, attached to the VPC. In the provided templates, each public subnet has a NAT gateway with an EIP address. These NAT gateways allow cluster resources, like private subnet instances, to reach the internet and are not required for some restricted network or proxy scenarios.						
Network access control	<ul style="list-style-type: none"> <li>• <b>AWS::EC2::NetworkAcl</b></li> <li>• <b>AWS::EC2::NetworkAclEntry</b></li> </ul>	<p>You must allow the VPC to access the following ports:</p> <table border="1"> <thead> <tr> <th>Port</th> <th>Reason</th> </tr> </thead> <tbody> <tr> <td><b>80</b></td> <td>Inbound HTTP traffic</td> </tr> <tr> <td><b>443</b></td> <td>Inbound HTTPS traffic</td> </tr> </tbody> </table>	Port	Reason	<b>80</b>	Inbound HTTP traffic	<b>443</b>	Inbound HTTPS traffic
Port	Reason							
<b>80</b>	Inbound HTTP traffic							
<b>443</b>	Inbound HTTPS traffic							

Component	AWS type	Description	
		<b>22</b>	Inbound SSH traffic
		<b>1024 - 65535</b>	Inbound ephemeral traffic
		<b>0 - 65535</b>	Outbound ephemeral traffic
Private subnets	<ul style="list-style-type: none"> <li>● <b>AWS::EC2::Subnet</b></li> <li>● <b>AWS::EC2::RouteTable</b></li> <li>● <b>AWS::EC2::SubnetRouteTableAssociation</b></li> </ul>	Your VPC can have private subnets. The provided CloudFormation templates can create private subnets for between 1 and 3 availability zones. If you use private subnets, you must provide appropriate routes and tables for them.	

#### 4.10.5.2. VPC validation

To ensure that the subnets that you provide are suitable, the installation program confirms the following data:

- All the subnets that you specify exist.
- You provide private subnets.
- The subnet CIDRs belong to the machine CIDR that you specified.
- You provide subnets for each availability zone. Each availability zone contains no more than one public and one private subnet. If you use a private cluster, provide only a private subnet for each availability zone. Otherwise, provide exactly one public and private subnet for each availability zone.
- You provide a public subnet for each private subnet availability zone. Machines are not provisioned in availability zones that you do not provide private subnets for.

If you destroy a cluster that uses an existing VPC, the VPC is not deleted. When you remove the OpenShift Container Platform cluster from a VPC, the **kubernetes.io/cluster/.\*: shared** tag is removed from the subnets that it used.

#### 4.10.5.3. Division of permissions

Starting with OpenShift Container Platform 4.3, you do not need all of the permissions that are required for an installation program-provisioned infrastructure cluster to deploy a cluster. This change mimics the division of permissions that you might have at your company: some individuals can create different resource in your clouds than others. For example, you might be able to create application-specific items, like instances, buckets, and load balancers, but not networking-related components such as VPCs, subnets, or ingress rules.

The AWS credentials that you use when you create your cluster do not need the networking permissions that are required to make VPCs and core networking components within the VPC, such as subnets,

routing tables, internet gateways, NAT, and VPN. You still need permission to make the application resources that the machines within the cluster require, such as ELBs, security groups, S3 buckets, and nodes.

#### 4.10.5.4. Isolation between clusters

If you deploy OpenShift Container Platform to an existing network, the isolation of cluster services is reduced in the following ways:

- You can install multiple OpenShift Container Platform clusters in the same VPC.
- ICMP ingress is allowed from the entire network.
- TCP 22 ingress (SSH) is allowed to the entire network.
- Control plane TCP 6443 ingress (Kubernetes API) is allowed to the entire network.
- Control plane TCP 22623 ingress (MCS) is allowed to the entire network.

#### 4.10.6. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

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



#### IMPORTANT

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

#### 4.10.7. Generating a key pair for cluster node SSH access

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

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

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



### IMPORTANT

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



### NOTE

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

## Procedure

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

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

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



### NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

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

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

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

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



### NOTE

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

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

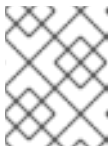
■



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

### Example output

```
Agent pid 31874
```



### NOTE

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

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

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

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

### Example output

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

### Next steps

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

## 4.10.8. Uploading a custom RHCOS AMI in AWS

If you are deploying to a custom Amazon Web Services (AWS) region, you must upload a custom Red Hat Enterprise Linux CoreOS (RHCOS) Amazon Machine Image (AMI) that belongs to that region.

### Prerequisites

- You configured an AWS account.
- You created an Amazon S3 bucket with the required IAM [service role](#).
- You uploaded your RHCOS VMDK file to Amazon S3. The RHCOS VMDK file must be the highest version that is less than or equal to the OpenShift Container Platform version you are installing.
- You downloaded the AWS CLI and installed it on your computer. See [Install the AWS CLI Using the Bundled Installer](#).

### Procedure

1. Export your AWS profile as an environment variable:

```
$ export AWS_PROFILE=<aws_profile> 1
```

- 1 The AWS profile name that holds your AWS credentials, like **govcloud**.

- Export the region to associate with your custom AMI as an environment variable:

```
$ export AWS_DEFAULT_REGION=<aws_region> 1
```

- The AWS region, like **us-gov-east-1**.

- Export the version of RHCOS you uploaded to Amazon S3 as an environment variable:

```
$ export RHCOS_VERSION=<version> 1
```

- The RHCOS VMDK version, like **4.9.0**.

- Export the Amazon S3 bucket name as an environment variable:

```
$ export VMIMPORT_BUCKET_NAME=<s3_bucket_name>
```

- Create the **containers.json** file and define your RHCOS VMDK file:

```
$ cat <<EOF > containers.json
{
  "Description": "rhcos-{RHCOS_VERSION}-x86_64-aws.x86_64",
  "Format": "vmdk",
  "UserBucket": {
    "S3Bucket": "{VMIMPORT_BUCKET_NAME}",
    "S3Key": "rhcos-{RHCOS_VERSION}-x86_64-aws.x86_64.vmdk"
  }
}
EOF
```

- Import the RHCOS disk as an Amazon EBS snapshot:

```
$ aws ec2 import-snapshot --region {AWS_DEFAULT_REGION} \
  --description "<description>" 1
  --disk-container "file://<file_path>/containers.json" 2
```

- The description of your RHCOS disk being imported, like **rhcos-**{RHCOS\_VERSION}**-x86\_64-aws.x86\_64**.

- The file path to the JSON file describing your RHCOS disk. The JSON file should contain your Amazon S3 bucket name and key.

- Check the status of the image import:

```
$ watch -n 5 aws ec2 describe-import-snapshot-tasks --region {AWS_DEFAULT_REGION}
```

### Example output

```
{
  "ImportSnapshotTasks": [
    {
      "Description": "rhcos-4.7.0-x86_64-aws.x86_64",
```

```

    "ImportTaskId": "import-snap-fh6i8uil",
    "SnapshotTaskDetail": {
      "Description": "rhcos-4.7.0-x86_64-aws.x86_64",
      "DiskImageSize": 819056640.0,
      "Format": "VMDK",
      "SnapshotId": "snap-06331325870076318",
      "Status": "completed",
      "UserBucket": {
        "S3Bucket": "external-images",
        "S3Key": "rhcos-4.7.0-x86_64-aws.x86_64.vmdk"
      }
    }
  }
]
}

```

Copy the **SnapshotId** to register the image.

8. Create a custom RHCOS AMI from the RHCOS snapshot:

```

$ aws ec2 register-image \
  --region ${AWS_DEFAULT_REGION} \
  --architecture x86_64 \ 1
  --description "rhcos-${RHCOS_VERSION}-x86_64-aws.x86_64" \ 2
  --ena-support \
  --name "rhcos-${RHCOS_VERSION}-x86_64-aws.x86_64" \ 3
  --virtualization-type hvm \
  --root-device-name '/dev/xvda' \
  --block-device-mappings 'DeviceName=/dev/xvda,Ebs=
[DeleteOnTermination=true,SnapshotId=<snapshot_ID>' 4

```

- 1** The RHCOS VMDK architecture type, like **x86\_64**, **s390x**, or **ppc64le**.
- 2** The **Description** from the imported snapshot.
- 3** The name of the RHCOS AMI.
- 4** The **SnapshotID** from the imported snapshot.

To learn more about these APIs, see the AWS documentation for [importing snapshots](#) and [creating EBS-backed AMIs](#).

#### 4.10.9. Obtaining an AWS Marketplace image

If you are deploying an OpenShift Container Platform cluster using an AWS Marketplace image, you must first subscribe through AWS. Subscribing to the offer provides you with the AMI ID that the installation program uses to deploy worker nodes.



#### NOTE

Deploying an OpenShift Container Platform cluster using an AWS Marketplace image is not supported in the secret regions or China regions.

## Prerequisites

- You have an AWS account to purchase the offer. This account does not have to be the same account that is used to install the cluster.

## Procedure

1. Complete the OpenShift Container Platform subscription from the [AWS Marketplace](#).
2. Record the AMI ID for your specific region. As part of the installation process, you must update the **install-config.yaml** file with this value before deploying the cluster.

## Sample install-config.yaml file with AWS Marketplace worker nodes

```
apiVersion: v1
baseDomain: example.com
compute:
- hyperthreading: Enabled
  name: worker
  platform:
    aws:
      amiID: ami-06c4d345f7c207239 1
      type: m5.4xlarge
      replicas: 3
  metadata:
    name: test-cluster
  platform:
    aws:
      region: us-gov-west-1 2
sshKey: ssh-ed25519 AAAA...
pullSecret: '{"auths": ...}'
```

- 1** The AMI ID from your AWS Marketplace subscription.
- 2** Your AMI ID is associated with a specific AWS region. When creating the installation configuration file, ensure that you select the same AWS region that you specified when configuring your subscription.

### 4.10.10. Obtaining the installation program

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

## Prerequisites

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

## Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.

- Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



### IMPORTANT

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



### IMPORTANT

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

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

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

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

#### 4.10.11. Manually creating the installation configuration file

When installing OpenShift Container Platform on Amazon Web Services (AWS) into a region requiring a custom Red Hat Enterprise Linux CoreOS (RHCOS) AMI, you must manually generate your installation configuration file.

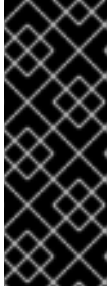
##### Prerequisites

- You have uploaded a custom RHCOS AMI.
- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

##### Procedure

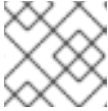
- Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```

**IMPORTANT**

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation\_directory>**.

**NOTE**

You must name this configuration file **install-config.yaml**.

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

**IMPORTANT**

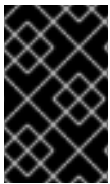
The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

#### 4.10.11.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.

**NOTE**

After installation, you cannot modify these parameters in the **install-config.yaml** file.

**IMPORTANT**

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

##### 4.10.11.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

**Table 4.32. Required parameters**

Parameter	Description	Values
-----------	-------------	--------

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;.&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}</b> . <b>{{.baseDomain}}</b> .	String of lowercase letters, hyphens (-), and periods (.), such as <b>dev</b> .
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws, baremetal, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object


Parameter	Description	Values
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } }</pre>

#### 4.10.11.1.2. Network configuration parameters


You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

**Table 4.33. Network parameters**

Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	Object <div style="display: flex; align-items: center; margin-top: 10px;">  <div> <p><b>NOTE</b></p> <p>You cannot modify parameters specified by the <b>networking</b> object after installation.</p> </div> </div>
<b>networking.network Type</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .




Parameter	Description	Values
<b>networking.clusterNetwork</b>	<p>The IP address blocks for pods.</p> <p>The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b>.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   clusterNetwork:     - cidr: 10.128.0.0/14       hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	<p>Required if you use <b>networking.clusterNetwork</b>. An IP address block.</p> <p>An IPv4 network.</p>	<p>An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b>.</p>
<b>networking.clusterNetwork.hostPrefix</b>	<p>The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b>. A <b>hostPrefix</b> value of <b>23</b> provides 510 (<math>2^{(32 - 23)} - 2</math>) pod IP addresses.</p>	<p>A subnet prefix.</p> <p>The default value is <b>23</b>.</p>
<b>networking.serviceNetwork</b>	<p>The IP address block for services. The default value is <b>172.30.0.0/16</b>.</p> <p>The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.</p>	<p>An array with an IP address block in CIDR format. For example:</p> <pre>networking:   serviceNetwork:     - 172.30.0.0/16</pre>
<b>networking.machineNetwork</b>	<p>The IP address blocks for machines.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   machineNetwork:     - cidr: 10.0.0.0/16</pre>
<b>networking.machineNetwork.cidr</b>	<p>Required if you use <b>networking.machineNetwork</b>. An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b>.</p>	<p>An IP network block in CIDR notation.</p> <p>For example, <b>10.0.0.0/16</b>.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p> </div> </div>



## 4.10.11.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:


Table 4.34. Optional parameters

Parameter	Description	Values
<b>additionalTrustBundle</b>	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
<b>compute</b>	The configuration for the machines that comprise the compute nodes.	Array of <b>MachinePool</b> objects.
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String
<b>compute.hyperthreading</b>	Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b> , on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.   <b>IMPORTANT</b> If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b>

Parameter	Description	Values
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String
<b>controlPlane.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div data-bbox="486 1093 593 1411" style="background-color: black; width: 67px; height: 142px; margin-bottom: 10px;"></div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platform</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>controlPlane.replicas</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.

Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.</p> <div data-bbox="485 517 595 864" style="border: 1px solid black; padding: 5px; margin-bottom: 10px;">  </div> <p><b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators reference content</i>.</p> <div data-bbox="485 913 595 1261" style="border: 1px solid black; padding: 5px;">  </div> <p><b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p>	<b>Mint, Passthrough, Manual</b> or an empty string ("").

Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start;"> <div style="width: 40px; height: 40px; background-color: black; margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 40px; height: 40px; background-color: black; margin-right: 10px;"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<b>Internal</b> or <b>External</b> . To deploy a private cluster, which cannot be accessed from the internet, set <b>publish</b> to <b>Internal</b> . The default value is <b>External</b> .

Parameter	Description	Values
<b>sshKey</b>	<p>The SSH key or keys to authenticate access your cluster machines.</p>  <p><b>NOTE</b></p> <p>For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.</p>	<p>One or more keys. For example:</p> <pre>sshKey: &lt;key1&gt; &lt;key2&gt; &lt;key3&gt;</pre>

#### 4.10.11.1.4. Optional AWS configuration parameters

Optional AWS configuration parameters are described in the following table:

Table 4.35. Optional AWS parameters

Parameter	Description	Values
<b>compute.platform.aws.amiID</b>	The AWS AMI used to boot compute machines for the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region.
<b>compute.platform.aws.iamRole</b>	A pre-existing AWS IAM role applied to the compute machine pool instance profiles. You can use these fields to match naming schemes and include predefined permissions boundaries for your IAM roles. If undefined, the installation program creates a new IAM role.	The name of a valid AWS IAM role.
<b>compute.platform.aws.rootVolume.iops</b>	The Input/Output Operations Per Second (IOPS) that is reserved for the root volume.	Integer, for example <b>4000</b> .
<b>compute.platform.aws.rootVolume.size</b>	The size in GiB of the root volume.	Integer, for example <b>500</b> .

Parameter	Description	Values
<b>compute.platform.aws.rootVolume.type</b>	The type of the root volume.	Valid <a href="#">AWS EBS volume type</a> , such as <b>io1</b> .
<b>compute.platform.aws.rootVolume.kmsKeyARN</b>	The Amazon Resource Name (key ARN) of a KMS key. This is required to encrypt OS volumes of worker nodes with a specific KMS key.	Valid <a href="#">key ID</a> or the <a href="#">key ARN</a>
<b>compute.platform.aws.type</b>	The EC2 instance type for the compute machines.	Valid AWS instance type, such as <b>m4.2xlarge</b> . See the <b>Instance types for machines</b> table that follows.
<b>compute.platform.aws.zones</b>	The availability zones where the installation program creates machines for the compute machine pool. If you provide your own VPC, you must provide a subnet in that availability zone.	A list of valid AWS availability zones, such as <b>us-east-1c</b> , in a <a href="#">YAML sequence</a> .
<b>compute.aws.region</b>	The AWS region that the installation program creates compute resources in.	Any valid <a href="#">AWS region</a> , such as <b>us-east-1</b> .
<b>controlPlane.platform.aws.amiID</b>	The AWS AMI used to boot control plane machines for the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region.
<b>controlPlane.platform.aws.iamRole</b>	A pre-existing AWS IAM role applied to the control plane machine pool instance profiles. You can use these fields to match naming schemes and include predefined permissions boundaries for your IAM roles. If undefined, the installation program creates a new IAM role.	The name of a valid AWS IAM role.
<b>controlPlane.platform.aws.rootVolume.kmsKeyARN</b>	The Amazon Resource Name (key ARN) of a KMS key. This is required to encrypt OS volumes of control plane nodes with a specific KMS key.	Valid <a href="#">key ID</a> and the <a href="#">key ARN</a>

Parameter	Description	Values
<b>controlPlane.platform.aws.type</b>	The EC2 instance type for the control plane machines.	Valid AWS instance type, such as <b>m5.xlarge</b> . See the <b>Instance types for machines</b> table that follows.
<b>controlPlane.platform.aws.zones</b>	The availability zones where the installation program creates machines for the control plane machine pool.	A list of valid AWS availability zones, such as <b>us-east-1c</b> , in a <a href="#">YAML sequence</a> .
<b>controlPlane.aws.region</b>	The AWS region that the installation program creates control plane resources in.	Valid <a href="#">AWS region</a> , such as <b>us-east-1</b> .
<b>platform.aws.amiID</b>	The AWS AMI used to boot all machines for the cluster. If set, the AMI must belong to the same region as the cluster. This is required for regions that require a custom RHCOS AMI.	Any published or custom RHCOS AMI that belongs to the set AWS region.
<b>platform.aws.hostedZone</b>	An existing Route 53 private hosted zone for the cluster. You can only use a pre-existing hosted zone when also supplying your own VPC. The hosted zone must already be associated with the user-provided VPC before installation. Also, the domain of the hosted zone must be the cluster domain or a parent of the cluster domain. If undefined, the installation program creates a new hosted zone.	String, for example <b>Z3URY6TWQ91KVV</b> .
<b>platform.aws.serviceEndpoints.name</b>	The AWS service endpoint name. Custom endpoints are only required for cases where alternative AWS endpoints, like FIPS, must be used. Custom API endpoints can be specified for EC2, S3, IAM, Elastic Load Balancing, Tagging, Route 53, and STS AWS services.	Valid <a href="#">AWS service endpoint</a> name.



Parameter	Description	Values
<b>platform.aws.serviceEndpoints.url</b>	The AWS service endpoint URL. The URL must use the <b>https</b> protocol and the host must trust the certificate.	Valid <a href="#">AWS service endpoint</a> URL.
<b>platform.aws.userTags</b>	A map of keys and values that the installation program adds as tags to all resources that it creates.	Any valid YAML map, such as key value pairs in the <b>&lt;key&gt;: &lt;value&gt;</b> format. For more information about AWS tags, see <a href="#">Tagging Your Amazon EC2 Resources</a> in the AWS documentation.
<b>platform.aws.subnets</b>	If you provide the VPC instead of allowing the installation program to create the VPC for you, specify the subnet for the cluster to use. The subnet must be part of the same <b>machineNetwork[].cidr</b> ranges that you specify. For a standard cluster, specify a public and a private subnet for each availability zone. For a private cluster, specify a private subnet for each availability zone.	Valid subnet IDs.

#### 4.10.11.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 4.36. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 7.9, or RHEL 8.4 [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.

2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.

#### 4.10.11.3. Supported AWS machine types

The following Amazon Web Services (AWS) instance types are supported with OpenShift Container Platform.

**Example 4.20. Instance types for machines**

Instance type	Bootstrap	Control plane	Compute
<b>i3.large</b>	x		
<b>m4.large</b>			x
<b>m4.xlarge</b>		x	x
<b>m4.2xlarge</b>		x	x
<b>m4.4xlarge</b>		x	x
<b>m4.10xlarge</b>		x	x
<b>m4.16xlarge</b>		x	x
<b>m5.large</b>			x
<b>m5.xlarge</b>		x	x
<b>m5.2xlarge</b>		x	x
<b>m5.4xlarge</b>		x	x
<b>m5.8xlarge</b>		x	x
<b>m5.12xlarge</b>		x	x
<b>m5.16xlarge</b>		x	x
<b>m5a.large</b>			x

Instance type	Bootstrap	Control plane	Compute
<b>m5a.xlarge</b>		x	x
<b>m5a.2xlarge</b>		x	x
<b>m5a.4xlarge</b>		x	x
<b>m5a.8xlarge</b>		x	x
<b>m5a.12xlarge</b>		x	x
<b>m5a.16xlarge</b>		x	x
<b>m6i.xlarge</b>		x	x
<b>m6i.2xlarge</b>		x	x
<b>m6i.4xlarge</b>		x	x
<b>m6i.8xlarge</b>		x	x
<b>m6i.16xlarge</b>		x	x
<b>c4.2xlarge</b>		x	x
<b>c4.4xlarge</b>		x	x
<b>c4.8xlarge</b>		x	x
<b>c5.xlarge</b>			x
<b>c5.2xlarge</b>		x	x
<b>c5.4xlarge</b>		x	x
<b>c5.9xlarge</b>		x	x
<b>c5.12xlarge</b>		x	x
<b>c5.18xlarge</b>		x	x
<b>c5.24xlarge</b>		x	x
<b>c5a.xlarge</b>			x

Instance type	Bootstrap	Control plane	Compute
<b>c5a.2xlarge</b>		x	x
<b>c5a.4xlarge</b>		x	x
<b>c5a.8xlarge</b>		x	x
<b>c5a.12xlarge</b>		x	x
<b>c5a.16xlarge</b>		x	x
<b>c5a.24xlarge</b>		x	x
<b>r4.large</b>			x
<b>r4.xlarge</b>		x	x
<b>r4.2xlarge</b>		x	x
<b>r4.4xlarge</b>		x	x
<b>r4.8xlarge</b>		x	x
<b>r4.16xlarge</b>		x	x
<b>r5.large</b>			x
<b>r5.xlarge</b>		x	x
<b>r5.2xlarge</b>		x	x
<b>r5.4xlarge</b>		x	x
<b>r5.8xlarge</b>		x	x
<b>r5.12xlarge</b>		x	x
<b>r5.16xlarge</b>		x	x
<b>r5.24xlarge</b>		x	x
<b>r5a.large</b>			x
<b>r5a.xlarge</b>		x	x

Instance type	Bootstrap	Control plane	Compute
<b>r5a.2xlarge</b>		x	x
<b>r5a.4xlarge</b>		x	x
<b>r5a.8xlarge</b>		x	x
<b>r5a.12xlarge</b>		x	x
<b>r5a.16xlarge</b>		x	x
<b>r5a.24xlarge</b>		x	x
<b>t3.large</b>			x
<b>t3.xlarge</b>			x
<b>t3.2xlarge</b>			x
<b>t3a.large</b>			x
<b>t3a.xlarge</b>			x
<b>t3a.2xlarge</b>			x

#### 4.10.11.4. Sample customized install-config.yaml file for AWS

You can customize the installation configuration file (**install-config.yaml**) to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.



#### IMPORTANT

This sample YAML file is provided for reference only. Use it as a resource to enter parameter values into the installation configuration file that you created manually.

```

apiVersion: v1
baseDomain: example.com 1
credentialsMode: Mint 2
controlPlane: 3 4
  hyperthreading: Enabled 5
name: master
platform:
  aws:
    zones:
      - us-gov-west-1a

```

```

- us-gov-west-1b
rootVolume:
  iops: 4000
  size: 500
  type: io1 6
  type: m5.xlarge
replicas: 3
compute: 7
- hyperthreading: Enabled 8
name: worker
platform:
  aws:
    rootVolume:
      iops: 2000
      size: 500
      type: io1 9
      type: c5.4xlarge
    zones:
      - us-gov-west-1c
replicas: 3
metadata:
  name: test-cluster 10
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
networkType: OpenShiftSDN
serviceNetwork:
  - 172.30.0.0/16
platform:
  aws:
    region: us-gov-west-1 11
    userTags:
      adminContact: jdoe
      costCenter: 7536
    subnets: 12
    - subnet-1
    - subnet-2
    - subnet-3
    amiID: ami-96c6f8f7 13 14
    serviceEndpoints: 15
    - name: ec2
      url: https://vpce-id.ec2.us-west-2.vpce.amazonaws.com
    hostedZone: Z3URY6TWQ91KVV 16
  fips: false 17
  sshKey: ssh-ed25519 AAAA... 18
  publish: Internal 19
  pullSecret: '{"auths": ...}' 20
  additionalTrustBundle: | 21
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----

```

- 1 10 11 13 20 Required.
- 2 Optional: Add this parameter to force the Cloud Credential Operator (CCO) to use the specified mode, instead of having the CCO dynamically try to determine the capabilities of the credentials. For details about CCO modes, see the *Cloud Credential Operator* entry in the *Platform Operators reference* content.
- 3 7 If you do not provide these parameters and values, the installation program provides the default value.
- 4 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. Only one control plane pool is used.
- 5 8 Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.



### IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger instance types, such as **m4.2xlarge** or **m5.2xlarge**, for your machines if you disable simultaneous multithreading.

- 6 9 To configure faster storage for etcd, especially for larger clusters, set the storage type as **io1** and set **iops** to **2000**.
- 12 If you provide your own VPC, specify subnets for each availability zone that your cluster uses.
- 14 The ID of the AMI used to boot machines for the cluster. If set, the AMI must belong to the same region as the cluster.
- 15 The AWS service endpoints. Custom endpoints are required when installing to an unknown AWS region. The endpoint URL must use the **https** protocol and the host must trust the certificate.
- 16 The ID of your existing Route 53 private hosted zone. Providing an existing hosted zone requires that you supply your own VPC and the hosted zone is already associated with the VPC prior to installing your cluster. If undefined, the installation program creates a new hosted zone.
- 17 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.



### IMPORTANT

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

- 18 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.

**NOTE**

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

- 19 How to publish the user-facing endpoints of your cluster. Set **publish** to **Internal** to deploy a private cluster, which cannot be accessed from the internet. The default value is **External**.
- 21 The custom CA certificate. This is required when deploying to the AWS C2S Top Secret Region because the AWS API requires a custom CA trust bundle.

#### 4.10.11.5. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

##### Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

**NOTE**

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

- You have added the **ec2.<region>.amazonaws.com**, **elasticloadbalancing.<region>.amazonaws.com**, and **s3.<region>.amazonaws.com** endpoints to your VPC endpoint. These endpoints are required to complete requests from the nodes to the AWS EC2 API. Because the proxy works on the container level, not the node level, you must route these requests to the AWS EC2 API through the AWS private network. Adding the public IP address of the EC2 API to your allowlist in your proxy server is not sufficient.

##### Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
```

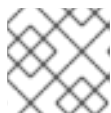


```

httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
noProxy: example.com 3
additionalTrustBundle: | 4
-----BEGIN CERTIFICATE-----
<MY_TRUSTED_CA_CERT>
-----END CERTIFICATE-----
...

```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations.
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.



#### NOTE

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



#### NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

### 4.10.12. Deploying the cluster

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



#### IMPORTANT

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

#### Prerequisites

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

## Procedure

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

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

- 1** For **<installation\_directory>**, specify the location of your customized **./install-config.yaml** file.
- 2** To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.



### NOTE

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

When the cluster deployment completes, directions for accessing your cluster, including a link to its web console and credentials for the **kubeadmin** user, display in your terminal.

## Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Ee6gm-ymBZj-
Wt5AL"
INFO Time elapsed: 36m22s
```



### NOTE

The cluster access and credential information also outputs to **<installation\_directory>/openshift\_install.log** when an installation succeeds.

**IMPORTANT**

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

**IMPORTANT**

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

2. Optional: Remove or disable the **AdministratorAccess** policy from the IAM account that you used to install the cluster.

**NOTE**

The elevated permissions provided by the **AdministratorAccess** policy are required only during installation.

### 4.10.13. Installing the OpenShift CLI by downloading the binary

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

**IMPORTANT**

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

#### Installing the OpenShift CLI on Linux

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

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

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

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

```
$ echo $PATH
```

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

```
$ oc <command>
```

### Installing the OpenShift CLI on Windows

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

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

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

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

### Installing the OpenShift CLI on macOS

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

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

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

```
$ oc <command>
```

#### 4.10.14. Logging in to the cluster by using the CLI

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

##### Prerequisites

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

##### Procedure

1. Export the **kubeadmin** credentials:

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

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

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

```
$ oc whoami
```

##### Example output

```
system:admin
```

#### 4.10.15. Logging in to the cluster by using the web console

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

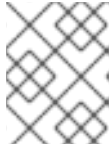
##### Prerequisites

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

##### Procedure

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

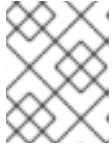
```
$ cat <installation_directory>/auth/kubeadmin-password
```

**NOTE**

Alternatively, you can obtain the **kubeadmin** password from the **<installation\_directory>/openshift\_install.log** log file on the installation host.

- List the OpenShift Container Platform web console route:

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

**NOTE**

Alternatively, you can obtain the OpenShift Container Platform route from the **<installation\_directory>/openshift\_install.log** log file on the installation host.

**Example output**

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

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

**Additional resources**

- See [Accessing the web console](#) for more details about accessing and understanding the OpenShift Container Platform web console.

**4.10.16. Telemetry access for OpenShift Container Platform**

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

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

**Additional resources**

- See [About remote health monitoring](#) for more information about the Telemetry service.

**4.10.17. Next steps**

- [Validating an installation.](#)
- [Customize your cluster.](#)
- If necessary, you can [opt out of remote health reporting](#).
- If necessary, you can [remove cloud provider credentials](#).

**4.11. INSTALLING A CLUSTER ON AWS CHINA**

In OpenShift Container Platform version 4.9, you can install a cluster to the following Amazon Web Services (AWS) China regions:

- **cn-north-1** (Beijing)
- **cn-northwest-1** (Ningxia)

### 4.11.1. Prerequisites

- You have an Internet Content Provider (ICP) license.
- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You [configured an AWS account](#) to host the cluster.
- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can [manually create and maintain IAM credentials](#).



#### IMPORTANT

If you have an AWS profile stored on your computer, it must not use a temporary session token that you generated while using a multi-factor authentication device. The cluster continues to use your current AWS credentials to create AWS resources for the entire life of the cluster, so you must use long-lived credentials. To generate appropriate keys, see [Managing Access Keys for IAM Users](#) in the AWS documentation. You can supply the keys when you run the installation program.

### 4.11.2. Installation requirements

Red Hat does not publish a Red Hat Enterprise Linux CoreOS (RHCOS) Amazon Machine Image (AMI) for the AWS China regions.

Before you can install the cluster, you must:

- Upload a custom RHCOS AMI.
- Manually create the installation configuration file (**install-config.yaml**).
- Specify the AWS region, and the accompanying custom AMI, in the installation configuration file.

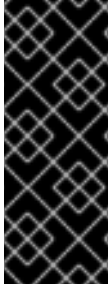
You cannot use the OpenShift Container Platform installation program to create the installation configuration file. The installer does not list an AWS region without native support for an RHCOS AMI.

### 4.11.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

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



### IMPORTANT

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

#### 4.11.4. Private clusters

You can deploy a private OpenShift Container Platform cluster that does not expose external endpoints. Private clusters are accessible from only an internal network and are not visible to the internet.

By default, OpenShift Container Platform is provisioned to use publicly-accessible DNS and endpoints. A private cluster sets the DNS, Ingress Controller, and API server to private when you deploy your cluster. This means that the cluster resources are only accessible from your internal network and are not visible to the internet.



### IMPORTANT

If the cluster has any public subnets, load balancer services created by administrators might be publicly accessible. To ensure cluster security, verify that these services are explicitly annotated as private.

To deploy a private cluster, you must:

- Use existing networking that meets your requirements. Your cluster resources might be shared between other clusters on the network.
- Deploy from a machine that has access to:
  - The API services for the cloud to which you provision.
  - The hosts on the network that you provision.
  - The internet to obtain installation media.

You can use any machine that meets these access requirements and follows your company's guidelines. For example, this machine can be a bastion host on your cloud network.



### NOTE

AWS China does not support a VPN connection between the VPC and your network. For more information about the Amazon VPC service in the Beijing and Ningxia regions, see [Amazon Virtual Private Cloud](#) in the AWS China documentation.



#### 4.11.4.1. Private clusters in AWS

To create a private cluster on Amazon Web Services (AWS), you must provide an existing private VPC and subnets to host the cluster. The installation program must also be able to resolve the DNS records that the cluster requires. The installation program configures the Ingress Operator and API server for access from only the private network.

The cluster still requires access to internet to access the AWS APIs.

The following items are not required or created when you install a private cluster:

- Public subnets
- Public load balancers, which support public ingress
- A public Route 53 zone that matches the **baseDomain** for the cluster

The installation program does use the **baseDomain** that you specify to create a private Route 53 zone and the required records for the cluster. The cluster is configured so that the Operators do not create public records for the cluster and all cluster machines are placed in the private subnets that you specify.

##### 4.11.4.1.1. Limitations

The ability to add public functionality to a private cluster is limited.

- You cannot make the Kubernetes API endpoints public after installation without taking additional actions, including creating public subnets in the VPC for each availability zone in use, creating a public load balancer, and configuring the control plane security groups to allow traffic from the internet on 6443 (Kubernetes API port).
- If you use a public Service type load balancer, you must tag a public subnet in each availability zone with **kubernetes.io/cluster/<cluster-infra-id>: shared** so that AWS can use them to create public load balancers.

#### 4.11.5. About using a custom VPC

In OpenShift Container Platform 4.9, you can deploy a cluster into existing subnets in an existing Amazon Virtual Private Cloud (VPC) in Amazon Web Services (AWS). By deploying OpenShift Container Platform into an existing AWS VPC, you might be able to avoid limit constraints in new accounts or more easily abide by the operational constraints that your company's guidelines set. If you cannot obtain the infrastructure creation permissions that are required to create the VPC yourself, use this installation option.

Because the installation program cannot know what other components are also in your existing subnets, it cannot choose subnet CIDRs and so forth on your behalf. You must configure networking for the subnets that you install your cluster to yourself.

##### 4.11.5.1. Requirements for using your VPC

The installation program no longer creates the following components:

- Internet gateways
- NAT gateways
- Subnets

- Route tables
- VPCs
- VPC DHCP options
- VPC endpoints

**NOTE**

The installation program requires that you use the cloud-provided DNS server. Using a custom DNS server is not supported and causes the installation to fail.

If you use a custom VPC, you must correctly configure it and its subnets for the installation program and the cluster to use. See [Amazon VPC console wizard configurations](#) and [Work with VPCs and subnets](#) in the AWS documentation for more information on creating and managing an AWS VPC.

The installation program cannot:

- Subdivide network ranges for the cluster to use.
- Set route tables for the subnets.
- Set VPC options like DHCP.

You must complete these tasks before you install the cluster. See [VPC networking components](#) and [Route tables for your VPC](#) for more information on configuring networking in an AWS VPC.

Your VPC must meet the following characteristics:

- The VPC must not use the **kubernetes.io/cluster/.\*: owned** tag. The installation program modifies your subnets to add the **kubernetes.io/cluster/.\*: shared** tag, so your subnets must have at least one free tag slot available for it. See [Tag Restrictions](#) in the AWS documentation to confirm that the installation program can add a tag to each subnet that you specify.
- You must enable the **enableDnsSupport** and **enableDnsHostnames** attributes in your VPC, so that the cluster can use the Route 53 zones that are attached to the VPC to resolve cluster's internal DNS records. See [DNS Support in Your VPC](#) in the AWS documentation. If you prefer to use your own Route 53 hosted private zone, you must associate the existing hosted zone with your VPC prior to installing a cluster. You can define your hosted zone using the **platform.aws.hostedZone** field in the **install-config.yaml** file.
- If you use a cluster with public access, you must create a public and a private subnet for each availability zone that your cluster uses. Each availability zone can contain no more than one public and one private subnet.

If you are working in a disconnected environment, you are unable to reach the public IP addresses for EC2 and ELB endpoints. To resolve this, you must create a VPC endpoint and attach it to the subnet that the clusters are using. The endpoints should be named as follows:

- **ec2.<region>.amazonaws.com.cn**
- **elasticloadbalancing.<region>.amazonaws.com**
- **s3.<region>.amazonaws.com**

## Required VPC components

You must provide a suitable VPC and subnets that allow communication to your machines.

Component	AWS type	Description										
VPC	<ul style="list-style-type: none"> <li>● <b>AWS::EC2::VPC</b></li> <li>● <b>AWS::EC2::VPCEndpoint</b></li> </ul>	You must provide a public VPC for the cluster to use. The VPC uses an endpoint that references the route tables for each subnet to improve communication with the registry that is hosted in S3.										
Public subnets	<ul style="list-style-type: none"> <li>● <b>AWS::EC2::Subnet</b></li> <li>● <b>AWS::EC2::SubnetNetworkACLAssociation</b></li> </ul>	Your VPC must have public subnets for between 1 and 3 availability zones and associate them with appropriate Ingress rules.										
Internet gateway	<ul style="list-style-type: none"> <li>● <b>AWS::EC2::InternetGateway</b></li> <li>● <b>AWS::EC2::VPCGatewayAttachment</b></li> <li>● <b>AWS::EC2::RouteTable</b></li> <li>● <b>AWS::EC2::Route</b></li> <li>● <b>AWS::EC2::SubnetRouteTableAssociation</b></li> <li>● <b>AWS::EC2::NatGateway</b></li> <li>● <b>AWS::EC2::EIP</b></li> </ul>	You must have a public internet gateway, with public routes, attached to the VPC. In the provided templates, each public subnet has a NAT gateway with an EIP address. These NAT gateways allow cluster resources, like private subnet instances, to reach the internet and are not required for some restricted network or proxy scenarios.										
Network access control	<ul style="list-style-type: none"> <li>● <b>AWS::EC2::NetworkACL</b></li> <li>● <b>AWS::EC2::NetworkACLEntry</b></li> </ul>	<p>You must allow the VPC to access the following ports:</p> <table border="1"> <thead> <tr> <th>Port</th> <th>Reason</th> </tr> </thead> <tbody> <tr> <td><b>80</b></td> <td>Inbound HTTP traffic</td> </tr> <tr> <td><b>443</b></td> <td>Inbound HTTPS traffic</td> </tr> <tr> <td><b>22</b></td> <td>Inbound SSH traffic</td> </tr> <tr> <td><b>1024 - 65535</b></td> <td>Inbound ephemeral traffic</td> </tr> </tbody> </table>	Port	Reason	<b>80</b>	Inbound HTTP traffic	<b>443</b>	Inbound HTTPS traffic	<b>22</b>	Inbound SSH traffic	<b>1024 - 65535</b>	Inbound ephemeral traffic
Port	Reason											
<b>80</b>	Inbound HTTP traffic											
<b>443</b>	Inbound HTTPS traffic											
<b>22</b>	Inbound SSH traffic											
<b>1024 - 65535</b>	Inbound ephemeral traffic											

Component	AWS type	Description	
		<b>0 - 65535</b>	Outbound ephemeral traffic
Private subnets	<ul style="list-style-type: none"> <li>● <b>AWS::EC2::Subnet</b></li> <li>● <b>AWS::EC2::RouteTable</b></li> <li>● <b>AWS::EC2::SubnetRouteTableAssociation</b></li> </ul>	Your VPC can have private subnets. The provided CloudFormation templates can create private subnets for between 1 and 3 availability zones. If you use private subnets, you must provide appropriate routes and tables for them.	

#### 4.11.5.2. VPC validation

To ensure that the subnets that you provide are suitable, the installation program confirms the following data:

- All the subnets that you specify exist.
- You provide private subnets.
- The subnet CIDRs belong to the machine CIDR that you specified.
- You provide subnets for each availability zone. Each availability zone contains no more than one public and one private subnet. If you use a private cluster, provide only a private subnet for each availability zone. Otherwise, provide exactly one public and private subnet for each availability zone.
- You provide a public subnet for each private subnet availability zone. Machines are not provisioned in availability zones that you do not provide private subnets for.

If you destroy a cluster that uses an existing VPC, the VPC is not deleted. When you remove the OpenShift Container Platform cluster from a VPC, the **kubernetes.io/cluster/.\*: shared** tag is removed from the subnets that it used.

#### 4.11.5.3. Division of permissions

Starting with OpenShift Container Platform 4.3, you do not need all of the permissions that are required for an installation program–provisioned infrastructure cluster to deploy a cluster. This change mimics the division of permissions that you might have at your company: some individuals can create different resource in your clouds than others. For example, you might be able to create application-specific items, like instances, buckets, and load balancers, but not networking–related components such as VPCs, subnets, or ingress rules.

The AWS credentials that you use when you create your cluster do not need the networking permissions that are required to make VPCs and core networking components within the VPC, such as subnets, routing tables, internet gateways, NAT, and VPN. You still need permission to make the application resources that the machines within the cluster require, such as ELBs, security groups, S3 buckets, and nodes.

#### 4.11.5.4. Isolation between clusters

If you deploy OpenShift Container Platform to an existing network, the isolation of cluster services is reduced in the following ways:

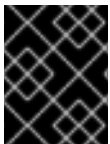
- You can install multiple OpenShift Container Platform clusters in the same VPC.
- ICMP ingress is allowed from the entire network.
- TCP 22 ingress (SSH) is allowed to the entire network.
- Control plane TCP 6443 ingress (Kubernetes API) is allowed to the entire network.
- Control plane TCP 22623 ingress (MCS) is allowed to the entire network.

#### 4.11.6. Generating a key pair for cluster node SSH access

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

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

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



#### IMPORTANT

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



#### NOTE

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

#### Procedure

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

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

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

**NOTE**

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

- View the public SSH key:

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

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

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

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

**NOTE**

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

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

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

**Example output**

```
Agent pid 31874
```

**NOTE**

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

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

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

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

**Example output**

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

**Next steps**

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

### 4.11.7. Uploading a custom RHCOS AMI in AWS

If you are deploying to a custom Amazon Web Services (AWS) region, you must upload a custom Red Hat Enterprise Linux CoreOS (RHCOS) Amazon Machine Image (AMI) that belongs to that region.

#### Prerequisites

- You configured an AWS account.
- You created an Amazon S3 bucket with the required IAM [service role](#).
- You uploaded your RHCOS VMDK file to Amazon S3. The RHCOS VMDK file must be the highest version that is less than or equal to the OpenShift Container Platform version you are installing.
- You downloaded the AWS CLI and installed it on your computer. See [Install the AWS CLI Using the Bundled Installer](#).

#### Procedure

1. Export your AWS profile as an environment variable:

```
$ export AWS_PROFILE=<aws_profile> 1
```

- 1 The AWS profile name that holds your AWS credentials, like **beijingadmin**.

2. Export the region to associate with your custom AMI as an environment variable:

```
$ export AWS_DEFAULT_REGION=<aws_region> 1
```

- 1 The AWS region, like **cn-north-1**.

3. Export the version of RHCOS you uploaded to Amazon S3 as an environment variable:

```
$ export RHCOS_VERSION=<version> 1
```

- 1 The RHCOS VMDK version, like **4.9.0**.

4. Export the Amazon S3 bucket name as an environment variable:

```
$ export VMIMPORT_BUCKET_NAME=<s3_bucket_name>
```

5. Create the **containers.json** file and define your RHCOS VMDK file:

```
$ cat <<EOF > containers.json
{
  "Description": "rhcos-${RHCOS_VERSION}-x86_64-aws.x86_64",
  "Format": "vmdk",
```

```
"UserBucket": {
  "S3Bucket": "${VMIMPORT_BUCKET_NAME}",
  "S3Key": "rhcos-${RHCOS_VERSION}-x86_64-aws.x86_64.vmdk"
}
}
EOF
```

6. Import the RHCOS disk as an Amazon EBS snapshot:

```
$ aws ec2 import-snapshot --region ${AWS_DEFAULT_REGION} \
  --description "<description>" \ 1
  --disk-container "file://<file_path>/containers.json" 2
```

- 1** The description of your RHCOS disk being imported, like **rhcos-\${RHCOS\_VERSION}-x86\_64-aws.x86\_64**.
- 2** The file path to the JSON file describing your RHCOS disk. The JSON file should contain your Amazon S3 bucket name and key.

7. Check the status of the image import:

```
$ watch -n 5 aws ec2 describe-import-snapshot-tasks --region ${AWS_DEFAULT_REGION}
```

### Example output

```
{
  "ImportSnapshotTasks": [
    {
      "Description": "rhcos-4.7.0-x86_64-aws.x86_64",
      "ImportTaskId": "import-snap-fh6i8uil",
      "SnapshotTaskDetail": {
        "Description": "rhcos-4.7.0-x86_64-aws.x86_64",
        "DiskImageSize": 819056640.0,
        "Format": "VMDK",
        "SnapshotId": "snap-06331325870076318",
        "Status": "completed",
        "UserBucket": {
          "S3Bucket": "external-images",
          "S3Key": "rhcos-4.7.0-x86_64-aws.x86_64.vmdk"
        }
      }
    }
  ]
}
```

Copy the **SnapshotId** to register the image.

8. Create a custom RHCOS AMI from the RHCOS snapshot:

```
$ aws ec2 register-image \
  --region ${AWS_DEFAULT_REGION} \
  --architecture x86_64 \ 1
  --description "rhcos-${RHCOS_VERSION}-x86_64-aws.x86_64" \ 2
```



```

--ena-support \
--name "rhcos-${RHCOS_VERSION}-x86_64-aws.x86_64" \ ❸
--virtualization-type hvm \
--root-device-name '/dev/xvda' \
--block-device-mappings 'DeviceName=/dev/xvda,Ebs=
{DeleteOnTermination=true,SnapshotId=<snapshot_ID>}' ❹

```

- ❶ The RHCOS VMDK architecture type, like **x86\_64**, **s390x**, or **ppc64le**.
- ❷ The **Description** from the imported snapshot.
- ❸ The name of the RHCOS AMI.
- ❹ The **SnapshotID** from the imported snapshot.

To learn more about these APIs, see the AWS documentation for [importing snapshots](#) and [creating EBS-backed AMIs](#).

### 4.11.8. Obtaining the installation program

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

#### Prerequisites

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

#### Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



#### IMPORTANT

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



#### IMPORTANT

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

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

—

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

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

### 4.11.9. Manually creating the installation configuration file

When installing OpenShift Container Platform on Amazon Web Services (AWS) into a region requiring a custom Red Hat Enterprise Linux CoreOS (RHCOS) AMI, you must manually generate your installation configuration file.

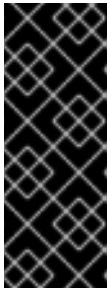
#### Prerequisites

- You have uploaded a custom RHCOS AMI.
- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

#### Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```



#### IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation\_directory>**.



#### NOTE

You must name this configuration file **install-config.yaml**.

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



#### IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

### 4.11.9.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.



#### NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.



#### IMPORTANT

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

#### 4.11.9.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 4.37. Required parameters

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;</b> , <b>&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object

Parameter	Description	Values
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}.{{.baseDomain}}</b> .	String of lowercase letters, hyphens (-), and periods (.), such as <b>dev</b> .
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws, baremetal, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } }</pre>

#### 4.11.9.1.2. Network configuration parameters


You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

**Table 4.38. Network parameters**

Parameter	Description	Values
-----------	-------------	--------

Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	Object  <b>NOTE</b> You cannot modify parameters specified by the <b>networking</b> object after installation.
<b>networking.networkType</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .
<b>networking.clusterNetwork</b>	The IP address blocks for pods.  The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b> .  If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example:  <pre>networking:   clusterNetwork:     - cidr: 10.128.0.0/14       hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	Required if you use <b>networking.clusterNetwork</b> . An IP address block.  An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b> .
<b>networking.clusterNetwork.hostPrefix</b>	The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b> . A <b>hostPrefix</b> value of <b>23</b> provides 510 ( $2^{(32 - 23)} - 2$ ) pod IP addresses.	A subnet prefix.  The default value is <b>23</b> .

Parameter	Description	Values
<b>networking.serviceNetwork</b>	<p>The IP address block for services. The default value is <b>172.30.0.0/16</b>.</p> <p>The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.</p>	<p>An array with an IP address block in CIDR format. For example:</p> <pre>networking:   serviceNetwork:     - 172.30.0.0/16</pre>
<b>networking.machineNetwork</b>	<p>The IP address blocks for machines.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   machineNetwork:     - cidr: 10.0.0.0/16</pre>
<b>networking.machineNetwork.cidr</b>	<p>Required if you use <b>networking.machineNetwork</b>. An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b>.</p>	<p>An IP network block in CIDR notation.</p> <p>For example, <b>10.0.0.0/16</b>.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p> </div> </div>


#### 4.11.9.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:



Table 4.39. Optional parameters

Parameter	Description	Values
<b>additionalTrustBundle</b>	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
<b>compute</b>	The configuration for the machines that comprise the compute nodes.	Array of <b>MachinePool</b> objects.


Parameter	Description	Values
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String
<b>compute.hyperthreading</b>	Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b> , on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.   <b>IMPORTANT</b>  If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b>
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String

Parameter	Description	Values
<b>controlPlane.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platform</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>controlPlane.replicas</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.



Parameter	Description	Values
<p><b>credentialsMode</b></p>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.</p> <div data-bbox="486 510 595 862" style="border: 1px solid black; padding: 5px; margin-bottom: 10px;">  </div> <p><b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators</i> reference content.</p> <div data-bbox="486 907 595 1258" style="border: 1px solid black; padding: 5px;">  </div> <p><b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p>	<p><b>Mint, Passthrough, Manual</b> or an empty string ("").</p>

Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start;"> <div style="width: 60px; height: 60px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 60px; height: 60px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<b>Internal</b> or <b>External</b> . The default value is <b>External</b> .  Setting this field to <b>Internal</b> is not supported on non-cloud platforms.

Parameter	Description	Values
<b>sshKey</b>	<p>The SSH key or keys to authenticate access your cluster machines.</p>  <p><b>NOTE</b></p> <p>For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.</p>	<p>One or more keys. For example:</p> <pre>sshKey:   &lt;key1&gt;   &lt;key2&gt;   &lt;key3&gt;</pre>

#### 4.11.9.2. Sample customized install-config.yaml file for AWS

You can customize the installation configuration file (**install-config.yaml**) to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.



#### IMPORTANT

This sample YAML file is provided for reference only. Use it as a resource to enter parameter values into the installation configuration file that you created manually.

```
apiVersion: v1
baseDomain: example.com 1
credentialsMode: Mint 2
controlPlane: 3 4
hyperthreading: Enabled 5
name: master
platform:
  aws:
    zones:
      - cn-north-1a
      - cn-north-1b
    rootVolume:
      iops: 4000
      size: 500
      type: io1 6
      type: m5.xlarge
    replicas: 3
  compute: 7
  - hyperthreading: Enabled 8
```

```

name: worker
platform:
  aws:
    rootVolume:
      iops: 2000
      size: 500
      type: io1 9
    type: c5.4xlarge
    zones:
      - cn-north-1a
  replicas: 3
metadata:
  name: test-cluster 10
networking:
  clusterNetwork:
    - cidr: 10.128.0.0/14
      hostPrefix: 23
  machineNetwork:
    - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
    - 172.30.0.0/16
platform:
  aws:
    region: cn-north-1 11
    userTags:
      adminContact: jdoe
      costCenter: 7536
    subnets: 12
      - subnet-1
      - subnet-2
      - subnet-3
    amiID: ami-96c6f8f7 13 14
    serviceEndpoints: 15
      - name: ec2
        url: https://vpce-id.ec2.cn-north-1.vpce.amazonaws.com.cn
    hostedZone: Z3URY6TWQ91KVV 16
  fips: false 17
  sshKey: ssh-ed25519 AAAA... 18
  publish: Internal 19
  pullSecret: '{"auths": ...}' 20

```

**1** **10** **11** **13** **20** Required.

**2** Optional: Add this parameter to force the Cloud Credential Operator (CCO) to use the specified mode, instead of having the CCO dynamically try to determine the capabilities of the credentials. For details about CCO modes, see the *Cloud Credential Operator* entry in the *Platform Operators reference* content.

**3** **7** If you do not provide these parameters and values, the installation program provides the default value.

**4** The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. Only one

control plane pool is used.

- 5 8 Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.



### IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger instance types, such as **m4.2xlarge** or **m5.2xlarge**, for your machines if you disable simultaneous multithreading.

- 6 9 To configure faster storage for etcd, especially for larger clusters, set the storage type as **io1** and set **iops** to **2000**.
- 12 If you provide your own VPC, specify subnets for each availability zone that your cluster uses.
- 14 The ID of the AMI used to boot machines for the cluster. If set, the AMI must belong to the same region as the cluster.
- 15 The AWS service endpoints. Custom endpoints are required when installing to an unknown AWS region. The endpoint URL must use the **https** protocol and the host must trust the certificate.
- 16 The ID of your existing Route 53 private hosted zone. Providing an existing hosted zone requires that you supply your own VPC and the hosted zone is already associated with the VPC prior to installing your cluster. If undefined, the installation program creates a new hosted zone.
- 17 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.



### IMPORTANT

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

- 18 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.



### NOTE

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

- 19 How to publish the user-facing endpoints of your cluster. Set **publish** to **Internal** to deploy a private cluster, which cannot be accessed from the internet. The default value is **External**.

#### 4.11.9.3. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

**Table 4.40. Minimum resource requirements**

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 7.9, or RHEL 8.4 [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.

#### 4.11.9.4. Supported AWS machine types

The following Amazon Web Services (AWS) instance types are supported with OpenShift Container Platform.

**Example 4.21. Instance types for machines**

Instance type	Bootstrap	Control plane	Compute
<b>i3.large</b>	x		
<b>m4.large</b>			x
<b>m4.xlarge</b>		x	x
<b>m4.2xlarge</b>		x	x
<b>m4.4xlarge</b>		x	x
<b>m4.10xlarge</b>		x	x

Instance type	Bootstrap	Control plane	Compute
<b>m4.16xlarge</b>		x	x
<b>m5.large</b>			x
<b>m5.xlarge</b>		x	x
<b>m5.2xlarge</b>		x	x
<b>m5.4xlarge</b>		x	x
<b>m5.8xlarge</b>		x	x
<b>m5.12xlarge</b>		x	x
<b>m5.16xlarge</b>		x	x
<b>m5a.large</b>			x
<b>m5a.xlarge</b>		x	x
<b>m5a.2xlarge</b>		x	x
<b>m5a.4xlarge</b>		x	x
<b>m5a.8xlarge</b>		x	x
<b>m5a.12xlarge</b>		x	x
<b>m5a.16xlarge</b>		x	x
<b>m6i.xlarge</b>		x	x
<b>m6i.2xlarge</b>		x	x
<b>m6i.4xlarge</b>		x	x
<b>m6i.8xlarge</b>		x	x
<b>m6i.16xlarge</b>		x	x
<b>c4.2xlarge</b>		x	x
<b>c4.4xlarge</b>		x	x

Instance type	Bootstrap	Control plane	Compute
<b>c4.8xlarge</b>		x	x
<b>c5.xlarge</b>			x
<b>c5.2xlarge</b>		x	x
<b>c5.4xlarge</b>		x	x
<b>c5.9xlarge</b>		x	x
<b>c5.12xlarge</b>		x	x
<b>c5.18xlarge</b>		x	x
<b>c5.24xlarge</b>		x	x
<b>c5a.xlarge</b>			x
<b>c5a.2xlarge</b>		x	x
<b>c5a.4xlarge</b>		x	x
<b>c5a.8xlarge</b>		x	x
<b>c5a.12xlarge</b>		x	x
<b>c5a.16xlarge</b>		x	x
<b>c5a.24xlarge</b>		x	x
<b>r4.large</b>			x
<b>r4.xlarge</b>		x	x
<b>r4.2xlarge</b>		x	x
<b>r4.4xlarge</b>		x	x
<b>r4.8xlarge</b>		x	x
<b>r4.16xlarge</b>		x	x
<b>r5.large</b>			x



Instance type	Bootstrap	Control plane	Compute
<b>r5.xlarge</b>		x	x
<b>r5.2xlarge</b>		x	x
<b>r5.4xlarge</b>		x	x
<b>r5.8xlarge</b>		x	x
<b>r5.12xlarge</b>		x	x
<b>r5.16xlarge</b>		x	x
<b>r5.24xlarge</b>		x	x
<b>r5a.large</b>			x
<b>r5a.xlarge</b>		x	x
<b>r5a.2xlarge</b>		x	x
<b>r5a.4xlarge</b>		x	x
<b>r5a.8xlarge</b>		x	x
<b>r5a.12xlarge</b>		x	x
<b>r5a.16xlarge</b>		x	x
<b>r5a.24xlarge</b>		x	x
<b>t3.large</b>			x
<b>t3.xlarge</b>			x
<b>t3.2xlarge</b>			x
<b>t3a.large</b>			x
<b>t3a.xlarge</b>			x
<b>t3a.2xlarge</b>			x

#### 4.11.9.5. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

## Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



### NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

- You have added the **ec2.<region>.amazonaws.com.cn**, **elasticloadbalancing.<region>.amazonaws.com**, and **s3.<region>.amazonaws.com** endpoints to your VPC endpoint. These endpoints are required to complete requests from the nodes to the AWS EC2 API. Because the proxy works on the container level, not the node level, you must route these requests to the AWS EC2 API through the AWS private network. Adding the public IP address of the EC2 API to your allowlist in your proxy server is not sufficient.

## Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
  -----BEGIN CERTIFICATE-----
  <MY_TRUSTED_CA_CERT>
  -----END CERTIFICATE-----
...
```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network

- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide



#### NOTE

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

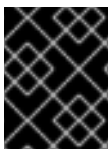


#### NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

### 4.11.10. Deploying the cluster

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



#### IMPORTANT

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

#### Prerequisites

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

#### Procedure

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

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

- 1 For **<installation\_directory>**, specify the location of your customized **./install-config.yaml** file.
- 2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

**NOTE**

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

When the cluster deployment completes, directions for accessing your cluster, including a link to its web console and credentials for the **kubeadmin** user, display in your terminal.

**Example output**

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Ee6gm-ymBZj-
Wt5AL"
INFO Time elapsed: 36m22s
```

**NOTE**

The cluster access and credential information also outputs to **<installation\_directory>/.openshift\_install.log** when an installation succeeds.

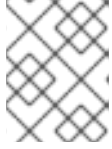
**IMPORTANT**

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

**IMPORTANT**

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

2. Optional: Remove or disable the **AdministratorAccess** policy from the IAM account that you used to install the cluster.

**NOTE**

The elevated permissions provided by the **AdministratorAccess** policy are required only during installation.

#### 4.11.11. Installing the OpenShift CLI by downloading the binary

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

**IMPORTANT**

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

#### Installing the OpenShift CLI on Linux

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

##### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

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

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

```
$ echo $PATH
```

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

```
$ oc <command>
```

#### Installing the OpenShift CLI on Windows

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

##### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.

5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

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

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

### Installing the OpenShift CLI on macOS

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

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

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

```
$ oc <command>
```

### 4.11.12. Logging in to the cluster by using the CLI

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

#### Prerequisites

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

#### Procedure

1. Export the **kubeadmin** credentials:

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

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

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

```
$ oc whoami
```

#### Example output

```
system:admin
```

### 4.11.13. Logging in to the cluster by using the web console

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

#### Prerequisites

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

#### Procedure

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

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



#### NOTE

Alternatively, you can obtain the **kubeadmin** password from the **<installation\_directory>/openshift\_install.log** log file on the installation host.

2. List the OpenShift Container Platform web console route:

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



#### NOTE

Alternatively, you can obtain the OpenShift Container Platform route from the **<installation\_directory>/openshift\_install.log** log file on the installation host.

#### Example output

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

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

### 4.11.14. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

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

### Additional resources

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

### 4.11.15. Next steps

- [Validating an installation](#).
- [Customize your cluster](#).
- If necessary, you can [opt out of remote health reporting](#).
- If necessary, you can [remove cloud provider credentials](#).

## 4.12. INSTALLING A CLUSTER ON USER-PROVISIONED INFRASTRUCTURE IN AWS BY USING CLOUDFORMATION TEMPLATES

In OpenShift Container Platform version 4.9, you can install a cluster on Amazon Web Services (AWS) that uses infrastructure that you provide.

One way to create this infrastructure is to use the provided CloudFormation templates. You can modify the templates to customize your infrastructure or use the information that they contain to create AWS objects according to your company's policies.



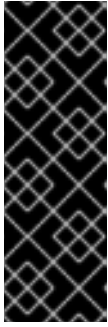
### IMPORTANT

The steps for performing a user-provisioned infrastructure installation are provided as an example only. Installing a cluster with infrastructure you provide requires knowledge of the cloud provider and the installation process of OpenShift Container Platform. Several CloudFormation templates are provided to assist in completing these steps or to help model your own. You are also free to create the required resources through other methods; the templates are just an example.

### 4.12.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You [configured an AWS account](#) to host the cluster.





### IMPORTANT

If you have an AWS profile stored on your computer, it must not use a temporary session token that you generated while using a multi-factor authentication device. The cluster continues to use your current AWS credentials to create AWS resources for the entire life of the cluster, so you must use key-based, long-lived credentials. To generate appropriate keys, see [Managing Access Keys for IAM Users](#) in the AWS documentation. You can supply the keys when you run the installation program.

- You downloaded the AWS CLI and installed it on your computer. See [Install the AWS CLI Using the Bundled Installer \(Linux, macOS, or UNIX\)](#) in the AWS documentation.
- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.



### NOTE

Be sure to also review this site list if you are configuring a proxy.

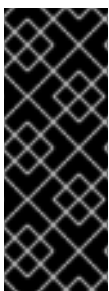
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can [manually create and maintain IAM credentials](#).

## 4.12.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

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



### IMPORTANT

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

## 4.12.3. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

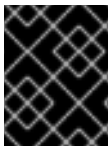
This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

### 4.12.3.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

**Table 4.41. Minimum required hosts**

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.



### IMPORTANT

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 7.9, or RHEL 8.4.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See [Red Hat Enterprise Linux technology capabilities and limits](#).

#### 4.12.3.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

**Table 4.42. Minimum resource requirements**

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 7.9, or RHEL 8.4 [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio:  $(\text{threads per core} \times \text{cores}) \times \text{sockets} = \text{vCPUs}$ .

2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.

#### 4.12.3.3. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

#### 4.12.3.4. Supported AWS machine types

The following Amazon Web Services (AWS) instance types are supported with OpenShift Container Platform.

Example 4.22. Instance types for machines

Instance type	Bootstrap	Control plane	Compute
<b>i3.large</b>	x		
<b>m4.large</b>			x
<b>m4.xlarge</b>		x	x
<b>m4.2xlarge</b>		x	x
<b>m4.4xlarge</b>		x	x
<b>m4.10xlarge</b>		x	x
<b>m4.16xlarge</b>		x	x
<b>m5.large</b>			x
<b>m5.xlarge</b>		x	x
<b>m5.2xlarge</b>		x	x

Instance type	Bootstrap	Control plane	Compute
<b>m5.4xlarge</b>		x	x
<b>m5.8xlarge</b>		x	x
<b>m5.12xlarge</b>		x	x
<b>m5.16xlarge</b>		x	x
<b>m5a.large</b>			x
<b>m5a.xlarge</b>		x	x
<b>m5a.2xlarge</b>		x	x
<b>m5a.4xlarge</b>		x	x
<b>m5a.8xlarge</b>		x	x
<b>m5a.12xlarge</b>		x	x
<b>m5a.16xlarge</b>		x	x
<b>m6i.xlarge</b>		x	x
<b>m6i.2xlarge</b>		x	x
<b>m6i.4xlarge</b>		x	x
<b>m6i.8xlarge</b>		x	x
<b>m6i.16xlarge</b>		x	x
<b>c4.2xlarge</b>		x	x
<b>c4.4xlarge</b>		x	x
<b>c4.8xlarge</b>		x	x
<b>c5.xlarge</b>			x
<b>c5.2xlarge</b>		x	x
<b>c5.4xlarge</b>		x	x
<b>c5.9xlarge</b>		x	x

Instance type	Bootstrap	Control plane	Compute
<b>c5.12xlarge</b>		x	x
<b>c5.18xlarge</b>		x	x
<b>c5.24xlarge</b>		x	x
<b>c5a.xlarge</b>			x
<b>c5a.2xlarge</b>		x	x
<b>c5a.4xlarge</b>		x	x
<b>c5a.8xlarge</b>		x	x
<b>c5a.12xlarge</b>		x	x
<b>c5a.16xlarge</b>		x	x
<b>c5a.24xlarge</b>		x	x
<b>r4.large</b>			x
<b>r4.xlarge</b>		x	x
<b>r4.2xlarge</b>		x	x
<b>r4.4xlarge</b>		x	x
<b>r4.8xlarge</b>		x	x
<b>r4.16xlarge</b>		x	x
<b>r5.large</b>			x
<b>r5.xlarge</b>		x	x
<b>r5.2xlarge</b>		x	x
<b>r5.4xlarge</b>		x	x
<b>r5.8xlarge</b>		x	x
<b>r5.12xlarge</b>		x	x
<b>r5.16xlarge</b>		x	x

Instance type	Bootstrap	Control plane	Compute
<b>r5.24xlarge</b>		x	x
<b>r5a.large</b>			x
<b>r5a.xlarge</b>		x	x
<b>r5a.2xlarge</b>		x	x
<b>r5a.4xlarge</b>		x	x
<b>r5a.8xlarge</b>		x	x
<b>r5a.12xlarge</b>		x	x
<b>r5a.16xlarge</b>		x	x
<b>r5a.24xlarge</b>		x	x
<b>t3.large</b>			x
<b>t3.xlarge</b>			x
<b>t3.2xlarge</b>			x
<b>t3a.large</b>			x
<b>t3a.xlarge</b>			x
<b>t3a.2xlarge</b>			x

#### 4.12.4. Required AWS infrastructure components

To install OpenShift Container Platform on user-provisioned infrastructure in Amazon Web Services (AWS), you must manually create both the machines and their supporting infrastructure.

For more information about the integration testing for different platforms, see the [OpenShift Container Platform 4.x Tested Integrations](#) page.

By using the provided CloudFormation templates, you can create stacks of AWS resources that represent the following components:

- An AWS Virtual Private Cloud (VPC)
- Networking and load balancing components
- Security groups and roles

- An OpenShift Container Platform bootstrap node
- OpenShift Container Platform control plane nodes
- An OpenShift Container Platform compute node

Alternatively, you can manually create the components or you can reuse existing infrastructure that meets the cluster requirements. Review the CloudFormation templates for more details about how the components interrelate.

#### 4.12.4.1. Other infrastructure components

- A VPC
- DNS entries
- Load balancers (classic or network) and listeners
- A public and a private Route 53 zone
- Security groups
- IAM roles
- S3 buckets

If you are working in a disconnected environment or use a proxy, you cannot reach the public IP addresses for EC2 and ELB endpoints. To reach these endpoints, you must create a VPC endpoint and attach it to the subnet that the clusters are using. Create the following endpoints:

- **ec2.<region>.amazonaws.com**
- **elasticloadbalancing.<region>.amazonaws.com**
- **s3.<region>.amazonaws.com**

#### Required VPC components

You must provide a suitable VPC and subnets that allow communication to your machines.

Component	AWS type	Description
VPC	<ul style="list-style-type: none"> <li>• <b>AWS::EC2::VPC</b></li> <li>• <b>AWS::EC2::VPCEndpoint</b></li> </ul>	You must provide a public VPC for the cluster to use. The VPC uses an endpoint that references the route tables for each subnet to improve communication with the registry that is hosted in S3.
Public subnets	<ul style="list-style-type: none"> <li>• <b>AWS::EC2::Subnet</b></li> <li>• <b>AWS::EC2::SubnetNetworkACLAssociation</b></li> </ul>	Your VPC must have public subnets for between 1 and 3 availability zones and associate them with appropriate Ingress rules.

Component	AWS type	Description												
Internet gateway	<ul style="list-style-type: none"> <li>● <b>AWS::EC2::InternetGateway</b></li> <li>● <b>AWS::EC2::VPCGatewayAttachment</b></li> <li>● <b>AWS::EC2::RouteTable</b></li> <li>● <b>AWS::EC2::Route</b></li> <li>● <b>AWS::EC2::SubnetRouteTableAssociation</b></li> <li>● <b>AWS::EC2::NatGateway</b></li> <li>● <b>AWS::EC2::EIP</b></li> </ul>	<p>You must have a public internet gateway, with public routes, attached to the VPC. In the provided templates, each public subnet has a NAT gateway with an EIP address. These NAT gateways allow cluster resources, like private subnet instances, to reach the internet and are not required for some restricted network or proxy scenarios.</p>												
Network access control	<ul style="list-style-type: none"> <li>● <b>AWS::EC2::NetworkAcl</b></li> <li>● <b>AWS::EC2::NetworkAclEntry</b></li> </ul>	<p>You must allow the VPC to access the following ports:</p> <table border="1"> <thead> <tr> <th>Port</th> <th>Reason</th> </tr> </thead> <tbody> <tr> <td><b>80</b></td> <td>Inbound HTTP traffic</td> </tr> <tr> <td><b>443</b></td> <td>Inbound HTTPS traffic</td> </tr> <tr> <td><b>22</b></td> <td>Inbound SSH traffic</td> </tr> <tr> <td><b>1024 - 65535</b></td> <td>Inbound ephemeral traffic</td> </tr> <tr> <td><b>0 - 65535</b></td> <td>Outbound ephemeral traffic</td> </tr> </tbody> </table>	Port	Reason	<b>80</b>	Inbound HTTP traffic	<b>443</b>	Inbound HTTPS traffic	<b>22</b>	Inbound SSH traffic	<b>1024 - 65535</b>	Inbound ephemeral traffic	<b>0 - 65535</b>	Outbound ephemeral traffic
Port	Reason													
<b>80</b>	Inbound HTTP traffic													
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<b>1024 - 65535</b>	Inbound ephemeral traffic													
<b>0 - 65535</b>	Outbound ephemeral traffic													
Private subnets	<ul style="list-style-type: none"> <li>● <b>AWS::EC2::Subnet</b></li> <li>● <b>AWS::EC2::RouteTable</b></li> <li>● <b>AWS::EC2::SubnetRouteTableAssociation</b></li> </ul>	<p>Your VPC can have private subnets. The provided CloudFormation templates can create private subnets for between 1 and 3 availability zones. If you use private subnets, you must provide appropriate routes and tables for them.</p>												

### Required DNS and load balancing components

Your DNS and load balancer configuration needs to use a public hosted zone and can use a private hosted zone similar to the one that the installation program uses if it provisions the cluster's infrastructure. You must create a DNS entry that resolves to your load balancer. An entry for **api**.



`<cluster_name>.<domain>` must point to the external load balancer, and an entry for `api-int.<cluster_name>.<domain>` must point to the internal load balancer.

The cluster also requires load balancers and listeners for port 6443, which are required for the Kubernetes API and its extensions, and port 22623, which are required for the Ignition config files for new machines. The targets will be the control plane nodes. Port 6443 must be accessible to both clients external to the cluster and nodes within the cluster. Port 22623 must be accessible to nodes within the cluster.

Component	AWS type	Description
DNS	<b>AWS::Route53::HostedZone</b>	The hosted zone for your internal DNS.
etcd record sets	<b>AWS::Route53::RecordSet</b>	The registration records for etcd for your control plane machines.
Public load balancer	<b>AWS::ElasticLoadBalancingV2::LoadBalancer</b>	The load balancer for your public subnets.
External API server record	<b>AWS::Route53::RecordSetGroup</b>	Alias records for the external API server.
External listener	<b>AWS::ElasticLoadBalancingV2::Listener</b>	A listener on port 6443 for the external load balancer.
External target group	<b>AWS::ElasticLoadBalancingV2::TargetGroup</b>	The target group for the external load balancer.
Private load balancer	<b>AWS::ElasticLoadBalancingV2::LoadBalancer</b>	The load balancer for your private subnets.
Internal API server record	<b>AWS::Route53::RecordSetGroup</b>	Alias records for the internal API server.
Internal listener	<b>AWS::ElasticLoadBalancingV2::Listener</b>	A listener on port 22623 for the internal load balancer.

Component	AWS type	Description
Internal target group	<b>AWS::ElasticLoadBalancingV2::TargetGroup</b>	The target group for the internal load balancer.
Internal listener	<b>AWS::ElasticLoadBalancingV2::Listener</b>	A listener on port 6443 for the internal load balancer.
Internal target group	<b>AWS::ElasticLoadBalancingV2::TargetGroup</b>	The target group for the internal load balancer.

## Security groups

The control plane and worker machines require access to the following ports:

Group	Type	IP Protocol	Port range
<b>MasterSecurityGroup</b>	<b>AWS::EC2::SecurityGroup</b>	<b>icmp</b>	<b>0</b>
		<b>tcp</b>	<b>22</b>
		<b>tcp</b>	<b>6443</b>
		<b>tcp</b>	<b>22623</b>
<b>WorkerSecurityGroup</b>	<b>AWS::EC2::SecurityGroup</b>	<b>icmp</b>	<b>0</b>
		<b>tcp</b>	<b>22</b>
<b>BootstrapSecurityGroup</b>	<b>AWS::EC2::SecurityGroup</b>	<b>tcp</b>	<b>22</b>
		<b>tcp</b>	<b>19531</b>

## Control plane Ingress

The control plane machines require the following Ingress groups. Each Ingress group is a **AWS::EC2::SecurityGroupIngress** resource.

Ingress group	Description	IP protocol	Port range
<b>MasterIngressEtcd</b>	etcd	<b>tcp</b>	<b>2379- 2380</b>

Ingress group	Description	IP protocol	Port range
<b>MasterIngress Vxlan</b>	Vxlan packets	<b>udp</b>	<b>4789</b>
<b>MasterIngress WorkerVxlan</b>	Vxlan packets	<b>udp</b>	<b>4789</b>
<b>MasterIngress Internal</b>	Internal cluster communication and Kubernetes proxy metrics	<b>tcp</b>	<b>9000 - 9999</b>
<b>MasterIngress WorkerIntern al</b>	Internal cluster communication	<b>tcp</b>	<b>9000 - 9999</b>
<b>MasterIngress Kube</b>	Kubernetes kubelet, scheduler and controller manager	<b>tcp</b>	<b>10250 - 10259</b>
<b>MasterIngress WorkerKube</b>	Kubernetes kubelet, scheduler and controller manager	<b>tcp</b>	<b>10250 - 10259</b>
<b>MasterIngress IngressServic es</b>	Kubernetes Ingress services	<b>tcp</b>	<b>30000 - 32767</b>
<b>MasterIngress WorkerIngress Services</b>	Kubernetes Ingress services	<b>tcp</b>	<b>30000 - 32767</b>
<b>MasterIngress Geneve</b>	Geneve packets	<b>udp</b>	<b>6081</b>
<b>MasterIngress WorkerGenev e</b>	Geneve packets	<b>udp</b>	<b>6081</b>
<b>MasterIngress IpsecIke</b>	IPsec IKE packets	<b>udp</b>	<b>500</b>
<b>MasterIngress WorkerIpsecIk e</b>	IPsec IKE packets	<b>udp</b>	<b>500</b>
<b>MasterIngress IpsecNat</b>	IPsec NAT-T packets	<b>udp</b>	<b>4500</b>
<b>MasterIngress WorkerIpsecN at</b>	IPsec NAT-T packets	<b>udp</b>	<b>4500</b>

Ingress group	Description	IP protocol	Port range
<b>MasterIngress IpsecEsp</b>	IPsec ESP packets	<b>50</b>	<b>All</b>
<b>MasterIngress WorkerIpsecE sp</b>	IPsec ESP packets	<b>50</b>	<b>All</b>
<b>MasterIngress InternalUDP</b>	Internal cluster communication	<b>udp</b>	<b>9000 - 9999</b>
<b>MasterIngress WorkerInterna IUDP</b>	Internal cluster communication	<b>udp</b>	<b>9000 - 9999</b>
<b>MasterIngress IngressServic esUDP</b>	Kubernetes Ingress services	<b>udp</b>	<b>30000 - 32767</b>
<b>MasterIngress WorkerIngress ServicesUDP</b>	Kubernetes Ingress services	<b>udp</b>	<b>30000 - 32767</b>

## Worker Ingress

The worker machines require the following Ingress groups. Each Ingress group is a **AWS::EC2::SecurityGroupIngress** resource.

Ingress group	Description	IP protocol	Port range
<b>WorkerIngress Vxlan</b>	Vxlan packets	<b>udp</b>	<b>4789</b>
<b>WorkerIngress WorkerVxlan</b>	Vxlan packets	<b>udp</b>	<b>4789</b>
<b>WorkerIngress Internal</b>	Internal cluster communication	<b>tcp</b>	<b>9000 - 9999</b>
<b>WorkerIngress WorkerInterna I</b>	Internal cluster communication	<b>tcp</b>	<b>9000 - 9999</b>
<b>WorkerIngress Kube</b>	Kubernetes kubelet, scheduler, and controller manager	<b>tcp</b>	<b>10250</b>
<b>WorkerIngress WorkerKube</b>	Kubernetes kubelet, scheduler, and controller manager	<b>tcp</b>	<b>10250</b>

Ingress group	Description	IP protocol	Port range
<b>WorkerIngress IngressServices</b>	Kubernetes Ingress services	<b>tcp</b>	<b>30000 - 32767</b>
<b>WorkerIngress WorkerIngress Services</b>	Kubernetes Ingress services	<b>tcp</b>	<b>30000 - 32767</b>
<b>WorkerIngress Geneve</b>	Geneve packets	<b>udp</b>	<b>6081</b>
<b>WorkerIngress MasterGeneve</b>	Geneve packets	<b>udp</b>	<b>6081</b>
<b>WorkerIngress IpsecIke</b>	IPsec IKE packets	<b>udp</b>	<b>500</b>
<b>WorkerIngress MasterIpsecIke</b>	IPsec IKE packets	<b>udp</b>	<b>500</b>
<b>WorkerIngress IpsecNat</b>	IPsec NAT-T packets	<b>udp</b>	<b>4500</b>
<b>WorkerIngress MasterIpsecNat</b>	IPsec NAT-T packets	<b>udp</b>	<b>4500</b>
<b>WorkerIngress IpsecEsp</b>	IPsec ESP packets	<b>50</b>	<b>All</b>
<b>WorkerIngress MasterIpsecEsp</b>	IPsec ESP packets	<b>50</b>	<b>All</b>
<b>WorkerIngress InternalUDP</b>	Internal cluster communication	<b>udp</b>	<b>9000 - 9999</b>
<b>WorkerIngress MasterInternal UDP</b>	Internal cluster communication	<b>udp</b>	<b>9000 - 9999</b>
<b>WorkerIngress IngressServices UDP</b>	Kubernetes Ingress services	<b>udp</b>	<b>30000 - 32767</b>

Ingress group	Description	IP protocol	Port range
<b>WorkerIngress MasterIngress ServicesUDP</b>	Kubernetes Ingress services	<b>udp</b>	<b>30000 - 32767</b>

### Roles and instance profiles

You must grant the machines permissions in AWS. The provided CloudFormation templates grant the machines **Allow** permissions for the following **AWS::IAM::Role** objects and provide a **AWS::IAM::InstanceProfile** for each set of roles. If you do not use the templates, you can grant the machines the following broad permissions or the following individual permissions.

Role	Effect	Action	Resource
Master	<b>Allow</b>	<b>ec2:*</b>	*
	<b>Allow</b>	<b>elasticloadbalancing:*</b>	*
	<b>Allow</b>	<b>iam:PassRole</b>	*
	<b>Allow</b>	<b>s3:GetObject</b>	*
Worker	<b>Allow</b>	<b>ec2:Describe*</b>	*
Bootstrap	<b>Allow</b>	<b>ec2:Describe*</b>	*
	<b>Allow</b>	<b>ec2:AttachVolume</b>	*
	<b>Allow</b>	<b>ec2:DetachVolume</b>	*

#### 4.12.4.2. Cluster machines

You need **AWS::EC2::Instance** objects for the following machines:

- A bootstrap machine. This machine is required during installation, but you can remove it after your cluster deploys.
- Three control plane machines. The control plane machines are not governed by a machine set.
- Compute machines. You must create at least two compute machines, which are also known as worker machines, during installation. These machines are not governed by a machine set.

#### 4.12.4.3. Required AWS permissions for the IAM user

**NOTE**

Your IAM user must have the permission **tag:GetResources** in the region **us-east-1** to delete the base cluster resources. As part of the AWS API requirement, the OpenShift Container Platform installation program performs various actions in this region.

When you attach the **AdministratorAccess** policy to the IAM user that you create in Amazon Web Services (AWS), you grant that user all of the required permissions. To deploy all components of an OpenShift Container Platform cluster, the IAM user requires the following permissions:

**Example 4.23. Required EC2 permissions for installation**

- **ec2:AuthorizeSecurityGroupEgress**
- **ec2:AuthorizeSecurityGroupIngress**
- **ec2:CopyImage**
- **ec2:CreateNetworkInterface**
- **ec2:AttachNetworkInterface**
- **ec2:CreateSecurityGroup**
- **ec2:CreateTags**
- **ec2:CreateVolume**
- **ec2>DeleteSecurityGroup**
- **ec2>DeleteSnapshot**
- **ec2>DeleteTags**
- **ec2:DeregisterImage**
- **ec2:DescribeAccountAttributes**
- **ec2:DescribeAddresses**
- **ec2:DescribeAvailabilityZones**
- **ec2:DescribeDhcpOptions**
- **ec2:DescribeImages**
- **ec2:DescribeInstanceAttribute**
- **ec2:DescribeInstanceCreditSpecifications**
- **ec2:DescribeInstances**
- **ec2:DescribeInstanceTypes**
- **ec2:DescribeInternetGateways**
- **ec2:DescribeKeyPairs**

- **ec2:DescribeNatGateways**
- **ec2:DescribeNetworkAcls**
- **ec2:DescribeNetworkInterfaces**
- **ec2:DescribePrefixLists**
- **ec2:DescribeRegions**
- **ec2:DescribeRouteTables**
- **ec2:DescribeSecurityGroups**
- **ec2:DescribeSubnets**
- **ec2:DescribeTags**
- **ec2:DescribeVolumes**
- **ec2:DescribeVpcAttribute**
- **ec2:DescribeVpcClassicLink**
- **ec2:DescribeVpcClassicLinkDnsSupport**
- **ec2:DescribeVpcEndpoints**
- **ec2:DescribeVpcs**
- **ec2:GetEbsDefaultKmsKeyId**
- **ec2:ModifyInstanceAttribute**
- **ec2:ModifyNetworkInterfaceAttribute**
- **ec2:RevokeSecurityGroupEgress**
- **ec2:RevokeSecurityGroupIngress**
- **ec2:RunInstances**
- **ec2:TerminateInstances**

Example 4.24. Required permissions for creating network resources during installation

- **ec2:AllocateAddress**
- **ec2:AssociateAddress**
- **ec2:AssociateDhcpOptions**
- **ec2:AssociateRouteTable**
- **ec2:AttachInternetGateway**
- **ec2:CreateDhcpOptions**



- **ec2:CreateInternetGateway**
- **ec2:CreateNatGateway**
- **ec2:CreateRoute**
- **ec2:CreateRouteTable**
- **ec2:CreateSubnet**
- **ec2:CreateVpc**
- **ec2:CreateVpcEndpoint**
- **ec2:ModifySubnetAttribute**
- **ec2:ModifyVpcAttribute**

**NOTE**

If you use an existing VPC, your account does not require these permissions for creating network resources.

**Example 4.25. Required Elastic Load Balancing permissions (ELB) for installation**

- **elasticloadbalancing:AddTags**
- **elasticloadbalancing:ApplySecurityGroupsToLoadBalancer**
- **elasticloadbalancing:AttachLoadBalancerToSubnets**
- **elasticloadbalancing:ConfigureHealthCheck**
- **elasticloadbalancing:CreateLoadBalancer**
- **elasticloadbalancing:CreateLoadBalancerListeners**
- **elasticloadbalancing>DeleteLoadBalancer**
- **elasticloadbalancing:DeregisterInstancesFromLoadBalancer**
- **elasticloadbalancing:DescribeInstanceHealth**
- **elasticloadbalancing:DescribeLoadBalancerAttributes**
- **elasticloadbalancing:DescribeLoadBalancers**
- **elasticloadbalancing:DescribeTags**
- **elasticloadbalancing:ModifyLoadBalancerAttributes**
- **elasticloadbalancing:RegisterInstancesWithLoadBalancer**
- **elasticloadbalancing:SetLoadBalancerPoliciesOfListener**

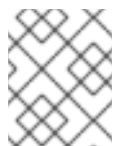
**Example 4.26. Required Elastic Load Balancing permissions (ELBv2) for installation**

- **elasticloadbalancing:AddTags**
- **elasticloadbalancing:CreateListener**
- **elasticloadbalancing:CreateLoadBalancer**
- **elasticloadbalancing:CreateTargetGroup**
- **elasticloadbalancing>DeleteLoadBalancer**
- **elasticloadbalancing:DeregisterTargets**
- **elasticloadbalancing:DescribeListeners**
- **elasticloadbalancing:DescribeLoadBalancerAttributes**
- **elasticloadbalancing:DescribeLoadBalancers**
- **elasticloadbalancing:DescribeTargetGroupAttributes**
- **elasticloadbalancing:DescribeTargetHealth**
- **elasticloadbalancing:ModifyLoadBalancerAttributes**
- **elasticloadbalancing:ModifyTargetGroup**
- **elasticloadbalancing:ModifyTargetGroupAttributes**
- **elasticloadbalancing:RegisterTargets**

**Example 4.27. Required IAM permissions for installation**

- **iam:AddRoleToInstanceProfile**
- **iam:CreateInstanceProfile**
- **iam:CreateRole**
- **iam>DeleteInstanceProfile**
- **iam>DeleteRole**
- **iam>DeleteRolePolicy**
- **iam:GetInstanceProfile**
- **iam:GetRole**
- **iam:GetRolePolicy**
- **iam:GetUser**
- **iam:ListInstanceProfilesForRole**

- **iam:ListRoles**
- **iam:ListUsers**
- **iam:PassRole**
- **iam:PutRolePolicy**
- **iam:RemoveRoleFromInstanceProfile**
- **iam:SimulatePrincipalPolicy**
- **iam:TagRole**



#### NOTE

If you have not created an elastic load balancer (ELB) in your AWS account, the IAM user also requires the **iam:CreateServiceLinkedRole** permission.

#### Example 4.28. Required Route 53 permissions for installation

- **route53:ChangeResourceRecordSets**
- **route53:ChangeTagsForResource**
- **route53:CreateHostedZone**
- **route53>DeleteHostedZone**
- **route53:GetChange**
- **route53:GetHostedZone**
- **route53:ListHostedZones**
- **route53:ListHostedZonesByName**
- **route53:ListResourceRecordSets**
- **route53:ListTagsForResource**
- **route53:UpdateHostedZoneComment**

#### Example 4.29. Required S3 permissions for installation

- **s3:CreateBucket**
- **s3>DeleteBucket**
- **s3:GetAccelerateConfiguration**
- **s3:GetBucketAcl**
- **s3:GetBucketCors**

- **s3:GetBucketLocation**
- **s3:GetBucketLogging**
- **s3:GetBucketObjectLockConfiguration**
- **s3:GetBucketReplication**
- **s3:GetBucketRequestPayment**
- **s3:GetBucketTagging**
- **s3:GetBucketVersioning**
- **s3:GetBucketWebsite**
- **s3:GetEncryptionConfiguration**
- **s3:GetLifecycleConfiguration**
- **s3:GetReplicationConfiguration**
- **s3:ListBucket**
- **s3:PutBucketAcl**
- **s3:PutBucketTagging**
- **s3:PutEncryptionConfiguration**

Example 4.30. S3 permissions that cluster Operators require

- **s3:DeleteObject**
- **s3:GetObject**
- **s3:GetObjectAcl**
- **s3:GetObjectTagging**
- **s3:GetObjectVersion**
- **s3:PutObject**
- **s3:PutObjectAcl**
- **s3:PutObjectTagging**

Example 4.31. Required permissions to delete base cluster resources

- **autoscaling:DescribeAutoScalingGroups**
- **ec2:DeleteNetworkInterface**
- **ec2:DeleteVolume**

- **elasticloadbalancing:DeleteTargetGroup**
- **elasticloadbalancing:DescribeTargetGroups**
- **iam:DeleteAccessKey**
- **iam:DeleteUser**
- **iam:ListAttachedRolePolicies**
- **iam:ListInstanceProfiles**
- **iam:ListRolePolicies**
- **iam:ListUserPolicies**
- **s3:DeleteObject**
- **s3:ListBucketVersions**
- **tag:GetResources**

Example 4.32. Required permissions to delete network resources

- **ec2:DeleteDhcpOptions**
- **ec2:DeleteInternetGateway**
- **ec2:DeleteNatGateway**
- **ec2:DeleteRoute**
- **ec2:DeleteRouteTable**
- **ec2:DeleteSubnet**
- **ec2:DeleteVpc**
- **ec2:DeleteVpcEndpoints**
- **ec2:DetachInternetGateway**
- **ec2:DisassociateRouteTable**
- **ec2:ReleaseAddress**
- **ec2:ReplaceRouteTableAssociation**



#### NOTE

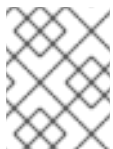
If you use an existing VPC, your account does not require these permissions to delete network resources. Instead, your account only requires the **tag:UntagResources** permission to delete network resources.

**Example 4.33. Required permissions to delete a cluster with shared instance roles**

- **iam:UntagRole**

**Example 4.34. Additional IAM and S3 permissions that are required to create manifests**

- **iam>DeleteAccessKey**
- **iam>DeleteUser**
- **iam>DeleteUserPolicy**
- **iam:GetUserPolicy**
- **iam>ListAccessKeys**
- **iam:PutUserPolicy**
- **iam:TagUser**
- **s3:PutBucketPublicAccessBlock**
- **s3:GetBucketPublicAccessBlock**
- **s3:PutLifecycleConfiguration**
- **s3:HeadBucket**
- **s3:ListBucketMultipartUploads**
- **s3:AbortMultipartUpload**

**NOTE**

If you are managing your cloud provider credentials with mint mode, the IAM user also requires the **iam:CreateAccessKey** and **iam:CreateUser** permissions.

**Example 4.35. Optional permissions for instance and quota checks for installation**

- **ec2:DescribeInstanceTypeOfferings**
- **servicequotas:ListAWSDefaultServiceQuotas**

#### 4.12.5. Obtaining an AWS Marketplace image

If you are deploying an OpenShift Container Platform cluster using an AWS Marketplace image, you must first subscribe through AWS. Subscribing to the offer provides you with the AMI ID that the installation program uses to deploy worker nodes.

**NOTE**

Deploying an OpenShift Container Platform cluster using an AWS Marketplace image is not supported in the secret regions or China regions.

**Prerequisites**

- You have an AWS account to purchase the offer. This account does not have to be the same account that is used to install the cluster.

**Procedure**

1. Complete the OpenShift Container Platform subscription from the [AWS Marketplace](#).
2. Record the AMI ID for your specific region. If you use the CloudFormation template to deploy your worker nodes, you must update the **worker0.type.properties.ImageID** parameter with this value.

**4.12.6. Obtaining the installation program**

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

**Prerequisites**

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

**Procedure**

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.

**IMPORTANT**

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

**IMPORTANT**

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

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

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

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

#### 4.12.7. Generating a key pair for cluster node SSH access

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

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

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



#### IMPORTANT

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



#### NOTE

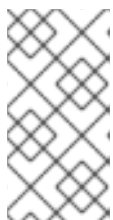
You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

#### Procedure

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

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

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



#### NOTE

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

- View the public SSH key:



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

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

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

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



#### NOTE

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

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

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

#### Example output

```
Agent pid 31874
```



#### NOTE

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

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

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

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

#### Example output

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

#### Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program. If you install a cluster on infrastructure that you provision, you must provide the key to the installation program.

### 4.12.8. Creating the installation files for AWS

To install OpenShift Container Platform on Amazon Web Services (AWS) using user-provisioned infrastructure, you must generate the files that the installation program needs to deploy your cluster and modify them so that the cluster creates only the machines that it will use. You generate and

customize the **install-config.yaml** file, Kubernetes manifests, and Ignition config files. You also have the option to first set up a separate **var** partition during the preparation phases of installation.

#### 4.12.8.1. Optional: Creating a separate **/var** partition

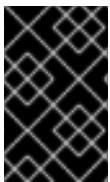
It is recommended that disk partitioning for OpenShift Container Platform be left to the installer. However, there are cases where you might want to create separate partitions in a part of the filesystem that you expect to grow.

OpenShift Container Platform supports the addition of a single partition to attach storage to either the **/var** partition or a subdirectory of **/var**. For example:

- **/var/lib/containers**: Holds container-related content that can grow as more images and containers are added to a system.
- **/var/lib/etcd**: Holds data that you might want to keep separate for purposes such as performance optimization of etcd storage.
- **/var**: Holds data that you might want to keep separate for purposes such as auditing.

Storing the contents of a **/var** directory separately makes it easier to grow storage for those areas as needed and reinstall OpenShift Container Platform at a later date and keep that data intact. With this method, you will not have to pull all your containers again, nor will you have to copy massive log files when you update systems.

Because **/var** must be in place before a fresh installation of Red Hat Enterprise Linux CoreOS (RHCOS), the following procedure sets up the separate **/var** partition by creating a machine config manifest that is inserted during the **openshift-install** preparation phases of an OpenShift Container Platform installation.



#### IMPORTANT

If you follow the steps to create a separate **/var** partition in this procedure, it is not necessary to create the Kubernetes manifest and Ignition config files again as described later in this section.

#### Procedure

1. Create a directory to hold the OpenShift Container Platform installation files:

```
$ mkdir $HOME/clusterconfig
```

2. Run **openshift-install** to create a set of files in the **manifest** and **openshift** subdirectories. Answer the system questions as you are prompted:

```
$ openshift-install create manifests --dir $HOME/clusterconfig
```

#### Example output

```
? SSH Public Key ...
INFO Credentials loaded from the "myprofile" profile in file "/home/myuser/.aws/credentials"
INFO Consuming Install Config from target directory
INFO Manifests created in: $HOME/clusterconfig/manifests and
$HOME/clusterconfig/openshift
```

- Optional: Confirm that the installation program created manifests in the **clusterconfig/openshift** directory:

```
$ ls $HOME/clusterconfig/openshift/
```

### Example output

```
99_kubeadmin-password-secret.yaml
99_openshift-cluster-api_master-machines-0.yaml
99_openshift-cluster-api_master-machines-1.yaml
99_openshift-cluster-api_master-machines-2.yaml
...
```

- Create a Butane config that configures the additional partition. For example, name the file **\$HOME/clusterconfig/98-var-partition.bu**, change the disk device name to the name of the storage device on the **worker** systems, and set the storage size as appropriate. This example places the **/var** directory on a separate partition:

```
variant: openshift
version: 4.9.0
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 98-var-partition
storage:
  disks:
    - device: /dev/<device_name> 1
      partitions:
        - label: var
          start_mib: <partition_start_offset> 2
          size_mib: <partition_size> 3
      filesystems:
        - device: /dev/disk/by-partlabel/var
          path: /var
          format: xfs
          mount_options: [defaults, prjquota] 4
          with_mount_unit: true
```

- 1 The storage device name of the disk that you want to partition.
- 2 When adding a data partition to the boot disk, a minimum value of 25000 MiB (Mebibytes) is recommended. The root file system is automatically resized to fill all available space up to the specified offset. If no value is specified, or if the specified value is smaller than the recommended minimum, the resulting root file system will be too small, and future reinstalls of RHCOS might overwrite the beginning of the data partition.
- 3 The size of the data partition in mebibytes.
- 4 The **prjquota** mount option must be enabled for filesystems used for container storage.

**NOTE**

When creating a separate **/var** partition, you cannot use different instance types for worker nodes, if the different instance types do not have the same device name.

5. Create a manifest from the Butane config and save it to the **clusterconfig/openshift** directory. For example, run the following command:

```
$ butane $HOME/clusterconfig/98-var-partition.bu -o $HOME/clusterconfig/openshift/98-var-partition.yaml
```

6. Run **openshift-install** again to create Ignition configs from a set of files in the **manifest** and **openshift** subdirectories:

```
$ openshift-install create ignition-configs --dir $HOME/clusterconfig
$ ls $HOME/clusterconfig/
auth bootstrap.ign master.ign metadata.json worker.ign
```

Now you can use the Ignition config files as input to the installation procedures to install Red Hat Enterprise Linux CoreOS (RHCOS) systems.

#### 4.12.8.2. Creating the installation configuration file

Generate and customize the installation configuration file that the installation program needs to deploy your cluster.

##### Prerequisites

- You obtained the OpenShift Container Platform installation program for user-provisioned infrastructure and the pull secret for your cluster.
- You checked that you are deploying your cluster to a region with an accompanying Red Hat Enterprise Linux CoreOS (RHCOS) AMI published by Red Hat. If you are deploying to a region that requires a custom AMI, such as an AWS GovCloud region, you must create the **install-config.yaml** file manually.

##### Procedure

1. Create the **install-config.yaml** file.
  - a. Change to the directory that contains the installation program and run the following command:

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

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



## IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

- b. At the prompts, provide the configuration details for your cloud:
  - i. Optional: Select an SSH key to use to access your cluster machines.



## NOTE

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

- ii. Select **aws** as the platform to target.
- iii. If you do not have an AWS profile stored on your computer, enter the AWS access key ID and secret access key for the user that you configured to run the installation program.



## NOTE

The AWS access key ID and secret access key are stored in `~/.aws/credentials` in the home directory of the current user on the installation host. You are prompted for the credentials by the installation program if the credentials for the exported profile are not present in the file. Any credentials that you provide to the installation program are stored in the file.

- iv. Select the AWS region to deploy the cluster to.
  - v. Select the base domain for the Route 53 service that you configured for your cluster.
  - vi. Enter a descriptive name for your cluster.
  - vii. Paste the [pull secret from the Red Hat OpenShift Cluster Manager](#) .
2. Optional: Back up the **install-config.yaml** file.



## IMPORTANT

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

### Additional resources

- See [Configuration and credential file settings](#) in the AWS documentation for more information about AWS profile and credential configuration.

### 4.12.8.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

#### Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



#### NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

- You have added the **ec2.<region>.amazonaws.com**, **elasticloadbalancing.<region>.amazonaws.com**, and **s3.<region>.amazonaws.com** endpoints to your VPC endpoint. These endpoints are required to complete requests from the nodes to the AWS EC2 API. Because the proxy works on the container level, not the node level, you must route these requests to the AWS EC2 API through the AWS private network. Adding the public IP address of the EC2 API to your allowlist in your proxy server is not sufficient.

#### Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
  additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
  ...
```

**1** A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.

**2** A proxy URL to use for creating HTTPS connections outside the cluster.

- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with `.` to match subdomains only. For
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

**NOTE**

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

**NOTE**

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

#### 4.12.8.4. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.

**IMPORTANT**

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

### Prerequisites

- You obtained the OpenShift Container Platform installation program.
- You created the **install-config.yaml** installation configuration file.

## Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

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

- 1** For **<installation\_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

2. Remove the Kubernetes manifest files that define the control plane machines:

```
$ rm -f <installation_directory>/openshift/99_openshift-cluster-api_master-machines-*.yaml
```

By removing these files, you prevent the cluster from automatically generating control plane machines.

3. Remove the Kubernetes manifest files that define the worker machines:

```
$ rm -f <installation_directory>/openshift/99_openshift-cluster-api_worker-machineset-*.yaml
```

Because you create and manage the worker machines yourself, you do not need to initialize these machines.

4. Check that the **mastersSchedulable** parameter in the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:

- a. Open the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** file.
- b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.
- c. Save and exit the file.

5. Optional: If you do not want [the Ingress Operator](#) to create DNS records on your behalf, remove the **privateZone** and **publicZone** sections from the **<installation\_directory>/manifests/cluster-dns-02-config.yml** DNS configuration file:

```
apiVersion: config.openshift.io/v1
kind: DNS
metadata:
  creationTimestamp: null
  name: cluster
spec:
  baseDomain: example.openshift.com
  privateZone: 1
  id: mycluster-100419-private-zone
```



```
publicZone: 2
  id: example.openshift.com
  status: {}
```

1 2 Remove this section completely.

If you do so, you must add ingress DNS records manually in a later step.

- To create the Ignition configuration files, run the following command from the directory that contains the installation program:

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

1 For **<installation\_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation\_directory>/auth** directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

#### 4.12.9. Extracting the infrastructure name

The Ignition config files contain a unique cluster identifier that you can use to uniquely identify your cluster in Amazon Web Services (AWS). The infrastructure name is also used to locate the appropriate AWS resources during an OpenShift Container Platform installation. The provided CloudFormation templates contain references to this infrastructure name, so you must extract it.

##### Prerequisites

- You obtained the OpenShift Container Platform installation program and the pull secret for your cluster.
- You generated the Ignition config files for your cluster.
- You installed the **jq** package.

##### Procedure

- To extract and view the infrastructure name from the Ignition config file metadata, run the following command:

```
$ jq -r .infraID <installation_directory>/metadata.json 1
```

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

### Example output

```
openshift-vw9j6 1
```

- 1 The output of this command is your cluster name and a random string.

## 4.12.10. Creating a VPC in AWS

You must create a Virtual Private Cloud (VPC) in Amazon Web Services (AWS) for your OpenShift Container Platform cluster to use. You can customize the VPC to meet your requirements, including VPN and route tables.

You can use the provided CloudFormation template and a custom parameter file to create a stack of AWS resources that represent the VPC.



### NOTE

If you do not use the provided CloudFormation template to create your AWS infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

### Prerequisites

- You configured an AWS account.
- You added your AWS keys and region to your local AWS profile by running **aws configure**.
- You generated the Ignition config files for your cluster.

### Procedure

1. Create a JSON file that contains the parameter values that the template requires:

```
[
  {
    "ParameterKey": "VpcCidr", 1
    "ParameterValue": "10.0.0.0/16" 2
  },
  {
    "ParameterKey": "AvailabilityZoneCount", 3
    "ParameterValue": "1" 4
  },
  {
    "ParameterKey": "SubnetBits", 5
    "ParameterValue": "12" 6
  }
]
```

- 1 The CIDR block for the VPC.
  - 2 Specify a CIDR block in the format **x.x.x.x/16-24**.
  - 3 The number of availability zones to deploy the VPC in.
  - 4 Specify an integer between **1** and **3**.
  - 5 The size of each subnet in each availability zone.
  - 6 Specify an integer between **5** and **13**, where **5** is **/27** and **13** is **/19**.
2. Copy the template from the **CloudFormation template for the VPC** section of this topic and save it as a YAML file on your computer. This template describes the VPC that your cluster requires.
  3. Launch the CloudFormation template to create a stack of AWS resources that represent the VPC:



### IMPORTANT

You must enter the command on a single line.

```
$ aws cloudformation create-stack --stack-name <name> 1
  --template-body file://<template>.yaml 2
  --parameters file://<parameters>.json 3
```

- 1 **<name>** is the name for the CloudFormation stack, such as **cluster-vpc**. You need the name of this stack if you remove the cluster.
- 2 **<template>** is the relative path to and name of the CloudFormation template YAML file that you saved.
- 3 **<parameters>** is the relative path to and name of the CloudFormation parameters JSON file.

### Example output

```
arn:aws:cloudformation:us-east-1:269333783861:stack/cluster-vpc/dbedae40-2fd3-11eb-820e-12a48460849f
```

4. Confirm that the template components exist:

```
$ aws cloudformation describe-stacks --stack-name <name>
```

After the **StackStatus** displays **CREATE\_COMPLETE**, the output displays values for the following parameters. You must provide these parameter values to the other CloudFormation templates that you run to create your cluster:

<b>VpcId</b>	The ID of your VPC.
--------------	---------------------

<b>PublicSubnetIds</b>	The IDs of the new public subnets.
<b>PrivateSubnetIds</b>	The IDs of the new private subnets.

#### 4.12.10.1. CloudFormation template for the VPC

You can use the following CloudFormation template to deploy the VPC that you need for your OpenShift Container Platform cluster.

##### Example 4.36. CloudFormation template for the VPC

```

AWSTemplateFormatVersion: 2010-09-09
Description: Template for Best Practice VPC with 1-3 AZs

Parameters:
  VpcCidr:
    AllowedPattern: ^(([0-9]|[1-9][0-9]|1[0-9]{2}|2[0-4][0-9]|25[0-5]).){3}([0-9]|[1-9][0-9]|1[0-9]{2}|2[0-4][0-9]|25[0-5])(\.(1[6-9]|2[0-4]))$
    ConstraintDescription: CIDR block parameter must be in the form x.x.x.x/16-24.
    Default: 10.0.0.0/16
    Description: CIDR block for VPC.
    Type: String
  AvailabilityZoneCount:
    ConstraintDescription: "The number of availability zones. (Min: 1, Max: 3)"
    MinValue: 1
    MaxValue: 3
    Default: 1
    Description: "How many AZs to create VPC subnets for. (Min: 1, Max: 3)"
    Type: Number
  SubnetBits:
    ConstraintDescription: CIDR block parameter must be in the form x.x.x.x/19-27.
    MinValue: 5
    MaxValue: 13
    Default: 12
    Description: "Size of each subnet to create within the availability zones. (Min: 5 = /27, Max: 13 = /19)"
    Type: Number

Metadata:
  AWS::CloudFormation::Interface:
    ParameterGroups:
      - Label:
          default: "Network Configuration"
        Parameters:
          - VpcCidr
          - SubnetBits
      - Label:
          default: "Availability Zones"
        Parameters:
          - AvailabilityZoneCount
    ParameterLabels:

```

```

AvailabilityZoneCount:
  default: "Availability Zone Count"
VpcCidr:
  default: "VPC CIDR"
SubnetBits:
  default: "Bits Per Subnet"

```

Conditions:

```

DoAz3: !Equals [3, !Ref AvailabilityZoneCount]
DoAz2: !Or [!Equals [2, !Ref AvailabilityZoneCount], Condition: DoAz3]

```

Resources:

VPC:

```

Type: "AWS::EC2::VPC"
Properties:
  EnableDnsSupport: "true"
  EnableDnsHostnames: "true"
  CidrBlock: !Ref VpcCidr

```

PublicSubnet:

```

Type: "AWS::EC2::Subnet"
Properties:
  VpcId: !Ref VPC
  CidrBlock: !Select [0, !Cidr [!Ref VpcCidr, 6, !Ref SubnetBits]]
  AvailabilityZone: !Select
  - 0
  - Fn::GetAZs: !Ref "AWS::Region"

```

PublicSubnet2:

```

Type: "AWS::EC2::Subnet"
Condition: DoAz2
Properties:
  VpcId: !Ref VPC
  CidrBlock: !Select [1, !Cidr [!Ref VpcCidr, 6, !Ref SubnetBits]]
  AvailabilityZone: !Select
  - 1
  - Fn::GetAZs: !Ref "AWS::Region"

```

PublicSubnet3:

```

Type: "AWS::EC2::Subnet"
Condition: DoAz3
Properties:
  VpcId: !Ref VPC
  CidrBlock: !Select [2, !Cidr [!Ref VpcCidr, 6, !Ref SubnetBits]]
  AvailabilityZone: !Select
  - 2
  - Fn::GetAZs: !Ref "AWS::Region"

```

InternetGateway:

```

Type: "AWS::EC2::InternetGateway"

```

GatewayToInternet:

```

Type: "AWS::EC2::VPCEGatewayAttachment"
Properties:
  VpcId: !Ref VPC
  InternetGatewayId: !Ref InternetGateway

```

PublicRouteTable:

```

Type: "AWS::EC2::RouteTable"
Properties:
  VpcId: !Ref VPC

```

PublicRoute:

```
Type: "AWS::EC2::Route"
DependsOn: GatewayToInternet
Properties:
  RouteTableId: !Ref PublicRouteTable
  DestinationCidrBlock: 0.0.0.0/0
  GatewayId: !Ref InternetGateway
PublicSubnetRouteTableAssociation:
  Type: "AWS::EC2::SubnetRouteTableAssociation"
  Properties:
    SubnetId: !Ref PublicSubnet
    RouteTableId: !Ref PublicRouteTable
PublicSubnetRouteTableAssociation2:
  Type: "AWS::EC2::SubnetRouteTableAssociation"
  Condition: DoAz2
  Properties:
    SubnetId: !Ref PublicSubnet2
    RouteTableId: !Ref PublicRouteTable
PublicSubnetRouteTableAssociation3:
  Condition: DoAz3
  Type: "AWS::EC2::SubnetRouteTableAssociation"
  Properties:
    SubnetId: !Ref PublicSubnet3
    RouteTableId: !Ref PublicRouteTable
PrivateSubnet:
  Type: "AWS::EC2::Subnet"
  Properties:
    VpcId: !Ref VPC
    CidrBlock: !Select [3, !Cidr [!Ref VpcCidr, 6, !Ref SubnetBits]]
    AvailabilityZone: !Select
      - 0
      - Fn::GetAZs: !Ref "AWS::Region"
PrivateRouteTable:
  Type: "AWS::EC2::RouteTable"
  Properties:
    VpcId: !Ref VPC
PrivateSubnetRouteTableAssociation:
  Type: "AWS::EC2::SubnetRouteTableAssociation"
  Properties:
    SubnetId: !Ref PrivateSubnet
    RouteTableId: !Ref PrivateRouteTable
NAT:
  DependsOn:
    - GatewayToInternet
  Type: "AWS::EC2::NatGateway"
  Properties:
    AllocationId:
      "Fn::GetAtt":
        - EIP
        - AllocationId
    SubnetId: !Ref PublicSubnet
EIP:
  Type: "AWS::EC2::EIP"
  Properties:
    Domain: vpc
Route:
  Type: "AWS::EC2::Route"
```

```

Properties:
  RouteTableId:
    Ref: PrivateRouteTable
  DestinationCidrBlock: 0.0.0.0/0
  NatGatewayId:
    Ref: NAT
PrivateSubnet2:
  Type: "AWS::EC2::Subnet"
  Condition: DoAz2
  Properties:
    VpcId: !Ref VPC
    CidrBlock: !Select [4, !Cidr [!Ref VpcCidr, 6, !Ref SubnetBits]]
    AvailabilityZone: !Select
      - 1
      - Fn::GetAZs: !Ref "AWS::Region"
PrivateRouteTable2:
  Type: "AWS::EC2::RouteTable"
  Condition: DoAz2
  Properties:
    VpcId: !Ref VPC
PrivateSubnetRouteTableAssociation2:
  Type: "AWS::EC2::SubnetRouteTableAssociation"
  Condition: DoAz2
  Properties:
    SubnetId: !Ref PrivateSubnet2
    RouteTableId: !Ref PrivateRouteTable2
NAT2:
  DependsOn:
    - GatewayToInternet
  Type: "AWS::EC2::NatGateway"
  Condition: DoAz2
  Properties:
    AllocationId:
      "Fn::GetAtt":
        - EIP2
        - AllocationId
    SubnetId: !Ref PublicSubnet2
EIP2:
  Type: "AWS::EC2::EIP"
  Condition: DoAz2
  Properties:
    Domain: vpc
Route2:
  Type: "AWS::EC2::Route"
  Condition: DoAz2
  Properties:
    RouteTableId:
      Ref: PrivateRouteTable2
    DestinationCidrBlock: 0.0.0.0/0
    NatGatewayId:
      Ref: NAT2
PrivateSubnet3:
  Type: "AWS::EC2::Subnet"
  Condition: DoAz3
  Properties:
    VpcId: !Ref VPC

```

```
CidrBlock: !Select [5, !Cidr [!Ref VpcCidr, 6, !Ref SubnetBits]]
AvailabilityZone: !Select
- 2
- Fn::GetAZs: !Ref "AWS::Region"
PrivateRouteTable3:
  Type: "AWS::EC2::RouteTable"
  Condition: DoAz3
  Properties:
    Vpclid: !Ref VPC
PrivateSubnetRouteTableAssociation3:
  Type: "AWS::EC2::SubnetRouteTableAssociation"
  Condition: DoAz3
  Properties:
    SubnetId: !Ref PrivateSubnet3
    RouteTableId: !Ref PrivateRouteTable3
NAT3:
  DependsOn:
  - GatewayToInternet
  Type: "AWS::EC2::NatGateway"
  Condition: DoAz3
  Properties:
    AllocationId:
      Fn::GetAtt:
      - EIP3
      - AllocationId
    SubnetId: !Ref PublicSubnet3
EIP3:
  Type: "AWS::EC2::EIP"
  Condition: DoAz3
  Properties:
    Domain: vpc
Route3:
  Type: "AWS::EC2::Route"
  Condition: DoAz3
  Properties:
    RouteTableId:
      Ref: PrivateRouteTable3
    DestinationCidrBlock: 0.0.0.0/0
    NatGatewayId:
      Ref: NAT3
S3Endpoint:
  Type: AWS::EC2::VPCEndpoint
  Properties:
    PolicyDocument:
      Version: 2012-10-17
      Statement:
      - Effect: Allow
        Principal: '*'
        Action:
          - '*'
        Resource:
          - '*'
    RouteTableIds:
    - !Ref PublicRouteTable
    - !Ref PrivateRouteTable
    - !If [DoAz2, !Ref PrivateRouteTable2, !Ref "AWS::NoValue"]
```



```

- !If [DoAz3, !Ref PrivateRouteTable3, !Ref "AWS::NoValue"]
ServiceName: !Join
- "
- - com.amazonaws.
- !Ref 'AWS::Region'
- .s3
VpcId: !Ref VPC

Outputs:
VpcId:
Description: ID of the new VPC.
Value: !Ref VPC
PublicSubnetIds:
Description: Subnet IDs of the public subnets.
Value:
!Join [
  ",",
  [!Ref PublicSubnet, !If [DoAz2, !Ref PublicSubnet2, !Ref "AWS::NoValue"], !If [DoAz3, !Ref
PublicSubnet3, !Ref "AWS::NoValue"]]
]
PrivateSubnetIds:
Description: Subnet IDs of the private subnets.
Value:
!Join [
  ",",
  [!Ref PrivateSubnet, !If [DoAz2, !Ref PrivateSubnet2, !Ref "AWS::NoValue"], !If [DoAz3, !Ref
PrivateSubnet3, !Ref "AWS::NoValue"]]
]

```

### Additional resources

- You can view details about the CloudFormation stacks that you create by navigating to the [AWS CloudFormation console](#).

### 4.12.11. Creating networking and load balancing components in AWS

You must configure networking and classic or network load balancing in Amazon Web Services (AWS) that your OpenShift Container Platform cluster can use.

You can use the provided CloudFormation template and a custom parameter file to create a stack of AWS resources. The stack represents the networking and load balancing components that your OpenShift Container Platform cluster requires. The template also creates a hosted zone and subnet tags.

You can run the template multiple times within a single Virtual Private Cloud (VPC).



#### NOTE

If you do not use the provided CloudFormation template to create your AWS infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

## Prerequisites

- You configured an AWS account.
- You added your AWS keys and region to your local AWS profile by running **aws configure**.
- You generated the Ignition config files for your cluster.
- You created and configured a VPC and associated subnets in AWS.

## Procedure

1. Obtain the hosted zone ID for the Route 53 base domain that you specified in the **install-config.yaml** file for your cluster. You can obtain details about your hosted zone by running the following command:

```
$ aws route53 list-hosted-zones-by-name --dns-name <route53_domain> 1
```

- 1 For the **<route53\_domain>**, specify the Route 53 base domain that you used when you generated the **install-config.yaml** file for the cluster.

## Example output

```
mycluster.example.com. False 100
HOSTEDZONES 65F8F38E-2268-B835-E15C-AB55336FCBFA
/hostedzone/Z21IXYZABCZ2A4 mycluster.example.com. 10
```

In the example output, the hosted zone ID is **Z21IXYZABCZ2A4**.

2. Create a JSON file that contains the parameter values that the template requires:

```
[
  {
    "ParameterKey": "ClusterName", 1
    "ParameterValue": "mycluster" 2
  },
  {
    "ParameterKey": "InfrastructureName", 3
    "ParameterValue": "mycluster-<random_string>" 4
  },
  {
    "ParameterKey": "HostedZoneId", 5
    "ParameterValue": "<random_string>" 6
  },
  {
    "ParameterKey": "HostedZoneName", 7
    "ParameterValue": "example.com" 8
  },
  {
    "ParameterKey": "PublicSubnets", 9
    "ParameterValue": "subnet-<random_string>" 10
  },
  {
```

```

    "ParameterKey": "PrivateSubnets", 11
    "ParameterValue": "subnet-<random_string>" 12
  },
  {
    "ParameterKey": "VpcId", 13
    "ParameterValue": "vpc-<random_string>" 14
  }
]

```

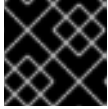
- 1** A short, representative cluster name to use for hostnames, etc.
  - 2** Specify the cluster name that you used when you generated the **install-config.yaml** file for the cluster.
  - 3** The name for your cluster infrastructure that is encoded in your Ignition config files for the cluster.
  - 4** Specify the infrastructure name that you extracted from the Ignition config file metadata, which has the format **<cluster-name>-<random-string>**.
  - 5** The Route 53 public zone ID to register the targets with.
  - 6** Specify the Route 53 public zone ID, which as a format similar to **Z21IXYZABCZ2A4**. You can obtain this value from the AWS console.
  - 7** The Route 53 zone to register the targets with.
  - 8** Specify the Route 53 base domain that you used when you generated the **install-config.yaml** file for the cluster. Do not include the trailing period (.) that is displayed in the AWS console.
  - 9** The public subnets that you created for your VPC.
  - 10** Specify the **PublicSubnetIds** value from the output of the CloudFormation template for the VPC.
  - 11** The private subnets that you created for your VPC.
  - 12** Specify the **PrivateSubnetIds** value from the output of the CloudFormation template for the VPC.
  - 13** The VPC that you created for the cluster.
  - 14** Specify the **VpcId** value from the output of the CloudFormation template for the VPC.
3. Copy the template from the **CloudFormation template for the network and load balancers** section of this topic and save it as a YAML file on your computer. This template describes the networking and load balancing objects that your cluster requires.



### IMPORTANT

If you are deploying your cluster to an AWS government or secret region, you must update the **InternalApiServerRecord** in the CloudFormation template to use **CNAME** records. Records of type **ALIAS** are not supported for AWS government regions.

- Launch the CloudFormation template to create a stack of AWS resources that provide the networking and load balancing components:



### IMPORTANT

You must enter the command on a single line.

```
$ aws cloudformation create-stack --stack-name <name> 1
  --template-body file://<template>.yaml 2
  --parameters file://<parameters>.json 3
  --capabilities CAPABILITY_NAMED_IAM 4
```

- 1** **<name>** is the name for the CloudFormation stack, such as **cluster-dns**. You need the name of this stack if you remove the cluster.
- 2** **<template>** is the relative path to and name of the CloudFormation template YAML file that you saved.
- 3** **<parameters>** is the relative path to and name of the CloudFormation parameters JSON file.
- 4** You must explicitly declare the **CAPABILITY\_NAMED\_IAM** capability because the provided template creates some **AWS::IAM::Role** resources.

### Example output

```
arn:aws:cloudformation:us-east-1:269333783861:stack/cluster-dns/cd3e5de0-2fd4-11eb-5cf0-12be5c33a183
```

- Confirm that the template components exist:

```
$ aws cloudformation describe-stacks --stack-name <name>
```

After the **StackStatus** displays **CREATE\_COMPLETE**, the output displays values for the following parameters. You must provide these parameter values to the other CloudFormation templates that you run to create your cluster:

<b>PrivateHostedZoneId</b>	Hosted zone ID for the private DNS.
<b>ExternalApiLoadBalancerName</b>	Full name of the external API load balancer.
<b>InternalApiLoadBalancerName</b>	Full name of the internal API load balancer.

<b>ApiServer DnsName</b>	Full hostname of the API server.
<b>RegisterN IbIpTarget sLambda</b>	Lambda ARN useful to help register/deregister IP targets for these load balancers.
<b>ExternalA piTargetG roupArn</b>	ARN of external API target group.
<b>InternalAp iTargetGr oupArn</b>	ARN of internal API target group.
<b>InternalSe rviceTarg etGroupA rn</b>	ARN of internal service target group.

#### 4.12.11.1. CloudFormation template for the network and load balancers

You can use the following CloudFormation template to deploy the networking objects and load balancers that you need for your OpenShift Container Platform cluster.

##### Example 4.37. CloudFormation template for the network and load balancers

```

AWSTemplateFormatVersion: 2010-09-09
Description: Template for OpenShift Cluster Network Elements (Route53 & LBs)

Parameters:
  ClusterName:
    AllowedPattern: ^([a-zA-Z][a-zA-Z0-9\-\-]{0,26})$
    MaxLength: 27
    MinLength: 1
    ConstraintDescription: Cluster name must be alphanumeric, start with a letter, and have a
    maximum of 27 characters.
    Description: A short, representative cluster name to use for host names and other identifying
    names.
    Type: String
  InfrastructureName:
    AllowedPattern: ^([a-zA-Z][a-zA-Z0-9\-\-]{0,26})$
    MaxLength: 27
    MinLength: 1
    ConstraintDescription: Infrastructure name must be alphanumeric, start with a letter, and have a
    maximum of 27 characters.
    Description: A short, unique cluster ID used to tag cloud resources and identify items owned or
    used by the cluster.
    Type: String
  HostedZoneId:
    Description: The Route53 public zone ID to register the targets with, such as

```

Z21XYZABCZ2A4.

Type: String

HostedZoneName:

Description: The Route53 zone to register the targets with, such as example.com. Omit the trailing period.

Type: String

Default: "example.com"

PublicSubnets:

Description: The internet-facing subnets.

Type: List<AWS::EC2::Subnet::Id>

PrivateSubnets:

Description: The internal subnets.

Type: List<AWS::EC2::Subnet::Id>

VpcId:

Description: The VPC-scoped resources will belong to this VPC.

Type: AWS::EC2::VPC::Id

Metadata:

AWS::CloudFormation::Interface:

ParameterGroups:

- Label:

default: "Cluster Information"

Parameters:

- ClusterName

- InfrastructureName

- Label:

default: "Network Configuration"

Parameters:

- VpcId

- PublicSubnets

- PrivateSubnets

- Label:

default: "DNS"

Parameters:

- HostedZoneName

- HostedZoneId

ParameterLabels:

ClusterName:

default: "Cluster Name"

InfrastructureName:

default: "Infrastructure Name"

VpcId:

default: "VPC ID"

PublicSubnets:

default: "Public Subnets"

PrivateSubnets:

default: "Private Subnets"

HostedZoneName:

default: "Public Hosted Zone Name"

HostedZoneId:

default: "Public Hosted Zone ID"

Resources:

ExtApiElb:

Type: AWS::ElasticLoadBalancingV2::LoadBalancer

Properties:

```
Name: !Join ["-", [!Ref InfrastructureName, "ext"]]
IpAddressType: ipv4
Subnets: !Ref PublicSubnets
Type: network
```

#### IntApiElb:

```
Type: AWS::ElasticLoadBalancingV2::LoadBalancer
Properties:
  Name: !Join ["-", [!Ref InfrastructureName, "int"]]
  Scheme: internal
  IpAddressType: ipv4
  Subnets: !Ref PrivateSubnets
  Type: network
```

#### IntDns:

```
Type: "AWS::Route53::HostedZone"
Properties:
  HostedZoneConfig:
    Comment: "Managed by CloudFormation"
  Name: !Join [".", [!Ref ClusterName, !Ref HostedZoneName]]
  HostedZoneTags:
    - Key: Name
      Value: !Join ["-", [!Ref InfrastructureName, "int"]]
    - Key: !Join [ "", ["kubernetes.io/cluster/", !Ref InfrastructureName] ]
      Value: "owned"
  VPCs:
    - VPCId: !Ref Vpclid
      VPCRegion: !Ref "AWS::Region"
```

#### ExternalApiServerRecord:

```
Type: AWS::Route53::RecordSetGroup
Properties:
  Comment: Alias record for the API server
  HostedZoneId: !Ref HostedZoneId
  RecordSets:
    - Name:
        !Join [
          ".",
          ["api", !Ref ClusterName, !Join [ "", [!Ref HostedZoneName, "."] ]],
        ]
      Type: A
      AliasTarget:
        HostedZoneId: !GetAtt ExtApiElb.CanonicalHostedZoneID
        DNSName: !GetAtt ExtApiElb.DNSName
```

#### InternalApiServerRecord:

```
Type: AWS::Route53::RecordSetGroup
Properties:
  Comment: Alias record for the API server
  HostedZoneId: !Ref IntDns
  RecordSets:
    - Name:
        !Join [
          ".",
          ["api", !Ref ClusterName, !Join [ "", [!Ref HostedZoneName, "."] ]],
        ]
```

```
Type: A
AliasTarget:
  HostedZoneId: !GetAtt IntApiElb.CanonicalHostedZoneID
  DNSName: !GetAtt IntApiElb.DNSName
- Name:
  !Join [
    ".",
    ["api-int", !Ref ClusterName, !Join ["", [!Ref HostedZoneName, "."]]],
  ]
Type: A
AliasTarget:
  HostedZoneId: !GetAtt IntApiElb.CanonicalHostedZoneID
  DNSName: !GetAtt IntApiElb.DNSName
```

```
ExternalApiListener:
Type: AWS::ElasticLoadBalancingV2::Listener
Properties:
DefaultActions:
- Type: forward
  TargetGroupArn:
    Ref: ExternalApiTargetGroup
LoadBalancerArn:
  Ref: ExtApiElb
Port: 6443
Protocol: TCP
```

```
ExternalApiTargetGroup:
Type: AWS::ElasticLoadBalancingV2::TargetGroup
Properties:
HealthCheckIntervalSeconds: 10
HealthCheckPath: "/readyz"
HealthCheckPort: 6443
HealthCheckProtocol: HTTPS
HealthyThresholdCount: 2
UnhealthyThresholdCount: 2
Port: 6443
Protocol: TCP
TargetType: ip
VpId:
  Ref: VpId
TargetGroupAttributes:
- Key: deregistration_delay.timeout_seconds
  Value: 60
```

```
InternalApiListener:
Type: AWS::ElasticLoadBalancingV2::Listener
Properties:
DefaultActions:
- Type: forward
  TargetGroupArn:
    Ref: InternalApiTargetGroup
LoadBalancerArn:
  Ref: IntApiElb
Port: 6443
Protocol: TCP
```



**InternalApiTargetGroup:**

Type: AWS::ElasticLoadBalancingV2::TargetGroup

## Properties:

HealthCheckIntervalSeconds: 10

HealthCheckPath: `"/readyz"`

HealthCheckPort: 6443

HealthCheckProtocol: HTTPS

HealthyThresholdCount: 2

UnhealthyThresholdCount: 2

Port: 6443

Protocol: TCP

TargetType: ip

## VpcId:

Ref: VpcId

## TargetGroupAttributes:

- Key: deregistration\_delay.timeout\_seconds

Value: 60

**InternalServiceInternalListener:**

Type: AWS::ElasticLoadBalancingV2::Listener

## Properties:

## DefaultActions:

- Type: forward

TargetGroupArn:

Ref: InternalServiceTargetGroup

## LoadBalancerArn:

Ref: IntApiElb

Port: 22623

Protocol: TCP

**InternalServiceTargetGroup:**

Type: AWS::ElasticLoadBalancingV2::TargetGroup

## Properties:

HealthCheckIntervalSeconds: 10

HealthCheckPath: `"/healthz"`

HealthCheckPort: 22623

HealthCheckProtocol: HTTPS

HealthyThresholdCount: 2

UnhealthyThresholdCount: 2

Port: 22623

Protocol: TCP

TargetType: ip

## VpcId:

Ref: VpcId

## TargetGroupAttributes:

- Key: deregistration\_delay.timeout\_seconds

Value: 60

**RegisterTargetLambdalaRole:**

Type: AWS::IAM::Role

## Properties:

RoleName: !Join ["-", [!Ref InfrastructureName, "nlb", "lambda", "role"]]

## AssumeRolePolicyDocument:

Version: "2012-10-17"

## Statement:

- Effect: "Allow"

```

Principal:
  Service:
    - "lambda.amazonaws.com"
  Action:
    - "sts:AssumeRole"
Path: "/"
Policies:
- PolicyName: !Join ["-", [!Ref InfrastructureName, "master", "policy"]]
  PolicyDocument:
    Version: "2012-10-17"
    Statement:
    - Effect: "Allow"
      Action:
        [
          "elasticloadbalancing:RegisterTargets",
          "elasticloadbalancing:DeregisterTargets",
        ]
      Resource: !Ref InternalApiTargetGroup
    - Effect: "Allow"
      Action:
        [
          "elasticloadbalancing:RegisterTargets",
          "elasticloadbalancing:DeregisterTargets",
        ]
      Resource: !Ref InternalServiceTargetGroup
    - Effect: "Allow"
      Action:
        [
          "elasticloadbalancing:RegisterTargets",
          "elasticloadbalancing:DeregisterTargets",
        ]
      Resource: !Ref ExternalApiTargetGroup

RegisterNlbTargets:
  Type: "AWS::Lambda::Function"
  Properties:
    Handler: "index.handler"
    Role:
      Fn::GetAtt:
        - "RegisterTargetLambdRole"
        - "Arn"
  Code:
    ZipFile: |
      import json
      import boto3
      import cfnresponse
      def handler(event, context):
        elb = boto3.client('elbv2')
        if event['RequestType'] == 'Delete':
          elb.deregister_targets(TargetGroupArn=event['ResourceProperties']
[TargetArn],Targets=[{'Id': event['ResourceProperties']['TargetIp']})
          elif event['RequestType'] == 'Create':
            elb.register_targets(TargetGroupArn=event['ResourceProperties']['TargetArn'],Targets=
[{'Id': event['ResourceProperties']['TargetIp']})
            responseData = {}
            cfnresponse.send(event, context, cfnresponse.SUCCESS, responseData,

```

```
event['ResourceProperties']['TargetArn']+event['ResourceProperties']['TargetIp'])
```

```
Runtime: "python3.7"
```

```
Timeout: 120
```

```
RegisterSubnetTagsLambdalamRole:
```

```
Type: AWS::IAM::Role
```

```
Properties:
```

```
RoleName: !Join ["-", [!Ref InfrastructureName, "subnet-tags-lambda-role"]]
```

```
AssumeRolePolicyDocument:
```

```
Version: "2012-10-17"
```

```
Statement:
```

```
- Effect: "Allow"
```

```
Principal:
```

```
Service:
```

```
- "lambda.amazonaws.com"
```

```
Action:
```

```
- "sts:AssumeRole"
```

```
Path: "/"
```

```
Policies:
```

```
- PolicyName: !Join ["-", [!Ref InfrastructureName, "subnet-tagging-policy"]]
```

```
PolicyDocument:
```

```
Version: "2012-10-17"
```

```
Statement:
```

```
- Effect: "Allow"
```

```
Action:
```

```
[
  "ec2:DeleteTags",
  "ec2:CreateTags"
]
```

```
Resource: "arn:aws:ec2:*:*:subnet/*"
```

```
- Effect: "Allow"
```

```
Action:
```

```
[
  "ec2:DescribeSubnets",
  "ec2:DescribeTags"
]
```

```
Resource: ""
```

```
RegisterSubnetTags:
```

```
Type: "AWS::Lambda::Function"
```

```
Properties:
```

```
Handler: "index.handler"
```

```
Role:
```

```
Fn::GetAtt:
```

```
- "RegisterSubnetTagsLambdalamRole"
```

```
- "Arn"
```

```
Code:
```

```
ZipFile: |
```

```
import json
```

```
import boto3
```

```
import cfnresponse
```

```
def handler(event, context):
```

```
    ec2_client = boto3.client('ec2')
```

```
    if event['RequestType'] == 'Delete':
```

```
        for subnet_id in event['ResourceProperties']['Subnets']:
```

```
            ec2_client.delete_tags(Resources=[subnet_id], Tags=[{'Key': 'kubernetes.io/cluster/' +
```

```

event['ResourceProperties']['InfrastructureName']);
  elif event['RequestType'] == 'Create':
    for subnet_id in event['ResourceProperties']['Subnets']:
      ec2_client.create_tags(Resources=[subnet_id], Tags=[{'Key': 'kubernetes.io/cluster/' +
event['ResourceProperties']['InfrastructureName'], 'Value': 'shared'}]);
    responseData = {}
    cfnresponse.send(event, context, cfnresponse.SUCCESS, responseData,
event['ResourceProperties']['InfrastructureName']+event['ResourceProperties']['Subnets'][0])
  Runtime: "python3.7"
  Timeout: 120

```

#### RegisterPublicSubnetTags:

Type: Custom::SubnetRegister

##### Properties:

ServiceToken: !GetAtt RegisterSubnetTags.Arn

InfrastructureName: !Ref InfrastructureName

Subnets: !Ref PublicSubnets

#### RegisterPrivateSubnetTags:

Type: Custom::SubnetRegister

##### Properties:

ServiceToken: !GetAtt RegisterSubnetTags.Arn

InfrastructureName: !Ref InfrastructureName

Subnets: !Ref PrivateSubnets

#### Outputs:

##### PrivateHostedZoneId:

Description: Hosted zone ID for the private DNS, which is required for private records.

Value: !Ref IntDns

##### ExternalApiLoadBalancerName:

Description: Full name of the external API load balancer.

Value: !GetAtt ExtApiElb.LoadBalancerFullName

##### InternalApiLoadBalancerName:

Description: Full name of the internal API load balancer.

Value: !GetAtt IntApiElb.LoadBalancerFullName

##### ApiServerDnsName:

Description: Full hostname of the API server, which is required for the Ignition config files.

Value: !Join [".", ["api-int", !Ref ClusterName, !Ref HostedZoneName]]

##### RegisterNlbIpTargetsLambda:

Description: Lambda ARN useful to help register or deregister IP targets for these load balancers.

Value: !GetAtt RegisterNlbIpTargets.Arn

##### ExternalApiTargetGroupArn:

Description: ARN of the external API target group.

Value: !Ref ExternalApiTargetGroup

##### InternalApiTargetGroupArn:

Description: ARN of the internal API target group.

Value: !Ref InternalApiTargetGroup

##### InternalServiceTargetGroupArn:

Description: ARN of the internal service target group.

Value: !Ref InternalServiceTargetGroup



## IMPORTANT

If you are deploying your cluster to an AWS government or secret region, you must update the **InternalApiServerRecord** to use **CNAME** records. Records of type **ALIAS** are not supported for AWS government regions. For example:

```
Type: CNAME
TTL: 10
ResourceRecords:
- !GetAtt IntApiElb.DNSName
```

### Additional resources

- You can view details about the CloudFormation stacks that you create by navigating to the [AWS CloudFormation console](#).
- You can view details about your hosted zones by navigating to the [AWS Route 53 console](#).
- See [Listing public hosted zones](#) in the AWS documentation for more information about listing public hosted zones.

## 4.12.12. Creating security group and roles in AWS

You must create security groups and roles in Amazon Web Services (AWS) for your OpenShift Container Platform cluster to use.

You can use the provided CloudFormation template and a custom parameter file to create a stack of AWS resources. The stack represents the security groups and roles that your OpenShift Container Platform cluster requires.



## NOTE

If you do not use the provided CloudFormation template to create your AWS infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

### Prerequisites

- You configured an AWS account.
- You added your AWS keys and region to your local AWS profile by running **aws configure**.
- You generated the Ignition config files for your cluster.
- You created and configured a VPC and associated subnets in AWS.

### Procedure

1. Create a JSON file that contains the parameter values that the template requires:

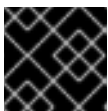
```
[
{
  "ParameterKey": "InfrastructureName", 1
```

```

    "ParameterValue": "mycluster-<random_string>" ❷
  },
  {
    "ParameterKey": "VpcCidr", ❸
    "ParameterValue": "10.0.0.0/16" ❹
  },
  {
    "ParameterKey": "PrivateSubnets", ❺
    "ParameterValue": "subnet-<random_string>" ❻
  },
  {
    "ParameterKey": "VpcId", ❼
    "ParameterValue": "vpc-<random_string>" ❽
  }
]

```

- ❶ The name for your cluster infrastructure that is encoded in your Ignition config files for the cluster.
  - ❷ Specify the infrastructure name that you extracted from the Ignition config file metadata, which has the format **<cluster-name>-<random-string>**.
  - ❸ The CIDR block for the VPC.
  - ❹ Specify the CIDR block parameter that you used for the VPC that you defined in the form **x.x.x.x/16-24**.
  - ❺ The private subnets that you created for your VPC.
  - ❻ Specify the **PrivateSubnetIds** value from the output of the CloudFormation template for the VPC.
  - ❼ The VPC that you created for the cluster.
  - ❽ Specify the **VpcId** value from the output of the CloudFormation template for the VPC.
2. Copy the template from the **CloudFormation template for security objects** section of this topic and save it as a YAML file on your computer. This template describes the security groups and roles that your cluster requires.
  3. Launch the CloudFormation template to create a stack of AWS resources that represent the security groups and roles:



### IMPORTANT

You must enter the command on a single line.

```

$ aws cloudformation create-stack --stack-name <name> ❶
  --template-body file://<template>.yaml ❷
  --parameters file://<parameters>.json ❸
  --capabilities CAPABILITY_NAMED_IAM ❹

```

- 1 **<name>** is the name for the CloudFormation stack, such as **cluster-sec**. You need the name of this stack if you remove the cluster.
- 2 **<template>** is the relative path to and name of the CloudFormation template YAML file that you saved.
- 3 **<parameters>** is the relative path to and name of the CloudFormation parameters JSON file.
- 4 You must explicitly declare the **CAPABILITY\_NAMED\_IAM** capability because the provided template creates some **AWS::IAM::Role** and **AWS::IAM::InstanceProfile** resources.

### Example output

```
arn:aws:cloudformation:us-east-1:269333783861:stack/cluster-sec/03bd4210-2ed7-11eb-6d7a-13fc0b61e9db
```

4. Confirm that the template components exist:

```
$ aws cloudformation describe-stacks --stack-name <name>
```

After the **StackStatus** displays **CREATE\_COMPLETE**, the output displays values for the following parameters. You must provide these parameter values to the other CloudFormation templates that you run to create your cluster:

<b>MasterSecurityGroupID</b>	Master Security Group ID
<b>WorkerSecurityGroupID</b>	Worker Security Group ID
<b>MasterInstanceProfile</b>	Master IAM Instance Profile
<b>WorkerInstanceProfile</b>	Worker IAM Instance Profile

#### 4.12.12.1. CloudFormation template for security objects

You can use the following CloudFormation template to deploy the security objects that you need for your OpenShift Container Platform cluster.

##### Example 4.38. CloudFormation template for security objects

```
AWSTemplateFormatVersion: 2010-09-09
Description: Template for OpenShift Cluster Security Elements (Security Groups & IAM)
```

## Parameters:

## InfrastructureName:

AllowedPattern: `^([a-zA-Z][a-zA-Z0-9\-\_]{0,26})$`

MaxLength: `27`

MinLength: `1`

ConstraintDescription: Infrastructure name must be alphanumeric, start with a letter, and have a maximum of `27` characters.

Description: A short, unique cluster ID used to tag cloud resources and identify items owned or used by the cluster.

Type: String

## VpcCidr:

AllowedPattern: `^(((0-9){1-9}|0-9)|1[0-9]{2}|2[0-4][0-9]|25[0-5])\.\.){3}((0-9){1-9}|1[0-9]{2}|2[0-4][0-9]|25[0-5])\.(1[6-9]|2[0-4])$`

ConstraintDescription: CIDR block parameter must be in the form `x.x.x.x/16-24`.

Default: `10.0.0.0/16`

Description: CIDR block for VPC.

Type: String

## VpcId:

Description: The VPC-scoped resources will belong to this VPC.

Type: `AWS::EC2::VPC::Id`

## PrivateSubnets:

Description: The internal subnets.

Type: `List<AWS::EC2::Subnet::Id>`

## Metadata:

## AWS::CloudFormation::Interface:

## ParameterGroups:

## - Label:

default: `"Cluster Information"`

## Parameters:

- InfrastructureName

## - Label:

default: `"Network Configuration"`

## Parameters:

- VpcId

- VpcCidr

- PrivateSubnets

## ParameterLabels:

## InfrastructureName:

default: `"Infrastructure Name"`

## VpcId:

default: `"VPC ID"`

## VpcCidr:

default: `"VPC CIDR"`

## PrivateSubnets:

default: `"Private Subnets"`

## Resources:

## MasterSecurityGroup:

Type: `AWS::EC2::SecurityGroup`

## Properties:

GroupDescription: Cluster Master Security Group

## SecurityGroupIngress:

- IpProtocol: `icmp`

FromPort: `0`



ToPort: 0  
 CidrIp: !Ref VpcCidr  
 - IpProtocol: tcp  
 FromPort: 22  
 ToPort: 22  
 CidrIp: !Ref VpcCidr  
 - IpProtocol: tcp  
 ToPort: 6443  
 FromPort: 6443  
 CidrIp: !Ref VpcCidr  
 - IpProtocol: tcp  
 FromPort: 22623  
 ToPort: 22623  
 CidrIp: !Ref VpcCidr  
 VpcId: !Ref VpcId

#### WorkerSecurityGroup:

Type: AWS::EC2::SecurityGroup  
 Properties:  
 GroupDescription: Cluster Worker Security Group  
 SecurityGroupIngress:  
 - IpProtocol: icmp  
 FromPort: 0  
 ToPort: 0  
 CidrIp: !Ref VpcCidr  
 - IpProtocol: tcp  
 FromPort: 22  
 ToPort: 22  
 CidrIp: !Ref VpcCidr  
 VpcId: !Ref VpcId

#### MasterIngressEtcd:

Type: AWS::EC2::SecurityGroupIngress  
 Properties:  
 GroupId: !GetAtt MasterSecurityGroup.GroupId  
 SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId  
 Description: etcd  
 FromPort: 2379  
 ToPort: 2380  
 IpProtocol: tcp

#### MasterIngressVxlan:

Type: AWS::EC2::SecurityGroupIngress  
 Properties:  
 GroupId: !GetAtt MasterSecurityGroup.GroupId  
 SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId  
 Description: Vxlan packets  
 FromPort: 4789  
 ToPort: 4789  
 IpProtocol: udp

#### MasterIngressWorkerVxlan:

Type: AWS::EC2::SecurityGroupIngress  
 Properties:  
 GroupId: !GetAtt MasterSecurityGroup.GroupId  
 SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId

Description: Vxlan packets  
FromPort: 4789  
ToPort: 4789  
IpProtocol: udp

MasterIngressGeneve:

Type: AWS::EC2::SecurityGroupIngress  
Properties:  
GroupId: !GetAtt MasterSecurityGroup.GroupId  
SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId  
Description: Geneve packets  
FromPort: 6081  
ToPort: 6081  
IpProtocol: udp

MasterIngressWorkerGeneve:

Type: AWS::EC2::SecurityGroupIngress  
Properties:  
GroupId: !GetAtt MasterSecurityGroup.GroupId  
SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId  
Description: Geneve packets  
FromPort: 6081  
ToPort: 6081  
IpProtocol: udp

MasterIngressIpsecIke:

Type: AWS::EC2::SecurityGroupIngress  
Properties:  
GroupId: !GetAtt MasterSecurityGroup.GroupId  
SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId  
Description: IPsec IKE packets  
FromPort: 500  
ToPort: 500  
IpProtocol: udp

MasterIngressIpsecNat:

Type: AWS::EC2::SecurityGroupIngress  
Properties:  
GroupId: !GetAtt MasterSecurityGroup.GroupId  
SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId  
Description: IPsec NAT-T packets  
FromPort: 4500  
ToPort: 4500  
IpProtocol: udp

MasterIngressIpsecEsp:

Type: AWS::EC2::SecurityGroupIngress  
Properties:  
GroupId: !GetAtt MasterSecurityGroup.GroupId  
SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId  
Description: IPsec ESP packets  
IpProtocol: 50

MasterIngressWorkerIpsecIke:

Type: AWS::EC2::SecurityGroupIngress  
Properties:

GroupId: !GetAtt MasterSecurityGroup.GroupId  
SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId  
Description: IPsec IKE packets  
FromPort: 500  
ToPort: 500  
IpProtocol: udp

MasterIngressWorkerIpsecNat:  
Type: AWS::EC2::SecurityGroupIngress  
Properties:  
GroupId: !GetAtt MasterSecurityGroup.GroupId  
SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId  
Description: IPsec NAT-T packets  
FromPort: 4500  
ToPort: 4500  
IpProtocol: udp

MasterIngressWorkerIpsecEsp:  
Type: AWS::EC2::SecurityGroupIngress  
Properties:  
GroupId: !GetAtt MasterSecurityGroup.GroupId  
SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId  
Description: IPsec ESP packets  
IpProtocol: 50

MasterIngressInternal:  
Type: AWS::EC2::SecurityGroupIngress  
Properties:  
GroupId: !GetAtt MasterSecurityGroup.GroupId  
SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId  
Description: Internal cluster communication  
FromPort: 9000  
ToPort: 9999  
IpProtocol: tcp

MasterIngressWorkerInternal:  
Type: AWS::EC2::SecurityGroupIngress  
Properties:  
GroupId: !GetAtt MasterSecurityGroup.GroupId  
SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId  
Description: Internal cluster communication  
FromPort: 9000  
ToPort: 9999  
IpProtocol: tcp

MasterIngressInternalUDP:  
Type: AWS::EC2::SecurityGroupIngress  
Properties:  
GroupId: !GetAtt MasterSecurityGroup.GroupId  
SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId  
Description: Internal cluster communication  
FromPort: 9000  
ToPort: 9999  
IpProtocol: udp

MasterIngressWorkerInternalUDP:

Type: AWS::EC2::SecurityGroupIngress

Properties:

GroupId: !GetAtt MasterSecurityGroup.GroupId

SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId

Description: Internal cluster communication

FromPort: 9000

ToPort: 9999

IpProtocol: udp

MasterIngressKube:

Type: AWS::EC2::SecurityGroupIngress

Properties:

GroupId: !GetAtt MasterSecurityGroup.GroupId

SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId

Description: Kubernetes kubelet, scheduler and controller manager

FromPort: 10250

ToPort: 10259

IpProtocol: tcp

MasterIngressWorkerKube:

Type: AWS::EC2::SecurityGroupIngress

Properties:

GroupId: !GetAtt MasterSecurityGroup.GroupId

SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId

Description: Kubernetes kubelet, scheduler and controller manager

FromPort: 10250

ToPort: 10259

IpProtocol: tcp

MasterIngressIngressServices:

Type: AWS::EC2::SecurityGroupIngress

Properties:

GroupId: !GetAtt MasterSecurityGroup.GroupId

SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId

Description: Kubernetes ingress services

FromPort: 30000

ToPort: 32767

IpProtocol: tcp

MasterIngressWorkerIngressServices:

Type: AWS::EC2::SecurityGroupIngress

Properties:

GroupId: !GetAtt MasterSecurityGroup.GroupId

SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId

Description: Kubernetes ingress services

FromPort: 30000

ToPort: 32767

IpProtocol: tcp

MasterIngressIngressServicesUDP:

Type: AWS::EC2::SecurityGroupIngress

Properties:

GroupId: !GetAtt MasterSecurityGroup.GroupId

SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId

Description: Kubernetes ingress services

FromPort: 30000

ToPort: 32767  
IpProtocol: udp

MasterIngressWorkerIngressServicesUDP:

Type: AWS::EC2::SecurityGroupIngress  
Properties:  
  GroupId: !GetAtt MasterSecurityGroup.GroupId  
  SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId  
  Description: Kubernetes ingress services  
  FromPort: 30000  
  ToPort: 32767  
  IpProtocol: udp

WorkerIngressVxlan:

Type: AWS::EC2::SecurityGroupIngress  
Properties:  
  GroupId: !GetAtt WorkerSecurityGroup.GroupId  
  SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId  
  Description: Vxlan packets  
  FromPort: 4789  
  ToPort: 4789  
  IpProtocol: udp

WorkerIngressMasterVxlan:

Type: AWS::EC2::SecurityGroupIngress  
Properties:  
  GroupId: !GetAtt WorkerSecurityGroup.GroupId  
  SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId  
  Description: Vxlan packets  
  FromPort: 4789  
  ToPort: 4789  
  IpProtocol: udp

WorkerIngressGeneve:

Type: AWS::EC2::SecurityGroupIngress  
Properties:  
  GroupId: !GetAtt WorkerSecurityGroup.GroupId  
  SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId  
  Description: Geneve packets  
  FromPort: 6081  
  ToPort: 6081  
  IpProtocol: udp

WorkerIngressMasterGeneve:

Type: AWS::EC2::SecurityGroupIngress  
Properties:  
  GroupId: !GetAtt WorkerSecurityGroup.GroupId  
  SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId  
  Description: Geneve packets  
  FromPort: 6081  
  ToPort: 6081  
  IpProtocol: udp

WorkerIngressIpsecIke:

Type: AWS::EC2::SecurityGroupIngress  
Properties:

GroupId: !GetAtt WorkerSecurityGroup.GroupId  
SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId  
Description: IPsec IKE packets  
FromPort: 500  
ToPort: 500  
IpProtocol: udp

WorkerIngressIpsecNat:

Type: AWS::EC2::SecurityGroupIngress  
Properties:  
GroupId: !GetAtt WorkerSecurityGroup.GroupId  
SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId  
Description: IPsec NAT-T packets  
FromPort: 4500  
ToPort: 4500  
IpProtocol: udp

WorkerIngressIpsecEsp:

Type: AWS::EC2::SecurityGroupIngress  
Properties:  
GroupId: !GetAtt WorkerSecurityGroup.GroupId  
SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId  
Description: IPsec ESP packets  
IpProtocol: 50

WorkerIngressMasterIpsecIke:

Type: AWS::EC2::SecurityGroupIngress  
Properties:  
GroupId: !GetAtt WorkerSecurityGroup.GroupId  
SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId  
Description: IPsec IKE packets  
FromPort: 500  
ToPort: 500  
IpProtocol: udp

WorkerIngressMasterIpsecNat:

Type: AWS::EC2::SecurityGroupIngress  
Properties:  
GroupId: !GetAtt WorkerSecurityGroup.GroupId  
SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId  
Description: IPsec NAT-T packets  
FromPort: 4500  
ToPort: 4500  
IpProtocol: udp

WorkerIngressMasterIpsecEsp:

Type: AWS::EC2::SecurityGroupIngress  
Properties:  
GroupId: !GetAtt WorkerSecurityGroup.GroupId  
SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId  
Description: IPsec ESP packets  
IpProtocol: 50

WorkerIngressInternal:

Type: AWS::EC2::SecurityGroupIngress  
Properties:

GroupId: !GetAtt WorkerSecurityGroup.GroupId  
SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId  
Description: Internal cluster communication  
FromPort: 9000  
ToPort: 9999  
IpProtocol: tcp

WorkerIngressMasterInternal:

Type: AWS::EC2::SecurityGroupIngress  
Properties:  
GroupId: !GetAtt WorkerSecurityGroup.GroupId  
SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId  
Description: Internal cluster communication  
FromPort: 9000  
ToPort: 9999  
IpProtocol: tcp

WorkerIngressInternalUDP:

Type: AWS::EC2::SecurityGroupIngress  
Properties:  
GroupId: !GetAtt WorkerSecurityGroup.GroupId  
SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId  
Description: Internal cluster communication  
FromPort: 9000  
ToPort: 9999  
IpProtocol: udp

WorkerIngressMasterInternalUDP:

Type: AWS::EC2::SecurityGroupIngress  
Properties:  
GroupId: !GetAtt WorkerSecurityGroup.GroupId  
SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId  
Description: Internal cluster communication  
FromPort: 9000  
ToPort: 9999  
IpProtocol: udp

WorkerIngressKube:

Type: AWS::EC2::SecurityGroupIngress  
Properties:  
GroupId: !GetAtt WorkerSecurityGroup.GroupId  
SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId  
Description: Kubernetes secure kubelet port  
FromPort: 10250  
ToPort: 10250  
IpProtocol: tcp

WorkerIngressWorkerKube:

Type: AWS::EC2::SecurityGroupIngress  
Properties:  
GroupId: !GetAtt WorkerSecurityGroup.GroupId  
SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId  
Description: Internal Kubernetes communication  
FromPort: 10250  
ToPort: 10250  
IpProtocol: tcp

## WorkerIngressIngressServices:

Type: AWS::EC2::SecurityGroupIngress

## Properties:

GroupId: !GetAtt WorkerSecurityGroup.GroupId

SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId

Description: Kubernetes ingress services

FromPort: 30000

ToPort: 32767

IpProtocol: tcp

## WorkerIngressMasterIngressServices:

Type: AWS::EC2::SecurityGroupIngress

## Properties:

GroupId: !GetAtt WorkerSecurityGroup.GroupId

SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId

Description: Kubernetes ingress services

FromPort: 30000

ToPort: 32767

IpProtocol: tcp

## WorkerIngressIngressServicesUDP:

Type: AWS::EC2::SecurityGroupIngress

## Properties:

GroupId: !GetAtt WorkerSecurityGroup.GroupId

SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId

Description: Kubernetes ingress services

FromPort: 30000

ToPort: 32767

IpProtocol: udp

## WorkerIngressMasterIngressServicesUDP:

Type: AWS::EC2::SecurityGroupIngress

## Properties:

GroupId: !GetAtt WorkerSecurityGroup.GroupId

SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId

Description: Kubernetes ingress services

FromPort: 30000

ToPort: 32767

IpProtocol: udp

## MasterIamRole:

Type: AWS::IAM::Role

## Properties:

AssumeRolePolicyDocument:

Version: "2012-10-17"

Statement:

- Effect: "Allow"

Principal:

Service:

- "ec2.amazonaws.com"

Action:

- "sts:AssumeRole"

Policies:

- PolicyName: !Join ["-", [!Ref InfrastructureName, "master", "policy"]]

PolicyDocument:



Version: "2012-10-17"

Statement:

- Effect: "Allow"

Action:

- "ec2:AttachVolume"
- "ec2:AuthorizeSecurityGroupIngress"
- "ec2:CreateSecurityGroup"
- "ec2:CreateTags"
- "ec2:CreateVolume"
- "ec2>DeleteSecurityGroup"
- "ec2>DeleteVolume"
- "ec2:Describe\*"
- "ec2:DetachVolume"
- "ec2:ModifyInstanceAttribute"
- "ec2:ModifyVolume"
- "ec2:RevokeSecurityGroupIngress"
- "elasticloadbalancing:AddTags"
- "elasticloadbalancing:AttachLoadBalancerToSubnets"
- "elasticloadbalancing:ApplySecurityGroupsToLoadBalancer"
- "elasticloadbalancing:CreateListener"
- "elasticloadbalancing:CreateLoadBalancer"
- "elasticloadbalancing:CreateLoadBalancerPolicy"
- "elasticloadbalancing:CreateLoadBalancerListeners"
- "elasticloadbalancing:CreateTargetGroup"
- "elasticloadbalancing:ConfigureHealthCheck"
- "elasticloadbalancing>DeleteListener"
- "elasticloadbalancing>DeleteLoadBalancer"
- "elasticloadbalancing>DeleteLoadBalancerListeners"
- "elasticloadbalancing>DeleteTargetGroup"
- "elasticloadbalancing:DeregisterInstancesFromLoadBalancer"
- "elasticloadbalancing:DeregisterTargets"
- "elasticloadbalancing:Describe\*"
- "elasticloadbalancing:DetachLoadBalancerFromSubnets"
- "elasticloadbalancing:ModifyListener"
- "elasticloadbalancing:ModifyLoadBalancerAttributes"
- "elasticloadbalancing:ModifyTargetGroup"
- "elasticloadbalancing:ModifyTargetGroupAttributes"
- "elasticloadbalancing:RegisterInstancesWithLoadBalancer"
- "elasticloadbalancing:RegisterTargets"
- "elasticloadbalancing:SetLoadBalancerPoliciesForBackendServer"
- "elasticloadbalancing:SetLoadBalancerPoliciesOfListener"
- "kms:DescribeKey"

Resource: "\*"

MasterInstanceProfile:

Type: "AWS::IAM::InstanceProfile"

Properties:

Roles:

- Ref: "MasterIamRole"

WorkerIamRole:

Type: AWS::IAM::Role

Properties:

AssumeRolePolicyDocument:

Version: "2012-10-17"

Statement:

```

- Effect: "Allow"
  Principal:
    Service:
      - "ec2.amazonaws.com"
  Action:
    - "sts:AssumeRole"
Policies:
- PolicyName: !Join ["-", [!Ref InfrastructureName, "worker", "policy"]]
  PolicyDocument:
    Version: "2012-10-17"
    Statement:
      - Effect: "Allow"
        Action:
          - "ec2:DescribeInstances"
          - "ec2:DescribeRegions"
        Resource: "*"

```

```

WorkerInstanceProfile:
  Type: "AWS::IAM::InstanceProfile"
  Properties:
    Roles:
      - Ref: "WorkerIamRole"

```

```

Outputs:
MasterSecurityGroupId:
  Description: Master Security Group ID
  Value: !GetAtt MasterSecurityGroup.GroupId

```

```

WorkerSecurityGroupId:
  Description: Worker Security Group ID
  Value: !GetAtt WorkerSecurityGroup.GroupId

```

```

MasterInstanceProfile:
  Description: Master IAM Instance Profile
  Value: !Ref MasterInstanceProfile

```

```

WorkerInstanceProfile:
  Description: Worker IAM Instance Profile
  Value: !Ref WorkerInstanceProfile

```

### Additional resources

- You can view details about the CloudFormation stacks that you create by navigating to the [AWS CloudFormation console](#).

### 4.12.13. Accessing RHCOS AMIs with stream metadata

In OpenShift Container Platform, *stream metadata* provides standardized metadata about RHCOS in the JSON format and injects the metadata into the cluster. Stream metadata is a stable format that supports multiple architectures and is intended to be self-documenting for maintaining automation.

You can use the **coreos print-stream-json** sub-command of **openshift-install** to access information about the boot images in the stream metadata format. This command provides a method for printing stream metadata in a scriptable, machine-readable format.

For user-provisioned installations, the **openshift-install** binary contains references to the version of RHCOS boot images that are tested for use with OpenShift Container Platform, such as the AWS AMI.

## Procedure

To parse the stream metadata, use one of the following methods:

- From a Go program, use the official **stream-metadata-go** library at <https://github.com/coreos/stream-metadata-go>. You can also view example code in the library.
- From another programming language, such as Python or Ruby, use the JSON library of your preferred programming language.
- From a command-line utility that handles JSON data, such as **jq**:
  - Print the current **x86\_64** AMI for an AWS region, such as **us-west-1**:

```
$ openshift-install coreos print-stream-json | jq -r
'.architectures.x86_64.images.aws.regions["us-west-1"].image'
```

### Example output

```
ami-0d3e625f84626bbda
```

The output of this command is the AWS AMI ID for the **us-west-1** region. The AMI must belong to the same region as the cluster.

## 4.12.14. RHCOS AMIs for the AWS infrastructure

Red Hat provides Red Hat Enterprise Linux CoreOS (RHCOS) AMIs that are valid for the various AWS regions that you can manually specify for your OpenShift Container Platform nodes.



### NOTE

By importing your own AMI, you can also install to regions that do not have a published RHCOS AMI.

Table 4.43. RHCOS AMIs

AWS zone	AWS AMI
<b>af-south-1</b>	<b>ami-0f3804f5a2f913dcc</b>
<b>ap-east-1</b>	<b>ami-0de1febb30a83da66</b>
<b>ap-northeast-1</b>	<b>ami-0183df96a3e002687</b>
<b>ap-northeast-2</b>	<b>ami-06b8798cd60242798</b>
<b>ap-northeast-3</b>	<b>ami-00b16b33aa0951016</b>
<b>ap-south-1</b>	<b>ami-007243f8ff78e8294</b>

AWS zone	AWS AMI
<b>ap-southeast-1</b>	<b>ami-079dfdacb5ab5a0d1</b>
<b>ap-southeast-2</b>	<b>ami-03882e39cb7785c32</b>
<b>ca-central-1</b>	<b>ami-05cba1f80cc8b1dbe</b>
<b>eu-central-1</b>	<b>ami-073c775bbe9cd434e</b>
<b>eu-north-1</b>	<b>ami-0763e6e75b681acc5</b>
<b>eu-south-1</b>	<b>ami-00d023f19775fb64b</b>
<b>eu-west-1</b>	<b>ami-0033e3f2331a530c4</b>
<b>eu-west-2</b>	<b>ami-00d8a741ebe74f0c4</b>
<b>eu-west-3</b>	<b>ami-09b04e7f60e3374a7</b>
<b>me-south-1</b>	<b>ami-0f8039330b6e54010</b>
<b>sa-east-1</b>	<b>ami-01af22f821b470ad1</b>
<b>us-east-1</b>	<b>ami-0c72f473496a7b1c2</b>
<b>us-east-2</b>	<b>ami-09e637fc5885c13cc</b>
<b>us-west-1</b>	<b>ami-0fa0f6fce7e63dd26</b>
<b>us-west-2</b>	<b>ami-084fb1316cd1ed4cc</b>

#### 4.12.14.1. AWS regions without a published RHCOS AMI

You can deploy an OpenShift Container Platform cluster to Amazon Web Services (AWS) regions without native support for a Red Hat Enterprise Linux CoreOS (RHCOS) Amazon Machine Image (AMI) or the AWS software development kit (SDK). If a published AMI is not available for an AWS region, you can upload a custom AMI prior to installing the cluster.

If you are deploying to a region not supported by the AWS SDK and you do not specify a custom AMI, the installation program copies the **us-east-1** AMI to the user account automatically. Then the installation program creates the control plane machines with encrypted EBS volumes using the default or user-specified Key Management Service (KMS) key. This allows the AMI to follow the same process workflow as published RHCOS AMIs.

A region without native support for an RHCOS AMI is not available to select from the terminal during cluster creation because it is not published. However, you can install to this region by configuring the custom AMI in the **install-config.yaml** file.

#### 4.12.14.2. Uploading a custom RHCOS AMI in AWS

If you are deploying to a custom Amazon Web Services (AWS) region, you must upload a custom Red Hat Enterprise Linux CoreOS (RHCOS) Amazon Machine Image (AMI) that belongs to that region.

##### Prerequisites

- You configured an AWS account.
- You created an Amazon S3 bucket with the required IAM [service role](#).
- You uploaded your RHCOS VMDK file to Amazon S3. The RHCOS VMDK file must be the highest version that is less than or equal to the OpenShift Container Platform version you are installing.
- You downloaded the AWS CLI and installed it on your computer. See [Install the AWS CLI Using the Bundled Installer](#).

##### Procedure

1. Export your AWS profile as an environment variable:

```
$ export AWS_PROFILE=<aws_profile> 1
```

2. Export the region to associate with your custom AMI as an environment variable:

```
$ export AWS_DEFAULT_REGION=<aws_region> 1
```

3. Export the version of RHCOS you uploaded to Amazon S3 as an environment variable:

```
$ export RHCOS_VERSION=<version> 1
```

1 1 1 The RHCOS VMDK version, like **4.9.0**.

4. Export the Amazon S3 bucket name as an environment variable:

```
$ export VMIMPORT_BUCKET_NAME=<s3_bucket_name>
```

5. Create the **containers.json** file and define your RHCOS VMDK file:

```
$ cat <<EOF > containers.json
{
  "Description": "rhcos-${RHCOS_VERSION}-x86_64-aws.x86_64",
  "Format": "vmdk",
  "UserBucket": {
    "S3Bucket": "${VMIMPORT_BUCKET_NAME}",
    "S3Key": "rhcos-${RHCOS_VERSION}-x86_64-aws.x86_64.vmdk"
  }
}
EOF
```

6. Import the RHCOS disk as an Amazon EBS snapshot:

```
$ aws ec2 import-snapshot --region ${AWS_DEFAULT_REGION} \
  --description "<description>" \ ❶
  --disk-container "file://<file_path>/containers.json" ❷
```

- ❶ The description of your RHCOS disk being imported, like **rhcos-\${RHCOS\_VERSION}-x86\_64-aws.x86\_64**.
- ❷ The file path to the JSON file describing your RHCOS disk. The JSON file should contain your Amazon S3 bucket name and key.

7. Check the status of the image import:

```
$ watch -n 5 aws ec2 describe-import-snapshot-tasks --region ${AWS_DEFAULT_REGION}
```

### Example output

```
{
  "ImportSnapshotTasks": [
    {
      "Description": "rhcos-4.7.0-x86_64-aws.x86_64",
      "ImportTaskId": "import-snap-fh6i8uil",
      "SnapshotTaskDetail": {
        "Description": "rhcos-4.7.0-x86_64-aws.x86_64",
        "DiskImageSize": 819056640.0,
        "Format": "VMDK",
        "SnapshotId": "snap-06331325870076318",
        "Status": "completed",
        "UserBucket": {
          "S3Bucket": "external-images",
          "S3Key": "rhcos-4.7.0-x86_64-aws.x86_64.vmdk"
        }
      }
    }
  ]
}
```

Copy the **SnapshotId** to register the image.

8. Create a custom RHCOS AMI from the RHCOS snapshot:

```
$ aws ec2 register-image \
  --region ${AWS_DEFAULT_REGION} \
  --architecture x86_64 \ ❶
  --description "rhcos-${RHCOS_VERSION}-x86_64-aws.x86_64" \ ❷
  --ena-support \
  --name "rhcos-${RHCOS_VERSION}-x86_64-aws.x86_64" \ ❸
  --virtualization-type hvm \
  --root-device-name '/dev/xvda' \
  --block-device-mappings 'DeviceName=/dev/xvda,Ebs=
  {DeleteOnTermination=true,SnapshotId=<snapshot_ID>}' ❹
```

- ❶ The RHCOS VMDK architecture type, like **x86\_64**, **s390x**, or **ppc64le**.

- 2 The **Description** from the imported snapshot.
- 3 The name of the RHCOS AMI.
- 4 The **SnapshotID** from the imported snapshot.

To learn more about these APIs, see the AWS documentation for [importing snapshots](#) and [creating EBS-backed AMIs](#).

#### 4.12.15. Creating the bootstrap node in AWS

You must create the bootstrap node in Amazon Web Services (AWS) to use during OpenShift Container Platform cluster initialization.

You can use the provided CloudFormation template and a custom parameter file to create a stack of AWS resources. The stack represents the bootstrap node that your OpenShift Container Platform installation requires.



#### NOTE

If you do not use the provided CloudFormation template to create your bootstrap node, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

#### Prerequisites

- You configured an AWS account.
- You added your AWS keys and region to your local AWS profile by running **aws configure**.
- You generated the Ignition config files for your cluster.
- You created and configured a VPC and associated subnets in AWS.
- You created and configured DNS, load balancers, and listeners in AWS.
- You created the security groups and roles required for your cluster in AWS.

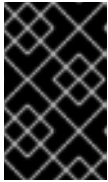
#### Procedure

1. Provide a location to serve the **bootstrap.ign** Ignition config file to your cluster. This file is located in your installation directory. One way to do this is to create an S3 bucket in your cluster's region and upload the Ignition config file to it.



#### IMPORTANT

The provided CloudFormation Template assumes that the Ignition config files for your cluster are served from an S3 bucket. If you choose to serve the files from another location, you must modify the templates.



## IMPORTANT

If you are deploying to a region that has endpoints that differ from the AWS SDK, or you are providing your own custom endpoints, you must use a presigned URL for your S3 bucket instead of the **s3://** schema.



## NOTE

The bootstrap Ignition config file does contain secrets, like X.509 keys. The following steps provide basic security for the S3 bucket. To provide additional security, you can enable an S3 bucket policy to allow only certain users, such as the OpenShift IAM user, to access objects that the bucket contains. You can avoid S3 entirely and serve your bootstrap Ignition config file from any address that the bootstrap machine can reach.

- a. Create the bucket:

```
$ aws s3 mb s3://<cluster-name>-infra 1
```

- 1** **<cluster-name>-infra** is the bucket name. When creating the **install-config.yaml** file, replace **<cluster-name>** with the name specified for the cluster.

- b. Upload the **bootstrap.ign** Ignition config file to the bucket:

```
$ aws s3 cp <installation_directory>/bootstrap.ign s3://<cluster-name>-  
infra/bootstrap.ign 1
```

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

- c. Verify that the file uploaded:

```
$ aws s3 ls s3://<cluster-name>-infra/
```

### Example output

```
2019-04-03 16:15:16 314878 bootstrap.ign
```

2. Create a JSON file that contains the parameter values that the template requires:

```
[  
  {  
    "ParameterKey": "InfrastructureName", 1  
    "ParameterValue": "mycluster-<random_string>" 2  
  },  
  {  
    "ParameterKey": "RhcosAmi", 3  
    "ParameterValue": "ami-<random_string>" 4  
  },  
  {  
    "ParameterKey": "AllowedBootstrapSshCidr", 5
```



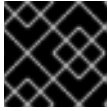
```

    "ParameterValue": "0.0.0.0/0" 6
  },
  {
    "ParameterKey": "PublicSubnet", 7
    "ParameterValue": "subnet-<random_string>" 8
  },
  {
    "ParameterKey": "MasterSecurityGroup", 9
    "ParameterValue": "sg-<random_string>" 10
  },
  {
    "ParameterKey": "VpcId", 11
    "ParameterValue": "vpc-<random_string>" 12
  },
  {
    "ParameterKey": "BootstrapIgnitionLocation", 13
    "ParameterValue": "s3://<bucket_name>/bootstrap.ign" 14
  },
  {
    "ParameterKey": "AutoRegisterELB", 15
    "ParameterValue": "yes" 16
  },
  {
    "ParameterKey": "RegisterNlbTargetsLambdaArn", 17
    "ParameterValue": "arn:aws:lambda:<region>:<account_number>:function:
<dns_stack_name>-RegisterNlbTargets-<random_string>" 18
  },
  {
    "ParameterKey": "ExternalApiTargetGroupArn", 19
    "ParameterValue": "arn:aws:elasticloadbalancing:<region>:
<account_number>:targetgroup/<dns_stack_name>-Exter-<random_string>" 20
  },
  {
    "ParameterKey": "InternalApiTargetGroupArn", 21
    "ParameterValue": "arn:aws:elasticloadbalancing:<region>:
<account_number>:targetgroup/<dns_stack_name>-Inter-<random_string>" 22
  },
  {
    "ParameterKey": "InternalServiceTargetGroupArn", 23
    "ParameterValue": "arn:aws:elasticloadbalancing:<region>:
<account_number>:targetgroup/<dns_stack_name>-Inter-<random_string>" 24
  }
]

```

- 1 The name for your cluster infrastructure that is encoded in your Ignition config files for the cluster.
- 2 Specify the infrastructure name that you extracted from the Ignition config file metadata, which has the format **<cluster-name>-<random-string>**.
- 3 Current Red Hat Enterprise Linux CoreOS (RHCOS) AMI to use for the bootstrap node.
- 4 Specify a valid **AWS::EC2::Image::Id** value.

- 5 CIDR block to allow SSH access to the bootstrap node.
  - 6 Specify a CIDR block in the format **x.x.x.x/16-24**.
  - 7 The public subnet that is associated with your VPC to launch the bootstrap node into.
  - 8 Specify the **PublicSubnetIds** value from the output of the CloudFormation template for the VPC.
  - 9 The master security group ID (for registering temporary rules)
  - 10 Specify the **MasterSecurityGroupId** value from the output of the CloudFormation template for the security group and roles.
  - 11 The VPC created resources will belong to.
  - 12 Specify the **VpcId** value from the output of the CloudFormation template for the VPC.
  - 13 Location to fetch bootstrap Ignition config file from.
  - 14 Specify the S3 bucket and file name in the form **s3://<bucket\_name>/bootstrap.ign**.
  - 15 Whether or not to register a network load balancer (NLB).
  - 16 Specify **yes** or **no**. If you specify **yes**, you must provide a Lambda Amazon Resource Name (ARN) value.
  - 17 The ARN for NLB IP target registration lambda group.
  - 18 Specify the **RegisterNlbTargetsLambda** value from the output of the CloudFormation template for DNS and load balancing. Use **arn:aws-us-gov** if deploying the cluster to an AWS GovCloud region.
  - 19 The ARN for external API load balancer target group.
  - 20 Specify the **ExternalApiTargetGroupArn** value from the output of the CloudFormation template for DNS and load balancing. Use **arn:aws-us-gov** if deploying the cluster to an AWS GovCloud region.
  - 21 The ARN for internal API load balancer target group.
  - 22 Specify the **InternalApiTargetGroupArn** value from the output of the CloudFormation template for DNS and load balancing. Use **arn:aws-us-gov** if deploying the cluster to an AWS GovCloud region.
  - 23 The ARN for internal service load balancer target group.
  - 24 Specify the **InternalServiceTargetGroupArn** value from the output of the CloudFormation template for DNS and load balancing. Use **arn:aws-us-gov** if deploying the cluster to an AWS GovCloud region.
3. Copy the template from the **CloudFormation template for the bootstrap machines** section of this topic and save it as a YAML file on your computer. This template describes the bootstrap machine that your cluster requires.
  4. Launch the CloudFormation template to create a stack of AWS resources that represent the bootstrap node:



## IMPORTANT

You must enter the command on a single line.

```
$ aws cloudformation create-stack --stack-name <name> 1
  --template-body file://<template>.yaml 2
  --parameters file://<parameters>.json 3
  --capabilities CAPABILITY_NAMED_IAM 4
```

- 1 **<name>** is the name for the CloudFormation stack, such as **cluster-bootstrap**. You need the name of this stack if you remove the cluster.
- 2 **<template>** is the relative path to and name of the CloudFormation template YAML file that you saved.
- 3 **<parameters>** is the relative path to and name of the CloudFormation parameters JSON file.
- 4 You must explicitly declare the **CAPABILITY\_NAMED\_IAM** capability because the provided template creates some **AWS::IAM::Role** and **AWS::IAM::InstanceProfile** resources.

### Example output

```
arn:aws:cloudformation:us-east-1:269333783861:stack/cluster-bootstrap/12944486-2add-11eb-9dee-12dace8e3a83
```

5. Confirm that the template components exist:

```
$ aws cloudformation describe-stacks --stack-name <name>
```

After the **StackStatus** displays **CREATE\_COMPLETE**, the output displays values for the following parameters. You must provide these parameter values to the other CloudFormation templates that you run to create your cluster:

<b>Bootstrap Instanceld</b>	The bootstrap Instance ID.
<b>Bootstrap PublicIp</b>	The bootstrap node public IP address.
<b>Bootstrap PrivateIp</b>	The bootstrap node private IP address.

#### 4.12.15.1. CloudFormation template for the bootstrap machine

You can use the following CloudFormation template to deploy the bootstrap machine that you need for your OpenShift Container Platform cluster.

#### Example 4.39. CloudFormation template for the bootstrap machine

■

AWSTemplateFormatVersion: [2010-09-09](#)

Description: Template for OpenShift Cluster Bootstrap (EC2 Instance, Security Groups and IAM)

Parameters:

InfrastructureName:

AllowedPattern: `^[a-zA-Z][a-zA-Z0-9\-\]{0,26}$`

MaxLength: [27](#)

MinLength: [1](#)

ConstraintDescription: Infrastructure name must be alphanumeric, start with a letter, and have a maximum of [27](#) characters.

Description: A short, unique cluster ID used to tag cloud resources and identify items owned or used by the cluster.

Type: String

RhcosAmi:

Description: Current Red Hat Enterprise Linux CoreOS AMI to use for bootstrap.

Type: `AWS::EC2::Image::Id`

AllowedBootstrapSshCidr:

AllowedPattern: `^((([0-9]{1-9}|[0-9]{2}|2[0-4][0-9]|25[0-5])\.){3}([0-9]{1-9}|[0-9]{2}|2[0-4][0-9]|25[0-5])|([0-9]{1-9}|2[0-9]|3[0-2]))$`

ConstraintDescription: CIDR block parameter must be in the form x.x.x.x/0-32.

Default: [0.0.0.0/0](#)

Description: CIDR block to allow SSH access to the bootstrap node.

Type: String

PublicSubnet:

Description: The public subnet to launch the bootstrap node into.

Type: `AWS::EC2::Subnet::Id`

MasterSecurityGroupId:

Description: The master security group ID for registering temporary rules.

Type: `AWS::EC2::SecurityGroup::Id`

VpcId:

Description: The VPC-scoped resources will belong to this VPC.

Type: `AWS::EC2::VPC::Id`

BootstrapIgnitionLocation:

Default: `s3://my-s3-bucket/bootstrap.ign`

Description: Ignition config file location.

Type: String

AutoRegisterELB:

Default: `"yes"`

AllowedValues:

- `"yes"`

- `"no"`

Description: Do you want to invoke NLB registration, which requires a Lambda ARN parameter?

Type: String

RegisterNlbTargetsLambdaArn:

Description: ARN for NLB IP target registration lambda.

Type: String

ExternalApiTargetGroupArn:

Description: ARN for external API load balancer target group.

Type: String

InternalApiTargetGroupArn:

Description: ARN for internal API load balancer target group.

Type: String

InternalServiceTargetGroupArn:

Description: ARN for internal service load balancer target group.

Type: String

```

Metadata:
  AWS::CloudFormation::Interface:
    ParameterGroups:
      - Label:
          default: "Cluster Information"
        Parameters:
          - InfrastructureName
      - Label:
          default: "Host Information"
        Parameters:
          - RhcosAmi
          - BootstrapIgnitionLocation
          - MasterSecurityGroupId
      - Label:
          default: "Network Configuration"
        Parameters:
          - VpcId
          - AllowedBootstrapSshCidr
          - PublicSubnet
      - Label:
          default: "Load Balancer Automation"
        Parameters:
          - AutoRegisterELB
          - RegisterNlbTargetsLambdaArn
          - ExternalApiTargetGroupArn
          - InternalApiTargetGroupArn
          - InternalServiceTargetGroupArn
    ParameterLabels:
      InfrastructureName:
        default: "Infrastructure Name"
      VpcId:
        default: "VPC ID"
      AllowedBootstrapSshCidr:
        default: "Allowed SSH Source"
      PublicSubnet:
        default: "Public Subnet"
      RhcosAmi:
        default: "Red Hat Enterprise Linux CoreOS AMI ID"
      BootstrapIgnitionLocation:
        default: "Bootstrap Ignition Source"
      MasterSecurityGroupId:
        default: "Master Security Group ID"
      AutoRegisterELB:
        default: "Use Provided ELB Automation"

```

```

Conditions:
  DoRegistration: !Equals ["yes", !Ref AutoRegisterELB]

```

```

Resources:
  BootstrapIamRole:
    Type: AWS::IAM::Role
    Properties:
      AssumeRolePolicyDocument:
        Version: "2012-10-17"
        Statement:
          - Effect: "Allow"

```

Principal:  
Service:  
- "ec2.amazonaws.com"  
Action:  
- "sts:AssumeRole"  
Path: "/"  
Policies:  
- PolicyName: !Join ["-", [!Ref InfrastructureName, "bootstrap", "policy"]]  
PolicyDocument:  
Version: "2012-10-17"  
Statement:  
- Effect: "Allow"  
Action: "ec2:Describe\*"  
Resource: "\*"   
- Effect: "Allow"  
Action: "ec2:AttachVolume"  
Resource: "\*"   
- Effect: "Allow"  
Action: "ec2:DetachVolume"  
Resource: "\*"   
- Effect: "Allow"  
Action: "s3:GetObject"  
Resource: "\*"

BootstrapInstanceProfile:  
Type: "AWS::IAM::InstanceProfile"  
Properties:  
Path: "/"  
Roles:  
- Ref: "BootstrapIamRole"

BootstrapSecurityGroup:  
Type: AWS::EC2::SecurityGroup  
Properties:  
GroupDescription: Cluster Bootstrap Security Group  
SecurityGroupIngress:  
- IpProtocol: tcp  
FromPort: 22  
ToPort: 22  
CidrIp: !Ref AllowedBootstrapSshCidr  
- IpProtocol: tcp  
ToPort: 19531  
FromPort: 19531  
CidrIp: 0.0.0.0/0  
VpcId: !Ref VpcId

BootstrapInstance:  
Type: AWS::EC2::Instance  
Properties:  
ImageId: !Ref RhcosAmi  
IamInstanceProfile: !Ref BootstrapInstanceProfile  
InstanceType: "i3.large"  
NetworkInterfaces:  
- AssociatePublicIpAddress: "true"  
DeviceIndex: "0"  
GroupSet:

```

- !Ref "BootstrapSecurityGroup"
- !Ref "MasterSecurityGroupId"
SubnetId: !Ref "PublicSubnet"
UserData:
  Fn::Base64: !Sub
  - '{"ignition":{"config":{"replace":{"source":"${S3Loc}"}},"version":"3.1.0"}}'
  - {
    S3Loc: !Ref BootstrapIgnitionLocation
  }

```

```

RegisterBootstrapApiTarget:
  Condition: DoRegistration
  Type: Custom::NLBRegister
  Properties:
    ServiceToken: !Ref RegisterNlbTargetsLambdaArn
    TargetArn: !Ref ExternalApiTargetGroupArn
    TargetIp: !GetAtt BootstrapInstance.PrivateIp

```

```

RegisterBootstrapInternalApiTarget:
  Condition: DoRegistration
  Type: Custom::NLBRegister
  Properties:
    ServiceToken: !Ref RegisterNlbTargetsLambdaArn
    TargetArn: !Ref InternalApiTargetGroupArn
    TargetIp: !GetAtt BootstrapInstance.PrivateIp

```

```

RegisterBootstrapInternalServiceTarget:
  Condition: DoRegistration
  Type: Custom::NLBRegister
  Properties:
    ServiceToken: !Ref RegisterNlbTargetsLambdaArn
    TargetArn: !Ref InternalServiceTargetGroupArn
    TargetIp: !GetAtt BootstrapInstance.PrivateIp

```

```

Outputs:
BootstrapInstanceId:
  Description: Bootstrap Instance ID.
  Value: !Ref BootstrapInstance

```

```

BootstrapPublicIp:
  Description: The bootstrap node public IP address.
  Value: !GetAtt BootstrapInstance.PublicIp

```

```

BootstrapPrivateIp:
  Description: The bootstrap node private IP address.
  Value: !GetAtt BootstrapInstance.PrivateIp

```

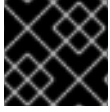
### Additional resources

- You can view details about the CloudFormation stacks that you create by navigating to the [AWS CloudFormation console](#).
- See [RHCOS AMIs for the AWS infrastructure](#) for details about the Red Hat Enterprise Linux CoreOS (RHCOS) AMIs for the AWS zones.

## 4.12.16. Creating the control plane machines in AWS

You must create the control plane machines in Amazon Web Services (AWS) that your cluster will use.

You can use the provided CloudFormation template and a custom parameter file to create a stack of AWS resources that represent the control plane nodes.



### IMPORTANT

The CloudFormation template creates a stack that represents three control plane nodes.



### NOTE

If you do not use the provided CloudFormation template to create your control plane nodes, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

### Prerequisites

- You configured an AWS account.
- You added your AWS keys and region to your local AWS profile by running **aws configure**.
- You generated the Ignition config files for your cluster.
- You created and configured a VPC and associated subnets in AWS.
- You created and configured DNS, load balancers, and listeners in AWS.
- You created the security groups and roles required for your cluster in AWS.
- You created the bootstrap machine.

### Procedure

1. Create a JSON file that contains the parameter values that the template requires:

```
[
  {
    "ParameterKey": "InfrastructureName", 1
    "ParameterValue": "mycluster-<random_string>" 2
  },
  {
    "ParameterKey": "RhcocAmi", 3
    "ParameterValue": "ami-<random_string>" 4
  },
  {
    "ParameterKey": "AutoRegisterDNS", 5
    "ParameterValue": "yes" 6
  },
  {
    "ParameterKey": "PrivateHostedZoneId", 7
    "ParameterValue": "<random_string>" 8
  }
]
```



```

},
{
  "ParameterKey": "PrivateHostedZoneName", 9
  "ParameterValue": "mycluster.example.com" 10
},
{
  "ParameterKey": "Master0Subnet", 11
  "ParameterValue": "subnet-<random_string>" 12
},
{
  "ParameterKey": "Master1Subnet", 13
  "ParameterValue": "subnet-<random_string>" 14
},
{
  "ParameterKey": "Master2Subnet", 15
  "ParameterValue": "subnet-<random_string>" 16
},
{
  "ParameterKey": "MasterSecurityGroupID", 17
  "ParameterValue": "sg-<random_string>" 18
},
{
  "ParameterKey": "IgnitionLocation", 19
  "ParameterValue": "https://api-int.<cluster_name>.<domain_name>:22623/config/master"
20
},
{
  "ParameterKey": "CertificateAuthorities", 21
  "ParameterValue": "data:text/plain;charset=utf-8;base64,ABC...xYz==" 22
},
{
  "ParameterKey": "MasterInstanceProfileName", 23
  "ParameterValue": "<roles_stack>-MasterInstanceProfile-<random_string>" 24
},
{
  "ParameterKey": "MasterInstanceType", 25
  "ParameterValue": "m5.xlarge" 26
},
{
  "ParameterKey": "AutoRegisterELB", 27
  "ParameterValue": "yes" 28
},
{
  "ParameterKey": "RegisterNlbTargetsLambdaArn", 29
  "ParameterValue": "arn:aws:lambda:<region>:<account_number>:function:
<dns_stack_name>-RegisterNlbTargets-<random_string>" 30
},
{
  "ParameterKey": "ExternalApiTargetGroupArn", 31
  "ParameterValue": "arn:aws:elasticloadbalancing:<region>:
<account_number>:targetgroup/<dns_stack_name>-Exter-<random_string>" 32
},
{

```

```

    "ParameterKey": "InternalApiTargetGroupArn", 33
    "ParameterValue": "arn:aws:elasticloadbalancing:<region>:
<account_number>:targetgroup/<dns_stack_name>-Inter-<random_string>" 34
  },
  {
    "ParameterKey": "InternalServiceTargetGroupArn", 35
    "ParameterValue": "arn:aws:elasticloadbalancing:<region>:
<account_number>:targetgroup/<dns_stack_name>-Inter-<random_string>" 36
  }
]

```

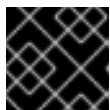
- 1** The name for your cluster infrastructure that is encoded in your Ignition config files for the cluster.
- 2** Specify the infrastructure name that you extracted from the Ignition config file metadata, which has the format **<cluster-name>-<random-string>**.
- 3** Current Red Hat Enterprise Linux CoreOS (RHCOS) AMI to use for the control plane machines.
- 4** Specify an **AWS::EC2::Image::Id** value.
- 5** Whether or not to perform DNS etcd registration.
- 6** Specify **yes** or **no**. If you specify **yes**, you must provide hosted zone information.
- 7** The Route 53 private zone ID to register the etcd targets with.
- 8** Specify the **PrivateHostedZoneId** value from the output of the CloudFormation template for DNS and load balancing.
- 9** The Route 53 zone to register the targets with.
- 10** Specify **<cluster\_name>.<domain\_name>** where **<domain\_name>** is the Route 53 base domain that you used when you generated **install-config.yaml** file for the cluster. Do not include the trailing period (.) that is displayed in the AWS console.
- 11 13 15** A subnet, preferably private, to launch the control plane machines on.
- 12 14 16** Specify a subnet from the **PrivateSubnets** value from the output of the CloudFormation template for DNS and load balancing.
- 17** The master security group ID to associate with control plane nodes.
- 18** Specify the **MasterSecurityGroupId** value from the output of the CloudFormation template for the security group and roles.
- 19** The location to fetch control plane Ignition config file from.
- 20** Specify the generated Ignition config file location, [https://api-int.<cluster\\_name>.<domain\\_name>:22623/config/master](https://api-int.<cluster_name>.<domain_name>:22623/config/master).
- 21** The base64 encoded certificate authority string to use.
- 22** Specify the value from the **master.ign** file that is in the installation directory. This value is the long string with the format **data:text/plain;charset=utf-8;base64,ABC...xYz==**.

- 23 The IAM profile to associate with control plane nodes.
- 24 Specify the **MasterInstanceProfile** parameter value from the output of the CloudFormation template for the security group and roles.
- 25 The type of AWS instance to use for the control plane machines.
- 26 Allowed values:
  - **m4.xlarge**
  - **m4.2xlarge**
  - **m4.4xlarge**
  - **m4.10xlarge**
  - **m4.16xlarge**
  - **m5.xlarge**
  - **m5.2xlarge**
  - **m5.4xlarge**
  - **m5.8xlarge**
  - **m5.12xlarge**
  - **m5.16xlarge**
  - **m5a.xlarge**
  - **m5a.2xlarge**
  - **m5a.4xlarge**
  - **m5a.8xlarge**
  - **m5a.12xlarge**
  - **m5a.16xlarge**
  - **c4.2xlarge**
  - **c4.4xlarge**
  - **c4.8xlarge**
  - **c5.2xlarge**
  - **c5.4xlarge**
  - **c5.9xlarge**
  - **c5.12xlarge**
  - **c5.18xlarge**

- **c5.24xlarge**
- **c5a.2xlarge**
- **c5a.4xlarge**
- **c5a.8xlarge**
- **c5a.12xlarge**
- **c5a.16xlarge**
- **c5a.24xlarge**
- **r4.xlarge**
- **r4.2xlarge**
- **r4.4xlarge**
- **r4.8xlarge**
- **r4.16xlarge**
- **r5.xlarge**
- **r5.2xlarge**
- **r5.4xlarge**
- **r5.8xlarge**
- **r5.12xlarge**
- **r5.16xlarge**
- **r5.24xlarge**
- **r5a.xlarge**
- **r5a.2xlarge**
- **r5a.4xlarge**
- **r5a.8xlarge**
- **r5a.12xlarge**
- **r5a.16xlarge**
- **r5a.24xlarge**

- 27 Whether or not to register a network load balancer (NLB).
- 28 Specify **yes** or **no**. If you specify **yes**, you must provide a Lambda Amazon Resource Name (ARN) value.
- 29 The ARN for NLB IP target registration lambda group.

- 30 Specify the **RegisterNlbTargetsLambda** value from the output of the CloudFormation template for DNS and load balancing. Use **arn:aws-us-gov** if deploying the cluster to an
  - 31 The ARN for external API load balancer target group.
  - 32 Specify the **ExternalApiTargetGroupArn** value from the output of the CloudFormation template for DNS and load balancing. Use **arn:aws-us-gov** if deploying the cluster to an AWS GovCloud region.
  - 33 The ARN for internal API load balancer target group.
  - 34 Specify the **InternalApiTargetGroupArn** value from the output of the CloudFormation template for DNS and load balancing. Use **arn:aws-us-gov** if deploying the cluster to an AWS GovCloud region.
  - 35 The ARN for internal service load balancer target group.
  - 36 Specify the **InternalServiceTargetGroupArn** value from the output of the CloudFormation template for DNS and load balancing. Use **arn:aws-us-gov** if deploying the cluster to an AWS GovCloud region.
2. Copy the template from the **CloudFormation template for control plane machines** section of this topic and save it as a YAML file on your computer. This template describes the control plane machines that your cluster requires.
  3. If you specified an **m5** instance type as the value for **MasterInstanceType**, add that instance type to the **MasterInstanceType.AllowedValues** parameter in the CloudFormation template.
  4. Launch the CloudFormation template to create a stack of AWS resources that represent the control plane nodes:



### IMPORTANT

You must enter the command on a single line.

```
$ aws cloudformation create-stack --stack-name <name> 1
  --template-body file://<template>.yaml 2
  --parameters file://<parameters>.json 3
```

- 1 **<name>** is the name for the CloudFormation stack, such as **cluster-control-plane**. You need the name of this stack if you remove the cluster.
- 2 **<template>** is the relative path to and name of the CloudFormation template YAML file that you saved.
- 3 **<parameters>** is the relative path to and name of the CloudFormation parameters JSON file.

### Example output

```
arn:aws:cloudformation:us-east-1:269333783861:stack/cluster-control-plane/21c7e2b0-2ee2-11eb-c6f6-0aa34627df4b
```

**NOTE**

The CloudFormation template creates a stack that represents three control plane nodes.

- Confirm that the template components exist:

```
$ aws cloudformation describe-stacks --stack-name <name>
```

#### 4.12.16.1. CloudFormation template for control plane machines

You can use the following CloudFormation template to deploy the control plane machines that you need for your OpenShift Container Platform cluster.

##### Example 4.40. CloudFormation template for control plane machines

```
AWSTemplateFormatVersion: 2010-09-09
Description: Template for OpenShift Cluster Node Launch (EC2 master instances)

Parameters:
  InfrastructureName:
    AllowedPattern: ^([a-zA-Z][a-zA-Z0-9\-\_]{0,26})$
    MaxLength: 27
    MinLength: 1
    ConstraintDescription: Infrastructure name must be alphanumeric, start with a letter, and have a
maximum of 27 characters.
    Description: A short, unique cluster ID used to tag nodes for the kubelet cloud provider.
    Type: String
  RhcosAmi:
    Description: Current Red Hat Enterprise Linux CoreOS AMI to use for bootstrap.
    Type: AWS::EC2::Image::Id
  AutoRegisterDNS:
    Default: "yes"
    AllowedValues:
      - "yes"
      - "no"
    Description: Do you want to invoke DNS etcd registration, which requires Hosted Zone
information?
    Type: String
  PrivateHostedZoneId:
    Description: The Route53 private zone ID to register the etcd targets with, such as
Z21IXYZABCZ2A4.
    Type: String
  PrivateHostedZoneName:
    Description: The Route53 zone to register the targets with, such as cluster.example.com. Omit
the trailing period.
    Type: String
  Master0Subnet:
    Description: The subnets, recommend private, to launch the master nodes into.
    Type: AWS::EC2::Subnet::Id
  Master1Subnet:
    Description: The subnets, recommend private, to launch the master nodes into.
    Type: AWS::EC2::Subnet::Id
  Master2Subnet:
    Description: The subnets, recommend private, to launch the master nodes into.
```

Type: AWS::EC2::Subnet::Id

MasterSecurityGroupId:  
Description: The master security group ID to associate with master nodes.  
Type: AWS::EC2::SecurityGroup::Id

IgnitionLocation:  
Default: `https://api-int.$CLUSTER_NAME.$DOMAIN:22623/config/master`  
Description: Ignition config file location.  
Type: String

CertificateAuthorities:  
Default: `data:text/plain;charset=utf-8;base64,ABC...xYz==`  
Description: Base64 encoded certificate authority string to use.  
Type: String

MasterInstanceProfileName:  
Description: IAM profile to associate with master nodes.  
Type: String

MasterInstanceType:  
Default: `m5.xlarge`  
Type: String

AutoRegisterELB:  
Default: `"yes"`  
AllowedValues:  
- `"yes"`  
- `"no"`  
Description: Do you want to invoke NLB registration, which requires a Lambda ARN parameter?  
Type: String

RegisterNlbTargetsLambdaArn:  
Description: ARN for NLB IP target registration lambda. Supply the value from the cluster infrastructure or select `"no"` for AutoRegisterELB.  
Type: String

ExternalApiTargetGroupArn:  
Description: ARN for external API load balancer target group. Supply the value from the cluster infrastructure or select `"no"` for AutoRegisterELB.  
Type: String

InternalApiTargetGroupArn:  
Description: ARN for internal API load balancer target group. Supply the value from the cluster infrastructure or select `"no"` for AutoRegisterELB.  
Type: String

InternalServiceTargetGroupArn:  
Description: ARN for internal service load balancer target group. Supply the value from the cluster infrastructure or select `"no"` for AutoRegisterELB.  
Type: String

Metadata:

AWS::CloudFormation::Interface:  
ParameterGroups:  
- Label:  
  default: `"Cluster Information"`  
Parameters:  
- InfrastructureName  
- Label:  
  default: `"Host Information"`  
Parameters:  
- MasterInstanceType  
- RhcosAmi  
- IgnitionLocation

```
- CertificateAuthorities
- MasterSecurityGroupld
- MasterInstanceProfileName
- Label:
  default: "Network Configuration"
Parameters:
- Vpcld
- AllowedBootstrapSshCidr
- Master0Subnet
- Master1Subnet
- Master2Subnet
- Label:
  default: "DNS"
Parameters:
- AutoRegisterDNS
- PrivateHostedZoneName
- PrivateHostedZoneld
- Label:
  default: "Load Balancer Automation"
Parameters:
- AutoRegisterELB
- RegisterNlbIpTargetsLambdaArn
- ExternalApiTargetGroupArn
- InternalApiTargetGroupArn
- InternalServiceTargetGroupArn
ParameterLabels:
InfrastructureName:
  default: "Infrastructure Name"
Vpcld:
  default: "VPC ID"
Master0Subnet:
  default: "Master-0 Subnet"
Master1Subnet:
  default: "Master-1 Subnet"
Master2Subnet:
  default: "Master-2 Subnet"
MasterInstanceType:
  default: "Master Instance Type"
MasterInstanceProfileName:
  default: "Master Instance Profile Name"
RhcosAmi:
  default: "Red Hat Enterprise Linux CoreOS AMI ID"
BootstrapIgnitionLocation:
  default: "Master Ignition Source"
CertificateAuthorities:
  default: "Ignition CA String"
MasterSecurityGroupld:
  default: "Master Security Group ID"
AutoRegisterDNS:
  default: "Use Provided DNS Automation"
AutoRegisterELB:
  default: "Use Provided ELB Automation"
PrivateHostedZoneName:
  default: "Private Hosted Zone Name"
PrivateHostedZoneld:
  default: "Private Hosted Zone ID"
```



## Conditions:

DoRegistration: !Equals ["yes", !Ref AutoRegisterELB]

DoDns: !Equals ["yes", !Ref AutoRegisterDNS]

## Resources:

## Master0:

Type: AWS::EC2::Instance

## Properties:

ImageId: !Ref RhcosAmi

BlockDeviceMappings:

- DeviceName: /dev/xvda

## Ebs:

VolumeSize: "120"

VolumeType: "gp2"

IamInstanceProfile: !Ref MasterInstanceProfileName

InstanceType: !Ref MasterInstanceType

## NetworkInterfaces:

- AssociatePublicIp: "false"

DeviceIndex: "0"

## GroupSet:

- !Ref "MasterSecurityGroupId"

SubnetId: !Ref "Master0Subnet"

## UserData:

Fn::Base64: !Sub

```
- '{"ignition":{"config":{"merge":{"source":"${SOURCE}"}}, "security":{"tls":
{"certificateAuthorities":[{"source":"${CA_BUNDLE}"}]}}, "version":"3.1.0"}'
```

```
- {
```

```
  SOURCE: !Ref IgnitionLocation,
```

```
  CA_BUNDLE: !Ref CertificateAuthorities,
```

```
}
```

## Tags:

- Key: !Join ["", ["kubernetes.io/cluster/", !Ref InfrastructureName]]

Value: "shared"

## RegisterMaster0:

Condition: DoRegistration

Type: Custom::NLBRegister

## Properties:

ServiceToken: !Ref RegisterNlbTargetsLambdaArn

TargetArn: !Ref ExternalApiTargetGroupArn

TargetIp: !GetAtt Master0.PrivateIp

## RegisterMaster0InternalApiTarget:

Condition: DoRegistration

Type: Custom::NLBRegister

## Properties:

ServiceToken: !Ref RegisterNlbTargetsLambdaArn

TargetArn: !Ref InternalApiTargetGroupArn

TargetIp: !GetAtt Master0.PrivateIp

## RegisterMaster0InternalServiceTarget:

Condition: DoRegistration

Type: Custom::NLBRegister

## Properties:

ServiceToken: !Ref RegisterNlbTargetsLambdaArn

TargetArn: !Ref InternalServiceTargetGroupArn  
 TargetIp: !GetAtt Master0.PrivateIp

#### Master1:

Type: AWS::EC2::Instance

Properties:

ImageId: !Ref RhcosAmi

BlockDeviceMappings:

- DeviceName: /dev/xvda

Ebs:

VolumeSize: "120"

VolumeType: "gp2"

IamInstanceProfile: !Ref MasterInstanceProfileName

InstanceType: !Ref MasterInstanceType

NetworkInterfaces:

- AssociatePublicIpAddress: "false"

DeviceIndex: "0"

GroupSet:

- !Ref "MasterSecurityGroupId"

SubnetId: !Ref "Master1Subnet"

UserData:

Fn::Base64: !Sub

```
- {"ignition":{"config":{"merge":{"source":"${SOURCE}"},"security":{"tls":{"certificateAuthorities":{"source":"${CA_BUNDLE}"},"version":"3.1.0"}}

```

- {

SOURCE: !Ref IgnitionLocation,

CA\_BUNDLE: !Ref CertificateAuthorities,

}

Tags:

- Key: !Join [ "", ["kubernetes.io/cluster/", !Ref InfrastructureName]]

Value: "shared"

#### RegisterMaster1:

Condition: DoRegistration

Type: Custom::NLBRegister

Properties:

ServiceToken: !Ref RegisterNlbTargetsLambdaArn

TargetArn: !Ref ExternalApiTargetGroupArn

TargetIp: !GetAtt Master1.PrivateIp

#### RegisterMaster1 InternalApiTarget:

Condition: DoRegistration

Type: Custom::NLBRegister

Properties:

ServiceToken: !Ref RegisterNlbTargetsLambdaArn

TargetArn: !Ref InternalApiTargetGroupArn

TargetIp: !GetAtt Master1.PrivateIp

#### RegisterMaster1 InternalServiceTarget:

Condition: DoRegistration

Type: Custom::NLBRegister

Properties:

ServiceToken: !Ref RegisterNlbTargetsLambdaArn

TargetArn: !Ref InternalServiceTargetGroupArn

TargetIp: !GetAtt Master1.PrivateIp

```

Master2:
  Type: AWS::EC2::Instance
  Properties:
    ImageId: !Ref RhcosAmi
    BlockDeviceMappings:
      - DeviceName: /dev/xvda
        Ebs:
          VolumeSize: "120"
          VolumeType: "gp2"
    IamInstanceProfile: !Ref MasterInstanceProfileName
    InstanceType: !Ref MasterInstanceType
    NetworkInterfaces:
      - AssociatePublicIp: "false"
        DeviceIndex: "0"
        GroupSet:
          - !Ref "MasterSecurityGroupId"
        SubnetId: !Ref "Master2Subnet"
    UserData:
      Fn::Base64: !Sub
        - '{"ignition":{"config":{"merge":[{"source":"${SOURCE}"}]},"security":{"tls":
{"certificateAuthorities":[{"source":"${CA_BUNDLE}"}]},"version":"3.1.0"}}'
          - {
              SOURCE: !Ref IgnitionLocation,
              CA_BUNDLE: !Ref CertificateAuthorities,
            }
    Tags:
      - Key: !Join [ "", ["kubernetes.io/cluster/", !Ref InfrastructureName] ]
        Value: "shared"

```

```

RegisterMaster2:
  Condition: DoRegistration
  Type: Custom::NLBRegister
  Properties:
    ServiceToken: !Ref RegisterNlbTargetsLambdaArn
    TargetArn: !Ref ExternalApiTargetGroupArn
    TargetIp: !GetAtt Master2.PrivateIp

```

```

RegisterMaster2InternalApiTarget:
  Condition: DoRegistration
  Type: Custom::NLBRegister
  Properties:
    ServiceToken: !Ref RegisterNlbTargetsLambdaArn
    TargetArn: !Ref InternalApiTargetGroupArn
    TargetIp: !GetAtt Master2.PrivateIp

```

```

RegisterMaster2InternalServiceTarget:
  Condition: DoRegistration
  Type: Custom::NLBRegister
  Properties:
    ServiceToken: !Ref RegisterNlbTargetsLambdaArn
    TargetArn: !Ref InternalServiceTargetGroupArn
    TargetIp: !GetAtt Master2.PrivateIp

```

```

EtcDnsRecords:
  Condition: DoDns
  Type: AWS::Route53::RecordSet

```

```
Properties:
  HostedZoneId: !Ref PrivateHostedZoneId
  Name: !Join [".", ["_etcd-server-ssl._tcp", !Ref PrivateHostedZoneName]]
  ResourceRecords:
  - !Join [
    "",
    ["0 10 2380", !Join [".", ["etcd-0", !Ref PrivateHostedZoneName]]],
  ]
  - !Join [
    "",
    ["0 10 2380", !Join [".", ["etcd-1", !Ref PrivateHostedZoneName]]],
  ]
  - !Join [
    "",
    ["0 10 2380", !Join [".", ["etcd-2", !Ref PrivateHostedZoneName]]],
  ]
  TTL: 60
  Type: SRV
```

```
Etcd0Record:
  Condition: DoDns
  Type: AWS::Route53::RecordSet
  Properties:
    HostedZoneId: !Ref PrivateHostedZoneId
    Name: !Join [".", ["etcd-0", !Ref PrivateHostedZoneName]]
    ResourceRecords:
    - !GetAtt Master0.PrivateIp
    TTL: 60
    Type: A
```

```
Etcd1Record:
  Condition: DoDns
  Type: AWS::Route53::RecordSet
  Properties:
    HostedZoneId: !Ref PrivateHostedZoneId
    Name: !Join [".", ["etcd-1", !Ref PrivateHostedZoneName]]
    ResourceRecords:
    - !GetAtt Master1.PrivateIp
    TTL: 60
    Type: A
```

```
Etcd2Record:
  Condition: DoDns
  Type: AWS::Route53::RecordSet
  Properties:
    HostedZoneId: !Ref PrivateHostedZoneId
    Name: !Join [".", ["etcd-2", !Ref PrivateHostedZoneName]]
    ResourceRecords:
    - !GetAtt Master2.PrivateIp
    TTL: 60
    Type: A
```

```
Outputs:
  PrivateIPs:
    Description: The control-plane node private IP addresses.
    Value:
```

```
!Join [
  "",
  !GetAtt Master0.PrivateIp, !GetAtt Master1.PrivateIp, !GetAtt Master2.PrivateIp]
]
```

### Additional resources

- You can view details about the CloudFormation stacks that you create by navigating to the [AWS CloudFormation console](#).

## 4.12.17. Creating the worker nodes in AWS

You can create worker nodes in Amazon Web Services (AWS) for your cluster to use.

You can use the provided CloudFormation template and a custom parameter file to create a stack of AWS resources that represent a worker node.



### IMPORTANT

The CloudFormation template creates a stack that represents one worker node. You must create a stack for each worker node.



### NOTE

If you do not use the provided CloudFormation template to create your worker nodes, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

### Prerequisites

- You configured an AWS account.
- You added your AWS keys and region to your local AWS profile by running **aws configure**.
- You generated the Ignition config files for your cluster.
- You created and configured a VPC and associated subnets in AWS.
- You created and configured DNS, load balancers, and listeners in AWS.
- You created the security groups and roles required for your cluster in AWS.
- You created the bootstrap machine.
- You created the control plane machines.

### Procedure

1. Create a JSON file that contains the parameter values that the CloudFormation template requires:

```
[
```

```

{
  "ParameterKey": "InfrastructureName", 1
  "ParameterValue": "mycluster-<random_string>" 2
},
{
  "ParameterKey": "RhcocAmi", 3
  "ParameterValue": "ami-<random_string>" 4
},
{
  "ParameterKey": "Subnet", 5
  "ParameterValue": "subnet-<random_string>" 6
},
{
  "ParameterKey": "WorkerSecurityGroupID", 7
  "ParameterValue": "sg-<random_string>" 8
},
{
  "ParameterKey": "IgnitionLocation", 9
  "ParameterValue": "https://api-int.<cluster_name>.<domain_name>:22623/config/worker"
10
},
{
  "ParameterKey": "CertificateAuthorities", 11
  "ParameterValue": "" 12
},
{
  "ParameterKey": "WorkerInstanceProfileName", 13
  "ParameterValue": "" 14
},
{
  "ParameterKey": "WorkerInstanceType", 15
  "ParameterValue": "m4.2xlarge" 16
}
]

```

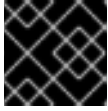
- 1 The name for your cluster infrastructure that is encoded in your Ignition config files for the cluster.
- 2 Specify the infrastructure name that you extracted from the Ignition config file metadata, which has the format **<cluster-name>-<random-string>**.
- 3 Current Red Hat Enterprise Linux CoreOS (RHCOS) AMI to use for the worker nodes.
- 4 Specify an **AWS::EC2::Image::Id** value.
- 5 A subnet, preferably private, to start the worker nodes on.
- 6 Specify a subnet from the **PrivateSubnets** value from the output of the CloudFormation template for DNS and load balancing.
- 7 The worker security group ID to associate with worker nodes.
- 8 Specify the **WorkerSecurityGroupID** value from the output of the CloudFormation template for the security group and roles.

- 9 The location to fetch the bootstrap Ignition config file from.
- 10 Specify the generated Ignition config location, [https://api-int.<cluster\\_name>.<domain\\_name>:22623/config/worker](https://api-int.<cluster_name>.<domain_name>:22623/config/worker).
- 11 Base64 encoded certificate authority string to use.
- 12 Specify the value from the **worker.ign** file that is in the installation directory. This value is the long string with the format **data:text/plain;charset=utf-8;base64,ABC...xYz==**.
- 13 The IAM profile to associate with worker nodes.
- 14 Specify the **WorkerInstanceProfile** parameter value from the output of the CloudFormation template for the security group and roles.
- 15 The type of AWS instance to use for the control plane machines.
- 16 Allowed values:
  - **m4.large**
  - **m4.xlarge**
  - **m4.2xlarge**
  - **m4.4xlarge**
  - **m4.10xlarge**
  - **m4.16xlarge**
  - **m5.large**
  - **m5.xlarge**
  - **m5.2xlarge**
  - **m5.4xlarge**
  - **m5.8xlarge**
  - **m5.12xlarge**
  - **m5.16xlarge**
  - **m5a.large**
  - **m5a.xlarge**
  - **m5a.2xlarge**
  - **m5a.4xlarge**
  - **m5a.8xlarge**
  - **m5a.12xlarge**
  - **m5a.16xlarge**

- **c4.large**
- **c4.xlarge**
- **c4.2xlarge**
- **c4.4xlarge**
- **c4.8xlarge**
- **c5.large**
- **c5.xlarge**
- **c5.2xlarge**
- **c5.4xlarge**
- **c5.9xlarge**
- **c5.12xlarge**
- **c5.18xlarge**
- **c5.24xlarge**
- **c5a.large**
- **c5a.xlarge**
- **c5a.2xlarge**
- **c5a.4xlarge**
- **c5a.8xlarge**
- **c5a.12xlarge**
- **c5a.16xlarge**
- **c5a.24xlarge**
- **r4.large**
- **r4.xlarge**
- **r4.2xlarge**
- **r4.4xlarge**
- **r4.8xlarge**
- **r4.16xlarge**
- **r5.large**
- **r5.xlarge**



- **r5.2xlarge**
  - **r5.4xlarge**
  - **r5.8xlarge**
  - **r5.12xlarge**
  - **r5.16xlarge**
  - **r5.24xlarge**
  - **r5a.large**
  - **r5a.xlarge**
  - **r5a.2xlarge**
  - **r5a.4xlarge**
  - **r5a.8xlarge**
  - **r5a.12xlarge**
  - **r5a.16xlarge**
  - **r5a.24xlarge**
  - **t3.large**
  - **t3.xlarge**
  - **t3.2xlarge**
  - **t3a.large**
  - **t3a.xlarge**
  - **t3a.2xlarge**
2. Copy the template from the **CloudFormation template for worker machines** section of this topic and save it as a YAML file on your computer. This template describes the networking objects and load balancers that your cluster requires.
  3. Optional: If you specified an **m5** instance type as the value for **WorkerInstanceType**, add that instance type to the **WorkerInstanceType.AllowedValues** parameter in the CloudFormation template.
  4. Optional: If you are deploying with an AWS Marketplace image, update the **Worker0.type.properties.ImageID** parameter with the AMI ID that you obtained from your subscription.
  5. Use the CloudFormation template to create a stack of AWS resources that represent a worker node:

**IMPORTANT**

You must enter the command on a single line.

```
$ aws cloudformation create-stack --stack-name <name> 1
  --template-body file://<template>.yaml \ 2
  --parameters file://<parameters>.json 3
```

- 1** **<name>** is the name for the CloudFormation stack, such as **cluster-worker-1**. You need the name of this stack if you remove the cluster.
- 2** **<template>** is the relative path to and name of the CloudFormation template YAML file that you saved.
- 3** **<parameters>** is the relative path to and name of the CloudFormation parameters JSON file.

**Example output**

```
arn:aws:cloudformation:us-east-1:269333783861:stack/cluster-worker-1/729ee301-1c2a-11eb-348f-sd9888c65b59
```

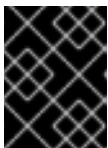
**NOTE**

The CloudFormation template creates a stack that represents one worker node.

6. Confirm that the template components exist:

```
$ aws cloudformation describe-stacks --stack-name <name>
```

7. Continue to create worker stacks until you have created enough worker machines for your cluster. You can create additional worker stacks by referencing the same template and parameter files and specifying a different stack name.

**IMPORTANT**

You must create at least two worker machines, so you must create at least two stacks that use this CloudFormation template.

**4.12.17.1. CloudFormation template for worker machines**

You can use the following CloudFormation template to deploy the worker machines that you need for your OpenShift Container Platform cluster.

**Example 4.41. CloudFormation template for worker machines**

```
AWSTemplateFormatVersion: 2010-09-09
Description: Template for OpenShift Cluster Node Launch (EC2 worker instance)

Parameters:
  InfrastructureName:
```

AllowedPattern: ^([a-zA-Z][a-zA-Z0-9\-\]{0,26})\$

MaxLength: 27

MinLength: 1

ConstraintDescription: Infrastructure name must be alphanumeric, start with a letter, and have a maximum of 27 characters.

Description: A short, unique cluster ID used to tag nodes for the kubelet cloud provider.

Type: String

RhcosAmi:

Description: Current Red Hat Enterprise Linux CoreOS AMI to use for bootstrap.

Type: AWS::EC2::Image::Id

Subnet:

Description: The subnets, recommend private, to launch the master nodes into.

Type: AWS::EC2::Subnet::Id

WorkerSecurityGroupId:

Description: The master security group ID to associate with master nodes.

Type: AWS::EC2::SecurityGroup::Id

IgnitionLocation:

Default: https://api-int.\$CLUSTER\_NAME.\$DOMAIN:22623/config/worker

Description: Ignition config file location.

Type: String

CertificateAuthorities:

Default: data:text/plain;charset=utf-8;base64,ABC...xYz==

Description: Base64 encoded certificate authority string to use.

Type: String

WorkerInstanceProfileName:

Description: IAM profile to associate with master nodes.

Type: String

WorkerInstanceType:

Default: m5.large

Type: String

Metadata:

AWS::CloudFormation::Interface:

ParameterGroups:

- Label:

default: "Cluster Information"

Parameters:

- InfrastructureName

- Label:

default: "Host Information"

Parameters:

- WorkerInstanceType

- RhcosAmi

- IgnitionLocation

- CertificateAuthorities

- WorkerSecurityGroupId

- WorkerInstanceProfileName

- Label:

default: "Network Configuration"

Parameters:

- Subnet

ParameterLabels:

Subnet:

default: "Subnet"

InfrastructureName:

default: "Infrastructure Name"

```

WorkerInstanceType:
  default: "Worker Instance Type"
WorkerInstanceProfileName:
  default: "Worker Instance Profile Name"
RhcocAmi:
  default: "Red Hat Enterprise Linux CoreOS AMI ID"
IgnitionLocation:
  default: "Worker Ignition Source"
CertificateAuthorities:
  default: "Ignition CA String"
WorkerSecurityGroupId:
  default: "Worker Security Group ID"

Resources:
Worker0:
  Type: AWS::EC2::Instance
  Properties:
    ImageId: !Ref RhcocAmi
    BlockDeviceMappings:
      - DeviceName: /dev/xvda
        Ebs:
          VolumeSize: "120"
          VolumeType: "gp2"
    IamInstanceProfile: !Ref WorkerInstanceProfileName
    InstanceType: !Ref WorkerInstanceType
    NetworkInterfaces:
      - AssociatePublicIp: "false"
        DeviceIndex: "0"
        GroupSet:
          - !Ref "WorkerSecurityGroupId"
        SubnetId: !Ref "Subnet"
    UserData:
      Fn::Base64: !Sub
        - '{"ignition":{"config":{"merge":[{"source":"${SOURCE}"}]},"security":{"tls":
{"certificateAuthorities":[{"source":"${CA_BUNDLE}"}]},"version":"3.1.0"}}'
        - {
          SOURCE: !Ref IgnitionLocation,
          CA_BUNDLE: !Ref CertificateAuthorities,
        }
    Tags:
      - Key: !Join ["", ["kubernetes.io/cluster/", !Ref InfrastructureName]]
        Value: "shared"

Outputs:
PrivateIP:
  Description: The compute node private IP address.
  Value: !GetAtt Worker0.PrivateIp

```

### Additional resources

- You can view details about the CloudFormation stacks that you create by navigating to the [AWS CloudFormation console](#).

## 4.12.18. Initializing the bootstrap sequence on AWS with user-provisioned infrastructure

After you create all of the required infrastructure in Amazon Web Services (AWS), you can start the bootstrap sequence that initializes the OpenShift Container Platform control plane.

### Prerequisites

- You configured an AWS account.
- You added your AWS keys and region to your local AWS profile by running **aws configure**.
- You generated the Ignition config files for your cluster.
- You created and configured a VPC and associated subnets in AWS.
- You created and configured DNS, load balancers, and listeners in AWS.
- You created the security groups and roles required for your cluster in AWS.
- You created the bootstrap machine.
- You created the control plane machines.
- You created the worker nodes.

### Procedure

1. Change to the directory that contains the installation program and start the bootstrap process that initializes the OpenShift Container Platform control plane:

```
$ ./openshift-install wait-for bootstrap-complete --dir <installation_directory> \ 1
--log-level=info 2
```

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

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

### Example output

```
INFO Waiting up to 20m0s for the Kubernetes API at
https://api.mycluster.example.com:6443...
INFO API v1.22.1 up
INFO Waiting up to 30m0s for bootstrapping to complete...
INFO It is now safe to remove the bootstrap resources
INFO Time elapsed: 1s
```

If the command exits without a **FATAL** warning, your OpenShift Container Platform control plane has initialized.

**NOTE**

After the control plane initializes, it sets up the compute nodes and installs additional services in the form of Operators.

**Additional resources**

- See [Monitoring installation progress](#) for details about monitoring the installation, bootstrap, and control plane logs as an OpenShift Container Platform installation progresses.
- See [Gathering bootstrap node diagnostic data](#) for information about troubleshooting issues related to the bootstrap process.
- You can view details about the running instances that are created by using the [AWS EC2 console](#).

**4.12.19. Installing the OpenShift CLI by downloading the binary**

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

**IMPORTANT**

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

**Installing the OpenShift CLI on Linux**

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

**Procedure**

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

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

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

```
$ echo $PATH
```

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

```
$ oc <command>
```

**Installing the OpenShift CLI on Windows**

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

## Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

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

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

## Installing the OpenShift CLI on macOS

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

## Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

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

```
$ oc <command>
```

### 4.12.20. Logging in to the cluster by using the CLI

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

## Prerequisites

- You deployed an OpenShift Container Platform cluster.

- You installed the **oc** CLI.

### Procedure

- Export the **kubeadmin** credentials:

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

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

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

```
$ oc whoami
```

### Example output

```
system:admin
```

## 4.12.21. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

### Prerequisites

- You added machines to your cluster.

### Procedure

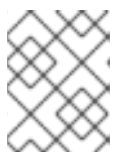
- Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

### Example output

```
NAME      STATUS   ROLES    AGE   VERSION
master-0  Ready   master   63m   v1.22.1
master-1  Ready   master   63m   v1.22.1
master-2  Ready   master   64m   v1.22.1
```

The output lists all of the machines that you created.



### NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

- Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:



```
$ oc get csr
```

### Example output

```
NAME      AGE   REQUESTOR                                     CONDITION
csr-8b2br 15m   system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper Pending
csr-8vnps 15m   system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper Pending
...
```

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

- If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:



#### NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.



#### NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{\n"}\n{{end}}\n{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```

**NOTE**

Some Operators might not become available until some CSRs are approved.

- Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

**Example output**

```
NAME      AGE   REQUESTOR                                     CONDITION
csr-bfd72 5m26s system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv 5m26s system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

- If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

**1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{"\n"}\n{{end}}{{end}}' | xargs oc adm certificate approve
```

- After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

**Example output**

```
NAME      STATUS  ROLES  AGE  VERSION
master-0  Ready   master 73m  v1.22.1
master-1  Ready   master 73m  v1.22.1
master-2  Ready   master 74m  v1.22.1
worker-0  Ready   worker 11m  v1.22.1
worker-1  Ready   worker 11m  v1.22.1
```

**NOTE**

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

## Additional information

- For more information on CSRs, see [Certificate Signing Requests](#).

### 4.12.22. Initial Operator configuration

After the control plane initializes, you must immediately configure some Operators so that they all become available.

#### Prerequisites

- Your control plane has initialized.

#### Procedure

1. Watch the cluster components come online:

```
$ watch -n5 oc get clusteroperators
```

#### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
authentication	4.9.0	True	False	False	19m
baremetal	4.9.0	True	False	False	37m
cloud-credential	4.9.0	True	False	False	40m
cluster-autoscaler	4.9.0	True	False	False	37m
config-operator	4.9.0	True	False	False	38m
console	4.9.0	True	False	False	26m
csi-snapshot-controller	4.9.0	True	False	False	37m
dns	4.9.0	True	False	False	37m
etcd	4.9.0	True	False	False	36m
image-registry	4.9.0	True	False	False	31m
ingress	4.9.0	True	False	False	30m
insights	4.9.0	True	False	False	31m
kube-apiserver	4.9.0	True	False	False	26m
kube-controller-manager	4.9.0	True	False	False	36m
kube-scheduler	4.9.0	True	False	False	36m
kube-storage-version-migrator	4.9.0	True	False	False	37m
machine-api	4.9.0	True	False	False	29m
machine-approver	4.9.0	True	False	False	37m
machine-config	4.9.0	True	False	False	36m
marketplace	4.9.0	True	False	False	37m
monitoring	4.9.0	True	False	False	29m
network	4.9.0	True	False	False	38m
node-tuning	4.9.0	True	False	False	37m
openshift-apiserver	4.9.0	True	False	False	32m
openshift-controller-manager	4.9.0	True	False	False	30m
openshift-samples	4.9.0	True	False	False	32m
operator-lifecycle-manager	4.9.0	True	False	False	37m
operator-lifecycle-manager-catalog	4.9.0	True	False	False	37m
operator-lifecycle-manager-packageserver	4.9.0	True	False	False	32m
service-ca	4.9.0	True	False	False	38m
storage	4.9.0	True	False	False	37m

2. Configure the Operators that are not available.

#### 4.12.22.1. Image registry storage configuration

Amazon Web Services provides default storage, which means the Image Registry Operator is available after installation. However, if the Registry Operator cannot create an S3 bucket and automatically configure storage, you must manually configure registry storage.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

You can configure registry storage for user-provisioned infrastructure in AWS to deploy OpenShift Container Platform to hidden regions. See [Configuring the registry for AWS user-provisioned infrastructure](#) for more information.

##### 4.12.22.1.1. Configuring registry storage for AWS with user-provisioned infrastructure

During installation, your cloud credentials are sufficient to create an Amazon S3 bucket and the Registry Operator will automatically configure storage.

If the Registry Operator cannot create an S3 bucket and automatically configure storage, you can create an S3 bucket and configure storage with the following procedure.

#### Prerequisites

- You have a cluster on AWS with user-provisioned infrastructure.
- For Amazon S3 storage, the secret is expected to contain two keys:
  - **REGISTRY\_STORAGE\_S3\_ACCESSKEY**
  - **REGISTRY\_STORAGE\_S3\_SECRETKEY**

#### Procedure

Use the following procedure if the Registry Operator cannot create an S3 bucket and automatically configure storage.

1. Set up a [Bucket Lifecycle Policy](#) to abort incomplete multipart uploads that are one day old.
2. Fill in the storage configuration in **configs.imageregistry.operator.openshift.io/cluster**:

```
$ oc edit configs.imageregistry.operator.openshift.io/cluster
```

#### Example configuration

```
storage:
  s3:
    bucket: <bucket-name>
    region: <region-name>
```

**WARNING**

To secure your registry images in AWS, [block public access](#) to the S3 bucket.

**4.12.22.1.2. Configuring storage for the image registry in non-production clusters**

You must configure storage for the Image Registry Operator. For non-production clusters, you can set the image registry to an empty directory. If you do so, all images are lost if you restart the registry.

**Procedure**

- To set the image registry storage to an empty directory:

```
$ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec": {"storage":{"emptyDir":{}}}'
```

**WARNING**

Configure this option for only non-production clusters.

If you run this command before the Image Registry Operator initializes its components, the **oc patch** command fails with the following error:

```
Error from server (NotFound): configs.imageregistry.operator.openshift.io "cluster" not found
```

Wait a few minutes and run the command again.

**4.12.23. Deleting the bootstrap resources**

After you complete the initial Operator configuration for the cluster, remove the bootstrap resources from Amazon Web Services (AWS).

**Prerequisites**

- You completed the initial Operator configuration for your cluster.

**Procedure**

- Delete the bootstrap resources. If you used the CloudFormation template, [delete its stack](#):
  - Delete the stack by using the AWS CLI:

```
$ aws cloudformation delete-stack --stack-name <name> 1
```

**1** `<name>` is the name of your bootstrap stack.

- Delete the stack by using the [AWS CloudFormation console](#).

#### 4.12.24. Creating the Ingress DNS Records

If you removed the DNS Zone configuration, manually create DNS records that point to the Ingress load balancer. You can create either a wildcard record or specific records. While the following procedure uses A records, you can use other record types that you require, such as CNAME or alias.

##### Prerequisites

- You deployed an OpenShift Container Platform cluster on Amazon Web Services (AWS) that uses infrastructure that you provisioned.
- You installed the OpenShift CLI (**oc**).
- You installed the **jq** package.
- You downloaded the AWS CLI and installed it on your computer. See [Install the AWS CLI Using the Bundled Installer \(Linux, macOS, or Unix\)](#).

##### Procedure

1. Determine the routes to create.
  - To create a wildcard record, use **\*.apps.<cluster\_name>.<domain\_name>**, where **<cluster\_name>** is your cluster name, and **<domain\_name>** is the Route 53 base domain for your OpenShift Container Platform cluster.
  - To create specific records, you must create a record for each route that your cluster uses, as shown in the output of the following command:

```
$ oc get --all-namespaces -o jsonpath='{range .items[*]}{range .status.ingress[*]}{.host} {"\n"}{end}{end}' routes
```

##### Example output

```
oauth-openshift.apps.<cluster_name>.<domain_name>
console-openshift-console.apps.<cluster_name>.<domain_name>
downloads-openshift-console.apps.<cluster_name>.<domain_name>
alertmanager-main-openshift-monitoring.apps.<cluster_name>.<domain_name>
grafana-openshift-monitoring.apps.<cluster_name>.<domain_name>
prometheus-k8s-openshift-monitoring.apps.<cluster_name>.<domain_name>
```

2. Retrieve the Ingress Operator load balancer status and note the value of the external IP address that it uses, which is shown in the **EXTERNAL-IP** column:

```
$ oc -n openshift-ingress get service router-default
```

##### Example output

NAME	TYPE	CLUSTER-IP	EXTERNAL-IP	PORT(S)
------	------	------------	-------------	---------

```
AGE
```

```
router-default LoadBalancer 172.30.62.215 ab3...28.us-east-2.elb.amazonaws.com
80:31499/TCP,443:30693/TCP 5m
```

3. Locate the hosted zone ID for the load balancer:

```
$ aws elb describe-load-balancers | jq -r '.LoadBalancerDescriptions[] | select(.DNSName ==
"<external_ip>").CanonicalHostedZoneNameID' 1
```

- 1** For **<external\_ip>**, specify the value of the external IP address of the Ingress Operator load balancer that you obtained.

### Example output

```
Z3AADJGX6KTTL2
```

The output of this command is the load balancer hosted zone ID.

4. Obtain the public hosted zone ID for your cluster's domain:

```
$ aws route53 list-hosted-zones-by-name \
  --dns-name "<domain_name>" \ 1
  --query 'HostedZones[? Config.PrivateZone != `true` && Name ==
`<domain_name>.`].Id' 2
  --output text
```

- 1** **2** For **<domain\_name>**, specify the Route 53 base domain for your OpenShift Container Platform cluster.

### Example output

```
/hostedzone/Z3URY6TWQ91KVV
```

The public hosted zone ID for your domain is shown in the command output. In this example, it is **Z3URY6TWQ91KVV**.

5. Add the alias records to your private zone:

```
$ aws route53 change-resource-record-sets --hosted-zone-id "<private_hosted_zone_id>" --
change-batch '{ 1
> "Changes": [
>   {
>     "Action": "CREATE",
>     "ResourceRecordSet": {
>       "Name": "\\052.apps.<cluster_domain>", 2
>       "Type": "A",
>       "AliasTarget":{
>         "HostedZoneId": "<hosted_zone_id>", 3
>         "DNSName": "<external_ip>.", 4
>         "EvaluateTargetHealth": false
>       }
>     }
>   }
> }
```

```
> }
> }
> ]
> }'
```

- 1 For **<private\_hosted\_zone\_id>**, specify the value from the output of the CloudFormation template for DNS and load balancing.
- 2 For **<cluster\_domain>**, specify the domain or subdomain that you use with your OpenShift Container Platform cluster.
- 3 For **<hosted\_zone\_id>**, specify the public hosted zone ID for the load balancer that you obtained.
- 4 For **<external\_ip>**, specify the value of the external IP address of the Ingress Operator load balancer. Ensure that you include the trailing period (.) in this parameter value.

6. Add the records to your public zone:

```
$ aws route53 change-resource-record-sets --hosted-zone-id "<public_hosted_zone_id>" --
change-batch '{
> "Changes": [
> {
>   "Action": "CREATE",
>   "ResourceRecordSet": {
>     "Name": "\\052.apps.<cluster_domain>",
>     "Type": "A",
>     "AliasTarget": {
>       "HostedZoneId": "<hosted_zone_id>",
>       "DNSName": "<external_ip>.",
>       "EvaluateTargetHealth": false
>     }
>   }
> }
> ]
> }'
```

- 1 For **<public\_hosted\_zone\_id>**, specify the public hosted zone for your domain.
- 2 For **<cluster\_domain>**, specify the domain or subdomain that you use with your OpenShift Container Platform cluster.
- 3 For **<hosted\_zone\_id>**, specify the public hosted zone ID for the load balancer that you obtained.
- 4 For **<external\_ip>**, specify the value of the external IP address of the Ingress Operator load balancer. Ensure that you include the trailing period (.) in this parameter value.

#### 4.12.25. Completing an AWS installation on user-provisioned infrastructure

After you start the OpenShift Container Platform installation on Amazon Web Service (AWS) user-provisioned infrastructure, monitor the deployment to completion.



## Prerequisites

- You removed the bootstrap node for an OpenShift Container Platform cluster on user-provisioned AWS infrastructure.
- You installed the **oc** CLI.

## Procedure

- From the directory that contains the installation program, complete the cluster installation:

```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

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

## Example output

```
INFO Waiting up to 40m0s for the cluster at https://api.mycluster.example.com:6443 to
initialize...
INFO Waiting up to 10m0s for the openshift-console route to be created...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Fe5en-ymBEc-
Wt6NL"
INFO Time elapsed: 1s
```

## IMPORTANT

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

### 4.12.26. Logging in to the cluster by using the web console

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

## Prerequisites

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

## Procedure

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

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



### NOTE

Alternatively, you can obtain the **kubeadmin** password from the **<installation\_directory>/openshift\_install.log** log file on the installation host.

2. List the OpenShift Container Platform web console route:

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



### NOTE

Alternatively, you can obtain the OpenShift Container Platform route from the **<installation\_directory>/openshift\_install.log** log file on the installation host.

## Example output

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

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

## Additional resources

- See [Accessing the web console](#) for more details about accessing and understanding the OpenShift Container Platform web console.

## 4.12.27. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

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

## Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service.

### 4.12.28. Additional resources

- See [Working with stacks](#) in the AWS documentation for more information about AWS CloudFormation stacks.

### 4.12.29. Next steps

- [Validating an installation.](#)
- [Customize your cluster.](#)
- If necessary, you can [opt out of remote health reporting](#) .
- If necessary, you can [remove cloud provider credentials](#).

## 4.13. INSTALLING A CLUSTER ON AWS IN A RESTRICTED NETWORK WITH USER-PROVISIONED INFRASTRUCTURE

In OpenShift Container Platform version 4.9, you can install a cluster on Amazon Web Services (AWS) using infrastructure that you provide and an internal mirror of the installation release content.



### IMPORTANT

While you can install an OpenShift Container Platform cluster by using mirrored installation release content, your cluster still requires internet access to use the AWS APIs.

One way to create this infrastructure is to use the provided CloudFormation templates. You can modify the templates to customize your infrastructure or use the information that they contain to create AWS objects according to your company's policies.

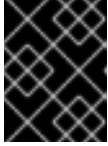


### IMPORTANT

The steps for performing a user-provisioned infrastructure installation are provided as an example only. Installing a cluster with infrastructure you provide requires knowledge of the cloud provider and the installation process of OpenShift Container Platform. Several CloudFormation templates are provided to assist in completing these steps or to help model your own. You are also free to create the required resources through other methods; the templates are just an example.

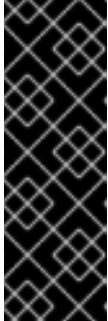
### 4.13.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You [created a mirror registry on your mirror host](#) and obtained the **imageContentSources** data for your version of OpenShift Container Platform.

**IMPORTANT**

Because the installation media is on the mirror host, you can use that computer to complete all installation steps.

- You [configured an AWS account](#) to host the cluster.

**IMPORTANT**

If you have an AWS profile stored on your computer, it must not use a temporary session token that you generated while using a multi-factor authentication device. The cluster continues to use your current AWS credentials to create AWS resources for the entire life of the cluster, so you must use key-based, long-lived credentials. To generate appropriate keys, see [Managing Access Keys for IAM Users](#) in the AWS documentation. You can supply the keys when you run the installation program.

- You downloaded the AWS CLI and installed it on your computer. See [Install the AWS CLI Using the Bundled Installer \(Linux, macOS, or Unix\)](#) in the AWS documentation.
- If you use a firewall and plan to use the Telemetry service, you [configured the firewall to allow the sites](#) that your cluster requires access to.

**NOTE**

Be sure to also review this site list if you are configuring a proxy.

- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can [manually create and maintain IAM credentials](#).

### 4.13.2. About installations in restricted networks

In OpenShift Container Platform 4.9, you can perform an installation that does not require an active connection to the internet to obtain software components. Restricted network installations can be completed using installer-provisioned infrastructure or user-provisioned infrastructure, depending on the cloud platform to which you are installing the cluster.

If you choose to perform a restricted network installation on a cloud platform, you still require access to its cloud APIs. Some cloud functions, like Amazon Web Service's Route 53 DNS and IAM services, require internet access. Depending on your network, you might require less internet access for an installation on bare metal hardware or on VMware vSphere.

To complete a restricted network installation, you must create a registry that mirrors the contents of the OpenShift Container Platform registry and contains the installation media. You can create this registry on a mirror host, which can access both the internet and your closed network, or by using other methods that meet your restrictions.



## IMPORTANT

Because of the complexity of the configuration for user-provisioned installations, consider completing a standard user-provisioned infrastructure installation before you attempt a restricted network installation using user-provisioned infrastructure. Completing this test installation might make it easier to isolate and troubleshoot any issues that might arise during your installation in a restricted network.

### 4.13.2.1. Additional limits

Clusters in restricted networks have the following additional limitations and restrictions:

- The **ClusterVersion** status includes an **Unable to retrieve available updates** error.
- By default, you cannot use the contents of the Developer Catalog because you cannot access the required image stream tags.

### 4.13.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to obtain the images that are necessary to install your cluster.

You must have internet access to:

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



## IMPORTANT

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

### 4.13.4. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

#### 4.13.4.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

**Table 4.44. Minimum required hosts**

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.



### IMPORTANT

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 7.9, or RHEL 8.4.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See [Red Hat Enterprise Linux technology capabilities and limits](#) .

#### 4.13.4.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

**Table 4.45. Minimum resource requirements**

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 7.9, or RHEL 8.4 [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio:  $(\text{threads per core} \times \text{cores}) \times \text{sockets} = \text{vCPUs}$ .
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so

you might need to over-allocate storage volume to obtain sufficient performance.

- As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.

#### 4.13.4.3. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

#### 4.13.4.4. Supported AWS machine types

The following Amazon Web Services (AWS) instance types are supported with OpenShift Container Platform.

Example 4.42. Instance types for machines

Instance type	Bootstrap	Control plane	Compute
<b>i3.large</b>	x		
<b>m4.large</b>			x
<b>m4.xlarge</b>		x	x
<b>m4.2xlarge</b>		x	x
<b>m4.4xlarge</b>		x	x
<b>m4.10xlarge</b>		x	x
<b>m4.16xlarge</b>		x	x
<b>m5.large</b>			x
<b>m5.xlarge</b>		x	x
<b>m5.2xlarge</b>		x	x
<b>m5.4xlarge</b>		x	x
<b>m5.8xlarge</b>		x	x

Instance type	Bootstrap	Control plane	Compute
<b>m5.12xlarge</b>		x	x
<b>m5.16xlarge</b>		x	x
<b>m5a.large</b>			x
<b>m5a.xlarge</b>		x	x
<b>m5a.2xlarge</b>		x	x
<b>m5a.4xlarge</b>		x	x
<b>m5a.8xlarge</b>		x	x
<b>m5a.12xlarge</b>		x	x
<b>m5a.16xlarge</b>		x	x
<b>m6i.xlarge</b>		x	x
<b>m6i.2xlarge</b>		x	x
<b>m6i.4xlarge</b>		x	x
<b>m6i.8xlarge</b>		x	x
<b>m6i.16xlarge</b>		x	x
<b>c4.2xlarge</b>		x	x
<b>c4.4xlarge</b>		x	x
<b>c4.8xlarge</b>		x	x
<b>c5.xlarge</b>			x
<b>c5.2xlarge</b>		x	x
<b>c5.4xlarge</b>		x	x
<b>c5.9xlarge</b>		x	x
<b>c5.12xlarge</b>		x	x



Instance type	Bootstrap	Control plane	Compute
<b>c5.18xlarge</b>		x	x
<b>c5.24xlarge</b>		x	x
<b>c5a.xlarge</b>			x
<b>c5a.2xlarge</b>		x	x
<b>c5a.4xlarge</b>		x	x
<b>c5a.8xlarge</b>		x	x
<b>c5a.12xlarge</b>		x	x
<b>c5a.16xlarge</b>		x	x
<b>c5a.24xlarge</b>		x	x
<b>r4.large</b>			x
<b>r4.xlarge</b>		x	x
<b>r4.2xlarge</b>		x	x
<b>r4.4xlarge</b>		x	x
<b>r4.8xlarge</b>		x	x
<b>r4.16xlarge</b>		x	x
<b>r5.large</b>			x
<b>r5.xlarge</b>		x	x
<b>r5.2xlarge</b>		x	x
<b>r5.4xlarge</b>		x	x
<b>r5.8xlarge</b>		x	x
<b>r5.12xlarge</b>		x	x
<b>r5.16xlarge</b>		x	x

Instance type	Bootstrap	Control plane	Compute
<b>r5.24xlarge</b>		x	x
<b>r5a.large</b>			x
<b>r5a.xlarge</b>		x	x
<b>r5a.2xlarge</b>		x	x
<b>r5a.4xlarge</b>		x	x
<b>r5a.8xlarge</b>		x	x
<b>r5a.12xlarge</b>		x	x
<b>r5a.16xlarge</b>		x	x
<b>r5a.24xlarge</b>		x	x
<b>t3.large</b>			x
<b>t3.xlarge</b>			x
<b>t3.2xlarge</b>			x
<b>t3a.large</b>			x
<b>t3a.xlarge</b>			x
<b>t3a.2xlarge</b>			x

#### 4.13.5. Required AWS infrastructure components

To install OpenShift Container Platform on user-provisioned infrastructure in Amazon Web Services (AWS), you must manually create both the machines and their supporting infrastructure.

For more information about the integration testing for different platforms, see the [OpenShift Container Platform 4.x Tested Integrations](#) page.

By using the provided CloudFormation templates, you can create stacks of AWS resources that represent the following components:

- An AWS Virtual Private Cloud (VPC)
- Networking and load balancing components

- Security groups and roles
- An OpenShift Container Platform bootstrap node
- OpenShift Container Platform control plane nodes
- An OpenShift Container Platform compute node

Alternatively, you can manually create the components or you can reuse existing infrastructure that meets the cluster requirements. Review the CloudFormation templates for more details about how the components interrelate.

#### 4.13.5.1. Other infrastructure components

- A VPC
- DNS entries
- Load balancers (classic or network) and listeners
- A public and a private Route 53 zone
- Security groups
- IAM roles
- S3 buckets

If you are working in a disconnected environment or use a proxy, you cannot reach the public IP addresses for EC2 and ELB endpoints. To reach these endpoints, you must create a VPC endpoint and attach it to the subnet that the clusters are using. Create the following endpoints:

- **ec2.<region>.amazonaws.com**
- **elasticloadbalancing.<region>.amazonaws.com**
- **s3.<region>.amazonaws.com**

#### Required VPC components

You must provide a suitable VPC and subnets that allow communication to your machines.

Component	AWS type	Description
VPC	<ul style="list-style-type: none"> <li>• <b>AWS::EC2::VPC</b></li> <li>• <b>AWS::EC2::VPCEndpoint</b></li> </ul>	You must provide a public VPC for the cluster to use. The VPC uses an endpoint that references the route tables for each subnet to improve communication with the registry that is hosted in S3.

Component	AWS type	Description												
Public subnets	<ul style="list-style-type: none"> <li>● <b>AWS::EC2::Subnet</b></li> <li>● <b>AWS::EC2::SubnetNetworkACLAssociation</b></li> </ul>	Your VPC must have public subnets for between 1 and 3 availability zones and associate them with appropriate Ingress rules.												
Internet gateway	<ul style="list-style-type: none"> <li>● <b>AWS::EC2::InternetGateway</b></li> <li>● <b>AWS::EC2::VPCGatewayAttachment</b></li> <li>● <b>AWS::EC2::RouteTable</b></li> <li>● <b>AWS::EC2::Route</b></li> <li>● <b>AWS::EC2::SubnetRouteTableAssociation</b></li> <li>● <b>AWS::EC2::NatGateway</b></li> <li>● <b>AWS::EC2::EIP</b></li> </ul>	You must have a public internet gateway, with public routes, attached to the VPC. In the provided templates, each public subnet has a NAT gateway with an EIP address. These NAT gateways allow cluster resources, like private subnet instances, to reach the internet and are not required for some restricted network or proxy scenarios.												
Network access control	<ul style="list-style-type: none"> <li>● <b>AWS::EC2::NetworkACL</b></li> <li>● <b>AWS::EC2::NetworkACLEntry</b></li> </ul>	<p>You must allow the VPC to access the following ports:</p> <table border="1"> <thead> <tr> <th>Port</th> <th>Reason</th> </tr> </thead> <tbody> <tr> <td><b>80</b></td> <td>Inbound HTTP traffic</td> </tr> <tr> <td><b>443</b></td> <td>Inbound HTTPS traffic</td> </tr> <tr> <td><b>22</b></td> <td>Inbound SSH traffic</td> </tr> <tr> <td><b>1024 - 65535</b></td> <td>Inbound ephemeral traffic</td> </tr> <tr> <td><b>0 - 65535</b></td> <td>Outbound ephemeral traffic</td> </tr> </tbody> </table>	Port	Reason	<b>80</b>	Inbound HTTP traffic	<b>443</b>	Inbound HTTPS traffic	<b>22</b>	Inbound SSH traffic	<b>1024 - 65535</b>	Inbound ephemeral traffic	<b>0 - 65535</b>	Outbound ephemeral traffic
Port	Reason													
<b>80</b>	Inbound HTTP traffic													
<b>443</b>	Inbound HTTPS traffic													
<b>22</b>	Inbound SSH traffic													
<b>1024 - 65535</b>	Inbound ephemeral traffic													
<b>0 - 65535</b>	Outbound ephemeral traffic													
Private subnets	<ul style="list-style-type: none"> <li>● <b>AWS::EC2::Subnet</b></li> <li>● <b>AWS::EC2::RouteTable</b></li> <li>● <b>AWS::EC2::SubnetRouteTableAssociation</b></li> </ul>	Your VPC can have private subnets. The provided CloudFormation templates can create private subnets for between 1 and 3 availability zones. If you use private subnets, you must provide appropriate routes and tables for them.												

## Required DNS and load balancing components

Your DNS and load balancer configuration needs to use a public hosted zone and can use a private hosted zone similar to the one that the installation program uses if it provisions the cluster's infrastructure. You must create a DNS entry that resolves to your load balancer. An entry for **api.<cluster\_name>.<domain>** must point to the external load balancer, and an entry for **api-int.<cluster\_name>.<domain>** must point to the internal load balancer.

The cluster also requires load balancers and listeners for port 6443, which are required for the Kubernetes API and its extensions, and port 22623, which are required for the Ignition config files for new machines. The targets will be the control plane nodes. Port 6443 must be accessible to both clients external to the cluster and nodes within the cluster. Port 22623 must be accessible to nodes within the cluster.

Component	AWS type	Description
DNS	<b>AWS::Route53::HostedZone</b>	The hosted zone for your internal DNS.
etcd record sets	<b>AWS::Route53::RecordSet</b>	The registration records for etcd for your control plane machines.
Public load balancer	<b>AWS::ElasticLoadBalancingV2::LoadBalancer</b>	The load balancer for your public subnets.
External API server record	<b>AWS::Route53::RecordSetGroup</b>	Alias records for the external API server.
External listener	<b>AWS::ElasticLoadBalancingV2::Listener</b>	A listener on port 6443 for the external load balancer.
External target group	<b>AWS::ElasticLoadBalancingV2::TargetGroup</b>	The target group for the external load balancer.
Private load balancer	<b>AWS::ElasticLoadBalancingV2::LoadBalancer</b>	The load balancer for your private subnets.
Internal API server record	<b>AWS::Route53::RecordSetGroup</b>	Alias records for the internal API server.

Component	AWS type	Description
Internal listener	<b>AWS::ElasticLoadBalancingV2::Listener</b>	A listener on port 22623 for the internal load balancer.
Internal target group	<b>AWS::ElasticLoadBalancingV2::TargetGroup</b>	The target group for the internal load balancer.
Internal listener	<b>AWS::ElasticLoadBalancingV2::Listener</b>	A listener on port 6443 for the internal load balancer.
Internal target group	<b>AWS::ElasticLoadBalancingV2::TargetGroup</b>	The target group for the internal load balancer.

## Security groups

The control plane and worker machines require access to the following ports:

Group	Type	IP Protocol	Port range
<b>MasterSecurityGroup</b>	<b>AWS::EC2::SecurityGroup</b>	<b>icmp</b>	<b>0</b>
		<b>tcp</b>	<b>22</b>
		<b>tcp</b>	<b>6443</b>
		<b>tcp</b>	<b>22623</b>
<b>WorkerSecurityGroup</b>	<b>AWS::EC2::SecurityGroup</b>	<b>icmp</b>	<b>0</b>
		<b>tcp</b>	<b>22</b>
<b>BootstrapSecurityGroup</b>	<b>AWS::EC2::SecurityGroup</b>	<b>tcp</b>	<b>22</b>
		<b>tcp</b>	<b>19531</b>

## Control plane Ingress

The control plane machines require the following Ingress groups. Each Ingress group is a **AWS::EC2::SecurityGroupIngress** resource.

Ingress group	Description	IP protocol	Port range
<b>MasterIngress Etc</b>	etcd	<b>tcp</b>	<b>2379- 2380</b>
<b>MasterIngress Vxlan</b>	Vxlan packets	<b>udp</b>	<b>4789</b>
<b>MasterIngress WorkerVxlan</b>	Vxlan packets	<b>udp</b>	<b>4789</b>
<b>MasterIngress Internal</b>	Internal cluster communication and Kubernetes proxy metrics	<b>tcp</b>	<b>9000 - 9999</b>
<b>MasterIngress WorkerIntern al</b>	Internal cluster communication	<b>tcp</b>	<b>9000 - 9999</b>
<b>MasterIngress Kube</b>	Kubernetes kubelet, scheduler and controller manager	<b>tcp</b>	<b>10250 - 10259</b>
<b>MasterIngress WorkerKube</b>	Kubernetes kubelet, scheduler and controller manager	<b>tcp</b>	<b>10250 - 10259</b>
<b>MasterIngress IngressServic es</b>	Kubernetes Ingress services	<b>tcp</b>	<b>30000 - 32767</b>
<b>MasterIngress WorkerIngress Services</b>	Kubernetes Ingress services	<b>tcp</b>	<b>30000 - 32767</b>
<b>MasterIngress Geneve</b>	Geneve packets	<b>udp</b>	<b>6081</b>
<b>MasterIngress WorkerGenev e</b>	Geneve packets	<b>udp</b>	<b>6081</b>
<b>MasterIngress Ipseclke</b>	IPsec IKE packets	<b>udp</b>	<b>500</b>
<b>MasterIngress WorkerIpseclk e</b>	IPsec IKE packets	<b>udp</b>	<b>500</b>
<b>MasterIngress IpsecNat</b>	IPsec NAT-T packets	<b>udp</b>	<b>4500</b>

Ingress group	Description	IP protocol	Port range
<b>MasterIngress WorkerIpsecNat</b>	IPsec NAT-T packets	<b>udp</b>	<b>4500</b>
<b>MasterIngress IpsecEsp</b>	IPsec ESP packets	<b>50</b>	<b>All</b>
<b>MasterIngress WorkerIpsecEsp</b>	IPsec ESP packets	<b>50</b>	<b>All</b>
<b>MasterIngress InternalUDP</b>	Internal cluster communication	<b>udp</b>	<b>9000 - 9999</b>
<b>MasterIngress WorkerInternalUDP</b>	Internal cluster communication	<b>udp</b>	<b>9000 - 9999</b>
<b>MasterIngress IngressServicesUDP</b>	Kubernetes Ingress services	<b>udp</b>	<b>30000 - 32767</b>
<b>MasterIngress WorkerIngressServicesUDP</b>	Kubernetes Ingress services	<b>udp</b>	<b>30000 - 32767</b>

## Worker Ingress

The worker machines require the following Ingress groups. Each Ingress group is a **AWS::EC2::SecurityGroupIngress** resource.

Ingress group	Description	IP protocol	Port range
<b>WorkerIngress Vxlan</b>	Vxlan packets	<b>udp</b>	<b>4789</b>
<b>WorkerIngress WorkerVxlan</b>	Vxlan packets	<b>udp</b>	<b>4789</b>
<b>WorkerIngress Internal</b>	Internal cluster communication	<b>tcp</b>	<b>9000 - 9999</b>
<b>WorkerIngress WorkerInternal</b>	Internal cluster communication	<b>tcp</b>	<b>9000 - 9999</b>



Ingress group	Description	IP protocol	Port range
<b>WorkerIngress Kube</b>	Kubernetes kubelet, scheduler, and controller manager	<b>tcp</b>	<b>10250</b>
<b>WorkerIngress WorkerKube</b>	Kubernetes kubelet, scheduler, and controller manager	<b>tcp</b>	<b>10250</b>
<b>WorkerIngress IngressServices</b>	Kubernetes Ingress services	<b>tcp</b>	<b>30000 - 32767</b>
<b>WorkerIngress WorkerIngress Services</b>	Kubernetes Ingress services	<b>tcp</b>	<b>30000 - 32767</b>
<b>WorkerIngress Geneve</b>	Geneve packets	<b>udp</b>	<b>6081</b>
<b>WorkerIngress MasterGeneve</b>	Geneve packets	<b>udp</b>	<b>6081</b>
<b>WorkerIngress IpsecIke</b>	IPsec IKE packets	<b>udp</b>	<b>500</b>
<b>WorkerIngress MasterIpsecIke</b>	IPsec IKE packets	<b>udp</b>	<b>500</b>
<b>WorkerIngress IpsecNat</b>	IPsec NAT-T packets	<b>udp</b>	<b>4500</b>
<b>WorkerIngress MasterIpsecNat</b>	IPsec NAT-T packets	<b>udp</b>	<b>4500</b>
<b>WorkerIngress IpsecEsp</b>	IPsec ESP packets	<b>50</b>	<b>All</b>
<b>WorkerIngress MasterIpsecEsp</b>	IPsec ESP packets	<b>50</b>	<b>All</b>
<b>WorkerIngress InternalUDP</b>	Internal cluster communication	<b>udp</b>	<b>9000 - 9999</b>
<b>WorkerIngress MasterInternal UDP</b>	Internal cluster communication	<b>udp</b>	<b>9000 - 9999</b>

Ingress group	Description	IP protocol	Port range
<b>WorkerIngressIngressServicesUDP</b>	Kubernetes Ingress services	<b>udp</b>	<b>30000 - 32767</b>
<b>WorkerIngressMasterIngressServicesUDP</b>	Kubernetes Ingress services	<b>udp</b>	<b>30000 - 32767</b>

## Roles and instance profiles

You must grant the machines permissions in AWS. The provided CloudFormation templates grant the machines **Allow** permissions for the following **AWS::IAM::Role** objects and provide a **AWS::IAM::InstanceProfile** for each set of roles. If you do not use the templates, you can grant the machines the following broad permissions or the following individual permissions.

Role	Effect	Action	Resource
Master	<b>Allow</b>	<b>ec2:*</b>	*
	<b>Allow</b>	<b>elasticloadbalancing:*</b>	*
	<b>Allow</b>	<b>iam:PassRole</b>	*
	<b>Allow</b>	<b>s3:GetObject</b>	*
Worker	<b>Allow</b>	<b>ec2:Describe*</b>	*
Bootstrap	<b>Allow</b>	<b>ec2:Describe*</b>	*
	<b>Allow</b>	<b>ec2:AttachVolume</b>	*
	<b>Allow</b>	<b>ec2:DetachVolume</b>	*

### 4.13.5.2. Cluster machines

You need **AWS::EC2::Instance** objects for the following machines:

- A bootstrap machine. This machine is required during installation, but you can remove it after your cluster deploys.
- Three control plane machines. The control plane machines are not governed by a machine set.
- Compute machines. You must create at least two compute machines, which are also known as worker machines, during installation. These machines are not governed by a machine set.

### 4.13.5.3. Required AWS permissions for the IAM user

**NOTE**

Your IAM user must have the permission **tag:GetResources** in the region **us-east-1** to delete the base cluster resources. As part of the AWS API requirement, the OpenShift Container Platform installation program performs various actions in this region.

When you attach the **AdministratorAccess** policy to the IAM user that you create in Amazon Web Services (AWS), you grant that user all of the required permissions. To deploy all components of an OpenShift Container Platform cluster, the IAM user requires the following permissions:

**Example 4.43. Required EC2 permissions for installation**

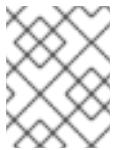
- **ec2:AuthorizeSecurityGroupEgress**
- **ec2:AuthorizeSecurityGroupIngress**
- **ec2:CopyImage**
- **ec2:CreateNetworkInterface**
- **ec2:AttachNetworkInterface**
- **ec2:CreateSecurityGroup**
- **ec2:CreateTags**
- **ec2:CreateVolume**
- **ec2>DeleteSecurityGroup**
- **ec2>DeleteSnapshot**
- **ec2>DeleteTags**
- **ec2:DeregisterImage**
- **ec2:DescribeAccountAttributes**
- **ec2:DescribeAddresses**
- **ec2:DescribeAvailabilityZones**
- **ec2:DescribeDhcpOptions**
- **ec2:DescribeImages**
- **ec2:DescribeInstanceAttribute**
- **ec2:DescribeInstanceCreditSpecifications**
- **ec2:DescribeInstances**
- **ec2:DescribeInstanceTypes**
- **ec2:DescribeInternetGateways**
- **ec2:DescribeKeyPairs**

- **ec2:DescribeNatGateways**
- **ec2:DescribeNetworkAcls**
- **ec2:DescribeNetworkInterfaces**
- **ec2:DescribePrefixLists**
- **ec2:DescribeRegions**
- **ec2:DescribeRouteTables**
- **ec2:DescribeSecurityGroups**
- **ec2:DescribeSubnets**
- **ec2:DescribeTags**
- **ec2:DescribeVolumes**
- **ec2:DescribeVpcAttribute**
- **ec2:DescribeVpcClassicLink**
- **ec2:DescribeVpcClassicLinkDnsSupport**
- **ec2:DescribeVpcEndpoints**
- **ec2:DescribeVpcs**
- **ec2:GetEbsDefaultKmsKeyId**
- **ec2:ModifyInstanceAttribute**
- **ec2:ModifyNetworkInterfaceAttribute**
- **ec2:RevokeSecurityGroupEgress**
- **ec2:RevokeSecurityGroupIngress**
- **ec2:RunInstances**
- **ec2:TerminateInstances**

Example 4.44. Required permissions for creating network resources during installation

- **ec2:AllocateAddress**
- **ec2:AssociateAddress**
- **ec2:AssociateDhcpOptions**
- **ec2:AssociateRouteTable**
- **ec2:AttachInternetGateway**
- **ec2:CreateDhcpOptions**

- **ec2:CreateInternetGateway**
- **ec2:CreateNatGateway**
- **ec2:CreateRoute**
- **ec2:CreateRouteTable**
- **ec2:CreateSubnet**
- **ec2:CreateVpc**
- **ec2:CreateVpcEndpoint**
- **ec2:ModifySubnetAttribute**
- **ec2:ModifyVpcAttribute**

**NOTE**

If you use an existing VPC, your account does not require these permissions for creating network resources.

**Example 4.45. Required Elastic Load Balancing permissions (ELB) for installation**

- **elasticloadbalancing:AddTags**
- **elasticloadbalancing:ApplySecurityGroupsToLoadBalancer**
- **elasticloadbalancing:AttachLoadBalancerToSubnets**
- **elasticloadbalancing:ConfigureHealthCheck**
- **elasticloadbalancing:CreateLoadBalancer**
- **elasticloadbalancing:CreateLoadBalancerListeners**
- **elasticloadbalancing>DeleteLoadBalancer**
- **elasticloadbalancing:DeregisterInstancesFromLoadBalancer**
- **elasticloadbalancing:DescribeInstanceHealth**
- **elasticloadbalancing:DescribeLoadBalancerAttributes**
- **elasticloadbalancing:DescribeLoadBalancers**
- **elasticloadbalancing:DescribeTags**
- **elasticloadbalancing:ModifyLoadBalancerAttributes**
- **elasticloadbalancing:RegisterInstancesWithLoadBalancer**
- **elasticloadbalancing:SetLoadBalancerPoliciesOfListener**

**Example 4.46. Required Elastic Load Balancing permissions (ELBv2) for installation**

- **elasticloadbalancing:AddTags**
- **elasticloadbalancing:CreateListener**
- **elasticloadbalancing:CreateLoadBalancer**
- **elasticloadbalancing:CreateTargetGroup**
- **elasticloadbalancing>DeleteLoadBalancer**
- **elasticloadbalancing:DeregisterTargets**
- **elasticloadbalancing:DescribeListeners**
- **elasticloadbalancing:DescribeLoadBalancerAttributes**
- **elasticloadbalancing:DescribeLoadBalancers**
- **elasticloadbalancing:DescribeTargetGroupAttributes**
- **elasticloadbalancing:DescribeTargetHealth**
- **elasticloadbalancing:ModifyLoadBalancerAttributes**
- **elasticloadbalancing:ModifyTargetGroup**
- **elasticloadbalancing:ModifyTargetGroupAttributes**
- **elasticloadbalancing:RegisterTargets**

**Example 4.47. Required IAM permissions for installation**

- **iam:AddRoleToInstanceProfile**
- **iam:CreateInstanceProfile**
- **iam:CreateRole**
- **iam>DeleteInstanceProfile**
- **iam>DeleteRole**
- **iam>DeleteRolePolicy**
- **iam:GetInstanceProfile**
- **iam:GetRole**
- **iam:GetRolePolicy**
- **iam:GetUser**
- **iam:ListInstanceProfilesForRole**

- **iam:ListRoles**
- **iam:ListUsers**
- **iam:PassRole**
- **iam:PutRolePolicy**
- **iam:RemoveRoleFromInstanceProfile**
- **iam:SimulatePrincipalPolicy**
- **iam:TagRole**

**NOTE**

If you have not created an elastic load balancer (ELB) in your AWS account, the IAM user also requires the **iam:CreateServiceLinkedRole** permission.

**Example 4.48. Required Route 53 permissions for installation**

- **route53:ChangeResourceRecordSets**
- **route53:ChangeTagsForResource**
- **route53:CreateHostedZone**
- **route53>DeleteHostedZone**
- **route53:GetChange**
- **route53:GetHostedZone**
- **route53:ListHostedZones**
- **route53:ListHostedZonesByName**
- **route53:ListResourceRecordSets**
- **route53:ListTagsForResource**
- **route53:UpdateHostedZoneComment**

**Example 4.49. Required S3 permissions for installation**

- **s3:CreateBucket**
- **s3>DeleteBucket**
- **s3:GetAccelerateConfiguration**
- **s3:GetBucketAcl**
- **s3:GetBucketCors**

- **s3:GetBucketLocation**
- **s3:GetBucketLogging**
- **s3:GetBucketObjectLockConfiguration**
- **s3:GetBucketReplication**
- **s3:GetBucketRequestPayment**
- **s3:GetBucketTagging**
- **s3:GetBucketVersioning**
- **s3:GetBucketWebsite**
- **s3:GetEncryptionConfiguration**
- **s3:GetLifecycleConfiguration**
- **s3:GetReplicationConfiguration**
- **s3:ListBucket**
- **s3:PutBucketAcl**
- **s3:PutBucketTagging**
- **s3:PutEncryptionConfiguration**

Example 4.50. S3 permissions that cluster Operators require

- **s3:DeleteObject**
- **s3:GetObject**
- **s3:GetObjectAcl**
- **s3:GetObjectTagging**
- **s3:GetObjectVersion**
- **s3:PutObject**
- **s3:PutObjectAcl**
- **s3:PutObjectTagging**

Example 4.51. Required permissions to delete base cluster resources

- **autoscaling:DescribeAutoScalingGroups**
- **ec2:DeleteNetworkInterface**
- **ec2:DeleteVolume**



- **elasticloadbalancing:DeleteTargetGroup**
- **elasticloadbalancing:DescribeTargetGroups**
- **iam:DeleteAccessKey**
- **iam:DeleteUser**
- **iam:ListAttachedRolePolicies**
- **iam:ListInstanceProfiles**
- **iam:ListRolePolicies**
- **iam:ListUserPolicies**
- **s3:DeleteObject**
- **s3:ListBucketVersions**
- **tag:GetResources**

Example 4.52. Required permissions to delete network resources

- **ec2:DeleteDhcpOptions**
- **ec2:DeleteInternetGateway**
- **ec2:DeleteNatGateway**
- **ec2:DeleteRoute**
- **ec2:DeleteRouteTable**
- **ec2:DeleteSubnet**
- **ec2:DeleteVpc**
- **ec2:DeleteVpcEndpoints**
- **ec2:DetachInternetGateway**
- **ec2:DisassociateRouteTable**
- **ec2:ReleaseAddress**
- **ec2:ReplaceRouteTableAssociation**



#### NOTE

If you use an existing VPC, your account does not require these permissions to delete network resources. Instead, your account only requires the **tag:UntagResources** permission to delete network resources.

**Example 4.53. Required permissions to delete a cluster with shared instance roles**

- **iam:UntagRole**

**Example 4.54. Additional IAM and S3 permissions that are required to create manifests**

- **iam>DeleteAccessKey**
- **iam>DeleteUser**
- **iam>DeleteUserPolicy**
- **iam:GetUserPolicy**
- **iam>ListAccessKeys**
- **iam:PutUserPolicy**
- **iam:TagUser**
- **s3:PutBucketPublicAccessBlock**
- **s3:GetBucketPublicAccessBlock**
- **s3:PutLifecycleConfiguration**
- **s3:HeadBucket**
- **s3:ListBucketMultipartUploads**
- **s3:AbortMultipartUpload**

**NOTE**

If you are managing your cloud provider credentials with mint mode, the IAM user also requires the **iam:CreateAccessKey** and **iam:CreateUser** permissions.

**Example 4.55. Optional permissions for instance and quota checks for installation**

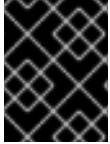
- **ec2:DescribeInstanceTypeOfferings**
- **servicequotas:ListAWSDefaultServiceQuotas**

### 4.13.6. Generating a key pair for cluster node SSH access

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

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

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



### IMPORTANT

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



### NOTE

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

## Procedure

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

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

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



### NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

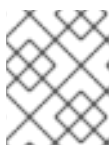
2. View the public SSH key:

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

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

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

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



### NOTE

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

#### Example output

```
Agent pid 31874
```



#### NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1** Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

#### Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

#### Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program. If you install a cluster on infrastructure that you provision, you must provide the key to the installation program.

### 4.13.7. Creating the installation files for AWS

To install OpenShift Container Platform on Amazon Web Services (AWS) using user-provisioned infrastructure, you must generate the files that the installation program needs to deploy your cluster and modify them so that the cluster creates only the machines that it will use. You generate and customize the **install-config.yaml** file, Kubernetes manifests, and Ignition config files. You also have the option to first set up a separate **var** partition during the preparation phases of installation.

#### 4.13.7.1. Optional: Creating a separate **/var** partition

It is recommended that disk partitioning for OpenShift Container Platform be left to the installer. However, there are cases where you might want to create separate partitions in a part of the filesystem that you expect to grow.

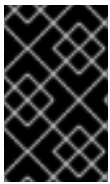
OpenShift Container Platform supports the addition of a single partition to attach storage to either the **/var** partition or a subdirectory of **/var**. For example:

- **/var/lib/containers**: Holds container-related content that can grow as more images and containers are added to a system.

- **/var/lib/etcd**: Holds data that you might want to keep separate for purposes such as performance optimization of etcd storage.
- **/var**: Holds data that you might want to keep separate for purposes such as auditing.

Storing the contents of a **/var** directory separately makes it easier to grow storage for those areas as needed and reinstall OpenShift Container Platform at a later date and keep that data intact. With this method, you will not have to pull all your containers again, nor will you have to copy massive log files when you update systems.

Because **/var** must be in place before a fresh installation of Red Hat Enterprise Linux CoreOS (RHCOS), the following procedure sets up the separate **/var** partition by creating a machine config manifest that is inserted during the **openshift-install** preparation phases of an OpenShift Container Platform installation.



### IMPORTANT

If you follow the steps to create a separate **/var** partition in this procedure, it is not necessary to create the Kubernetes manifest and Ignition config files again as described later in this section.

### Procedure

1. Create a directory to hold the OpenShift Container Platform installation files:

```
$ mkdir $HOME/clusterconfig
```

2. Run **openshift-install** to create a set of files in the **manifest** and **openshift** subdirectories. Answer the system questions as you are prompted:

```
$ openshift-install create manifests --dir $HOME/clusterconfig
```

### Example output

```
? SSH Public Key ...
INFO Credentials loaded from the "myprofile" profile in file "/home/myuser/.aws/credentials"
INFO Consuming Install Config from target directory
INFO Manifests created in: $HOME/clusterconfig/manifests and
$HOME/clusterconfig/openshift
```

3. Optional: Confirm that the installation program created manifests in the **clusterconfig/openshift** directory:

```
$ ls $HOME/clusterconfig/openshift/
```

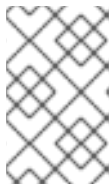
### Example output

```
99_kubeadmin-password-secret.yaml
99_openshift-cluster-api_master-machines-0.yaml
99_openshift-cluster-api_master-machines-1.yaml
99_openshift-cluster-api_master-machines-2.yaml
...
```

4. Create a Butane config that configures the additional partition. For example, name the file **\$HOME/clusterconfig/98-var-partition.bu**, change the disk device name to the name of the storage device on the **worker** systems, and set the storage size as appropriate. This example places the **/var** directory on a separate partition:

```
variant: openshift
version: 4.9.0
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 98-var-partition
storage:
  disks:
    - device: /dev/<device_name> 1
      partitions:
        - label: var
          start_mib: <partition_start_offset> 2
          size_mib: <partition_size> 3
      filesystems:
        - device: /dev/disk/by-partlabel/var
          path: /var
          format: xfs
          mount_options: [defaults, prjquota] 4
          with_mount_unit: true
```

- 1 The storage device name of the disk that you want to partition.
- 2 When adding a data partition to the boot disk, a minimum value of 25000 MiB (Mebibytes) is recommended. The root file system is automatically resized to fill all available space up to the specified offset. If no value is specified, or if the specified value is smaller than the recommended minimum, the resulting root file system will be too small, and future reinstalls of RHCOS might overwrite the beginning of the data partition.
- 3 The size of the data partition in mebibytes.
- 4 The **prjquota** mount option must be enabled for filesystems used for container storage.



#### NOTE

When creating a separate **/var** partition, you cannot use different instance types for worker nodes, if the different instance types do not have the same device name.

5. Create a manifest from the Butane config and save it to the **clusterconfig/openshift** directory. For example, run the following command:

```
$ butane $HOME/clusterconfig/98-var-partition.bu -o $HOME/clusterconfig/openshift/98-var-partition.yaml
```

6. Run **openshift-install** again to create Ignition configs from a set of files in the **manifest** and **openshift** subdirectories:

```
$ openshift-install create ignition-configs --dir $HOME/clusterconfig
$ ls $HOME/clusterconfig/
auth bootstrap.ign master.ign metadata.json worker.ign
```

Now you can use the Ignition config files as input to the installation procedures to install Red Hat Enterprise Linux CoreOS (RHCOS) systems.

#### 4.13.7.2. Creating the installation configuration file

Generate and customize the installation configuration file that the installation program needs to deploy your cluster.

##### Prerequisites

- You obtained the OpenShift Container Platform installation program for user-provisioned infrastructure and the pull secret for your cluster. For a restricted network installation, these files are on your mirror host.
- You checked that you are deploying your cluster to a region with an accompanying Red Hat Enterprise Linux CoreOS (RHCOS) AMI published by Red Hat. If you are deploying to a region that requires a custom AMI, such as an AWS GovCloud region, you must create the **install-config.yaml** file manually.

##### Procedure

1. Create the **install-config.yaml** file.
  - a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

- 1** For **<installation\_directory>**, specify the directory name to store the files that the installation program creates.



##### IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

- b. At the prompts, provide the configuration details for your cloud:
  - i. Optional: Select an SSH key to use to access your cluster machines.

**NOTE**

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

- ii. Select **aws** as the platform to target.
- iii. If you do not have an AWS profile stored on your computer, enter the AWS access key ID and secret access key for the user that you configured to run the installation program.

**NOTE**

The AWS access key ID and secret access key are stored in `~/.aws/credentials` in the home directory of the current user on the installation host. You are prompted for the credentials by the installation program if the credentials for the exported profile are not present in the file. Any credentials that you provide to the installation program are stored in the file.

- iv. Select the AWS region to deploy the cluster to.
  - v. Select the base domain for the Route 53 service that you configured for your cluster.
  - vi. Enter a descriptive name for your cluster.
  - vii. Paste the [pull secret from the Red Hat OpenShift Cluster Manager](#) .
2. Edit the **install-config.yaml** file to provide the additional information that is required for an installation in a restricted network.
    - a. Update the **pullSecret** value to contain the authentication information for your registry:

```
pullSecret: '{"auths":{"<local_registry>": {"auth": "<credentials>","email": "you@example.com"}}}'
```

For **<local\_registry>**, specify the registry domain name, and optionally the port, that your mirror registry uses to serve content. For example **registry.example.com** or **registry.example.com:5000**. For **<credentials>**, specify the base64-encoded user name and password for your mirror registry.

- b. Add the **additionalTrustBundle** parameter and value. The value must be the contents of the certificate file that you used for your mirror registry, which can be an existing, trusted certificate authority or the self-signed certificate that you generated for the mirror registry.

```
additionalTrustBundle: |
  -----BEGIN CERTIFICATE-----
  /-----END CERTIFICATE-----
```

- c. Add the image content resources:

```
imageContentSources:
```



```

- mirrors:
  - <local_registry>/<local_repository_name>/release
    source: quay.io/openshift-release-dev/ocp-release
- mirrors:
  - <local_registry>/<local_repository_name>/release
    source: quay.io/openshift-release-dev/ocp-v4.0-art-dev

```

Use the **imageContentSources** section from the output of the command to mirror the repository or the values that you used when you mirrored the content from the media that you brought into your restricted network.

- d. Optional: Set the publishing strategy to **Internal**:

```
publish: Internal
```

By setting this option, you create an internal Ingress Controller and a private load balancer.

3. Optional: Back up the **install-config.yaml** file.



### IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

### Additional resources

- See [Configuration and credential file settings](#) in the AWS documentation for more information about AWS profile and credential configuration.

#### 4.13.7.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

### Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



### NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

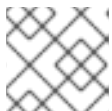
- You have added the **ec2.<region>.amazonaws.com**, **elasticloadbalancing.<region>.amazonaws.com**, and **s3.<region>.amazonaws.com** endpoints to your VPC endpoint. These endpoints are required to complete requests from the nodes to the AWS EC2 API. Because the proxy works on the container level, not the node level, you must route these requests to the AWS EC2 API through the AWS private network. Adding the public IP address of the EC2 API to your allowlist in your proxy server is not sufficient.

## Procedure

- Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
  -----BEGIN CERTIFICATE-----
  <MY_TRUSTED_CA_CERT>
  -----END CERTIFICATE-----
...
```

- A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- A proxy URL to use for creating HTTPS connections outside the cluster.
- A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations.
- If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.



### NOTE

The installation program does not support the proxy **readinessEndpoints** field.

- Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

**NOTE**

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

#### 4.13.7.4. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.

**IMPORTANT**

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

**Prerequisites**

- You obtained the OpenShift Container Platform installation program. For a restricted network installation, these files are on your mirror host.
- You created the **install-config.yaml** installation configuration file.

**Procedure**

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

- 1** For **<installation\_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

2. Remove the Kubernetes manifest files that define the control plane machines:

```
$ rm -f <installation_directory>/openshift/99_openshift-cluster-api_master-machines-*.yaml
```

By removing these files, you prevent the cluster from automatically generating control plane machines.

- Remove the Kubernetes manifest files that define the worker machines:

```
$ rm -f <installation_directory>/openshift/99_openshift-cluster-api_worker-machineset-*.yaml
```

Because you create and manage the worker machines yourself, you do not need to initialize these machines.

- Check that the **mastersSchedulable** parameter in the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:
  - Open the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** file.
  - Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.
  - Save and exit the file.
- Optional: If you do not want [the Ingress Operator](#) to create DNS records on your behalf, remove the **privateZone** and **publicZone** sections from the **<installation\_directory>/manifests/cluster-dns-02-config.yml** DNS configuration file:

```
apiVersion: config.openshift.io/v1
kind: DNS
metadata:
  creationTimestamp: null
  name: cluster
spec:
  baseDomain: example.openshift.com
  privateZone: 1
    id: mycluster-100419-private-zone
  publicZone: 2
    id: example.openshift.com
status: {}
```

- Remove this section completely.

If you do so, you must add ingress DNS records manually in a later step.

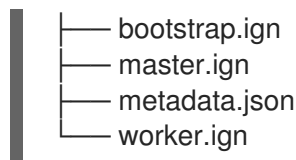
- To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

- For **<installation\_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation\_directory>/auth** directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
```



### 4.13.8. Extracting the infrastructure name

The Ignition config files contain a unique cluster identifier that you can use to uniquely identify your cluster in Amazon Web Services (AWS). The infrastructure name is also used to locate the appropriate AWS resources during an OpenShift Container Platform installation. The provided CloudFormation templates contain references to this infrastructure name, so you must extract it.

#### Prerequisites

- You obtained the OpenShift Container Platform installation program and the pull secret for your cluster.
- You generated the Ignition config files for your cluster.
- You installed the **jq** package.

#### Procedure

- To extract and view the infrastructure name from the Ignition config file metadata, run the following command:

```
$ jq -r .infraID <installation_directory>/metadata.json 1
```

- 1 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

#### Example output

```
openshift-vw9j6 1
```

- 1 The output of this command is your cluster name and a random string.

### 4.13.9. Creating a VPC in AWS

You must create a Virtual Private Cloud (VPC) in Amazon Web Services (AWS) for your OpenShift Container Platform cluster to use. You can customize the VPC to meet your requirements, including VPN and route tables.

You can use the provided CloudFormation template and a custom parameter file to create a stack of AWS resources that represent the VPC.



#### NOTE

If you do not use the provided CloudFormation template to create your AWS infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

## Prerequisites

- You configured an AWS account.
- You added your AWS keys and region to your local AWS profile by running **aws configure**.
- You generated the Ignition config files for your cluster.

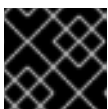
## Procedure

1. Create a JSON file that contains the parameter values that the template requires:

```
[
  {
    "ParameterKey": "VpcCidr", 1
    "ParameterValue": "10.0.0.0/16" 2
  },
  {
    "ParameterKey": "AvailabilityZoneCount", 3
    "ParameterValue": "1" 4
  },
  {
    "ParameterKey": "SubnetBits", 5
    "ParameterValue": "12" 6
  }
]
```

- 1** The CIDR block for the VPC.
- 2** Specify a CIDR block in the format **x.x.x.x/16-24**.
- 3** The number of availability zones to deploy the VPC in.
- 4** Specify an integer between **1** and **3**.
- 5** The size of each subnet in each availability zone.
- 6** Specify an integer between **5** and **13**, where **5** is /27 and **13** is /19.

2. Copy the template from the **CloudFormation template for the VPC** section of this topic and save it as a YAML file on your computer. This template describes the VPC that your cluster requires.
3. Launch the CloudFormation template to create a stack of AWS resources that represent the VPC:



### IMPORTANT

You must enter the command on a single line.

```
$ aws cloudformation create-stack --stack-name <name> 1
  --template-body file://<template>.yaml 2
  --parameters file://<parameters>.json 3
```

- 1 **<name>** is the name for the CloudFormation stack, such as **cluster-vpc**. You need the name of this stack if you remove the cluster.
- 2 **<template>** is the relative path to and name of the CloudFormation template YAML file that you saved.
- 3 **<parameters>** is the relative path to and name of the CloudFormation parameters JSON file.

### Example output

```
arn:aws:cloudformation:us-east-1:269333783861:stack/cluster-vpc/dbedae40-2fd3-11eb-820e-12a48460849f
```

4. Confirm that the template components exist:

```
$ aws cloudformation describe-stacks --stack-name <name>
```

After the **StackStatus** displays **CREATE\_COMPLETE**, the output displays values for the following parameters. You must provide these parameter values to the other CloudFormation templates that you run to create your cluster:

<b>VpcId</b>	The ID of your VPC.
<b>PublicSubnetIds</b>	The IDs of the new public subnets.
<b>PrivateSubnetIds</b>	The IDs of the new private subnets.

#### 4.13.9.1. CloudFormation template for the VPC

You can use the following CloudFormation template to deploy the VPC that you need for your OpenShift Container Platform cluster.

##### Example 4.56. CloudFormation template for the VPC

```
AWSTemplateFormatVersion: 2010-09-09
Description: Template for Best Practice VPC with 1-3 AZs

Parameters:
  VpcCidr:
    AllowedPattern: ^(((0-9){1,3}(0-9){1,3}|1[0-9]{2}|2[0-4][0-9]|25[0-5])\.)\.{3}((0-9){1,3}|1[0-9]{2}|2[0-4][0-9]|25[0-5])((1[6-9]|2[0-4]))$
    ConstraintDescription: CIDR block parameter must be in the form x.x.x.x/16-24.
    Default: 10.0.0.0/16
    Description: CIDR block for VPC.
    Type: String
  AvailabilityZoneCount:
    ConstraintDescription: "The number of availability zones. (Min: 1, Max: 3)"
    MinValue: 1
    MaxValue: 3
```

```

Default: 1
Description: "How many AZs to create VPC subnets for. (Min: 1, Max: 3)"
Type: Number
SubnetBits:
ConstraintDescription: CIDR block parameter must be in the form x.x.x.x/19-27.
MinValue: 5
MaxValue: 13
Default: 12
Description: "Size of each subnet to create within the availability zones. (Min: 5 = /27, Max: 13 =
/19)"
Type: Number

Metadata:
AWS::CloudFormation::Interface:
ParameterGroups:
- Label:
  default: "Network Configuration"
Parameters:
- VpcCidr
- SubnetBits
- Label:
  default: "Availability Zones"
Parameters:
- AvailabilityZoneCount
ParameterLabels:
AvailabilityZoneCount:
  default: "Availability Zone Count"
VpcCidr:
  default: "VPC CIDR"
SubnetBits:
  default: "Bits Per Subnet"

Conditions:
DoAz3: !Equals [3, !Ref AvailabilityZoneCount]
DoAz2: !Or [!Equals [2, !Ref AvailabilityZoneCount], Condition: DoAz3]

Resources:
VPC:
Type: "AWS::EC2::VPC"
Properties:
  EnableDnsSupport: "true"
  EnableDnsHostnames: "true"
  CidrBlock: !Ref VpcCidr
PublicSubnet:
Type: "AWS::EC2::Subnet"
Properties:
  VpcId: !Ref VPC
  CidrBlock: !Select [0, !Cidr [!Ref VpcCidr, 6, !Ref SubnetBits]]
  AvailabilityZone: !Select
  - 0
  - Fn::GetAZs: !Ref "AWS::Region"
PublicSubnet2:
Type: "AWS::EC2::Subnet"
Condition: DoAz2
Properties:
  VpcId: !Ref VPC

```



```

CidrBlock: !Select [1, !Cidr [!Ref VpcCidr, 6, !Ref SubnetBits]]
AvailabilityZone: !Select
- 1
- Fn::GetAZs: !Ref "AWS::Region"
PublicSubnet3:
Type: "AWS::EC2::Subnet"
Condition: DoAz3
Properties:
VpcId: !Ref VPC
CidrBlock: !Select [2, !Cidr [!Ref VpcCidr, 6, !Ref SubnetBits]]
AvailabilityZone: !Select
- 2
- Fn::GetAZs: !Ref "AWS::Region"
InternetGateway:
Type: "AWS::EC2::InternetGateway"
GatewayToInternet:
Type: "AWS::EC2::VPCGatewayAttachment"
Properties:
VpcId: !Ref VPC
InternetGatewayId: !Ref InternetGateway
PublicRouteTable:
Type: "AWS::EC2::RouteTable"
Properties:
VpcId: !Ref VPC
PublicRoute:
Type: "AWS::EC2::Route"
DependsOn: GatewayToInternet
Properties:
RouteTableId: !Ref PublicRouteTable
DestinationCidrBlock: 0.0.0.0/0
GatewayId: !Ref InternetGateway
PublicSubnetRouteTableAssociation:
Type: "AWS::EC2::SubnetRouteTableAssociation"
Properties:
SubnetId: !Ref PublicSubnet
RouteTableId: !Ref PublicRouteTable
PublicSubnetRouteTableAssociation2:
Type: "AWS::EC2::SubnetRouteTableAssociation"
Condition: DoAz2
Properties:
SubnetId: !Ref PublicSubnet2
RouteTableId: !Ref PublicRouteTable
PublicSubnetRouteTableAssociation3:
Condition: DoAz3
Type: "AWS::EC2::SubnetRouteTableAssociation"
Properties:
SubnetId: !Ref PublicSubnet3
RouteTableId: !Ref PublicRouteTable
PrivateSubnet:
Type: "AWS::EC2::Subnet"
Properties:
VpcId: !Ref VPC
CidrBlock: !Select [3, !Cidr [!Ref VpcCidr, 6, !Ref SubnetBits]]
AvailabilityZone: !Select
- 0
- Fn::GetAZs: !Ref "AWS::Region"

```

```
PrivateRouteTable:
  Type: "AWS::EC2::RouteTable"
  Properties:
    VpcId: !Ref VPC
PrivateSubnetRouteTableAssociation:
  Type: "AWS::EC2::SubnetRouteTableAssociation"
  Properties:
    SubnetId: !Ref PrivateSubnet
    RouteTableId: !Ref PrivateRouteTable
NAT:
  DependsOn:
    - GatewayToInternet
  Type: "AWS::EC2::NatGateway"
  Properties:
    AllocationId:
      "Fn::GetAtt":
        - EIP
        - AllocationId
    SubnetId: !Ref PublicSubnet
EIP:
  Type: "AWS::EC2::EIP"
  Properties:
    Domain: vpc
Route:
  Type: "AWS::EC2::Route"
  Properties:
    RouteTableId:
      Ref: PrivateRouteTable
    DestinationCidrBlock: 0.0.0.0/0
    NatGatewayId:
      Ref: NAT
PrivateSubnet2:
  Type: "AWS::EC2::Subnet"
  Condition: DoAz2
  Properties:
    VpcId: !Ref VPC
    CidrBlock: !Select [4, !Cidr [!Ref VpcCidr, 6, !Ref SubnetBits]]
    AvailabilityZone: !Select
      - 1
      - Fn::GetAZs: !Ref "AWS::Region"
PrivateRouteTable2:
  Type: "AWS::EC2::RouteTable"
  Condition: DoAz2
  Properties:
    VpcId: !Ref VPC
PrivateSubnetRouteTableAssociation2:
  Type: "AWS::EC2::SubnetRouteTableAssociation"
  Condition: DoAz2
  Properties:
    SubnetId: !Ref PrivateSubnet2
    RouteTableId: !Ref PrivateRouteTable2
NAT2:
  DependsOn:
    - GatewayToInternet
  Type: "AWS::EC2::NatGateway"
  Condition: DoAz2
```

```

Properties:
  AllocationId:
    "Fn::GetAtt":
      - EIP2
      - AllocationId
  SubnetId: !Ref PublicSubnet2
EIP2:
  Type: "AWS::EC2::EIP"
  Condition: DoAz2
  Properties:
    Domain: vpc
Route2:
  Type: "AWS::EC2::Route"
  Condition: DoAz2
  Properties:
    RouteTableId:
      Ref: PrivateRouteTable2
    DestinationCidrBlock: 0.0.0.0/0
    NatGatewayId:
      Ref: NAT2
PrivateSubnet3:
  Type: "AWS::EC2::Subnet"
  Condition: DoAz3
  Properties:
    VpcId: !Ref VPC
    CidrBlock: !Select [5, !Cidr [!Ref VpcCidr, 6, !Ref SubnetBits]]
    AvailabilityZone: !Select
      - 2
      - Fn::GetAZs: !Ref "AWS::Region"
PrivateRouteTable3:
  Type: "AWS::EC2::RouteTable"
  Condition: DoAz3
  Properties:
    VpcId: !Ref VPC
PrivateSubnetRouteTableAssociation3:
  Type: "AWS::EC2::SubnetRouteTableAssociation"
  Condition: DoAz3
  Properties:
    SubnetId: !Ref PrivateSubnet3
    RouteTableId: !Ref PrivateRouteTable3
NAT3:
  DependsOn:
    - GatewayToInternet
  Type: "AWS::EC2::NatGateway"
  Condition: DoAz3
  Properties:
    AllocationId:
      "Fn::GetAtt":
        - EIP3
        - AllocationId
    SubnetId: !Ref PublicSubnet3
EIP3:
  Type: "AWS::EC2::EIP"
  Condition: DoAz3
  Properties:
    Domain: vpc

```

```

Route3:
  Type: "AWS::EC2::Route"
  Condition: DoAz3
  Properties:
    RouteTableId:
      Ref: PrivateRouteTable3
    DestinationCidrBlock: 0.0.0.0/0
    NatGatewayId:
      Ref: NAT3
S3Endpoint:
  Type: AWS::EC2::VPCEndpoint
  Properties:
    PolicyDocument:
      Version: 2012-10-17
      Statement:
        - Effect: Allow
          Principal: '*'
          Action:
            - '*'
          Resource:
            - '*'
    RouteTableIds:
      - !Ref PublicRouteTable
      - !Ref PrivateRouteTable
      - !If [DoAz2, !Ref PrivateRouteTable2, !Ref "AWS::NoValue"]
      - !If [DoAz3, !Ref PrivateRouteTable3, !Ref "AWS::NoValue"]
    ServiceName: !Join
      - "
      - - com.amazonaws.
      - - !Ref 'AWS::Region'
      - - .s3
    VpId: !Ref VPC

Outputs:
VpId:
  Description: ID of the new VPC.
  Value: !Ref VPC
PublicSubnetIds:
  Description: Subnet IDs of the public subnets.
  Value:
    !Join [
      - "
      - [!Ref PublicSubnet, !If [DoAz2, !Ref PublicSubnet2, !Ref "AWS::NoValue"], !If [DoAz3, !Ref
PublicSubnet3, !Ref "AWS::NoValue"]]
    ]
PrivateSubnetIds:
  Description: Subnet IDs of the private subnets.
  Value:
    !Join [
      - "
      - [!Ref PrivateSubnet, !If [DoAz2, !Ref PrivateSubnet2, !Ref "AWS::NoValue"], !If [DoAz3, !Ref
PrivateSubnet3, !Ref "AWS::NoValue"]]
    ]

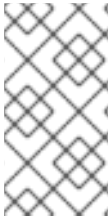
```

### 4.13.10. Creating networking and load balancing components in AWS

You must configure networking and classic or network load balancing in Amazon Web Services (AWS) that your OpenShift Container Platform cluster can use.

You can use the provided CloudFormation template and a custom parameter file to create a stack of AWS resources. The stack represents the networking and load balancing components that your OpenShift Container Platform cluster requires. The template also creates a hosted zone and subnet tags.

You can run the template multiple times within a single Virtual Private Cloud (VPC).



#### NOTE

If you do not use the provided CloudFormation template to create your AWS infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

#### Prerequisites

- You configured an AWS account.
- You added your AWS keys and region to your local AWS profile by running **aws configure**.
- You generated the Ignition config files for your cluster.
- You created and configured a VPC and associated subnets in AWS.

#### Procedure

1. Obtain the hosted zone ID for the Route 53 base domain that you specified in the **install-config.yaml** file for your cluster. You can obtain details about your hosted zone by running the following command:

```
$ aws route53 list-hosted-zones-by-name --dns-name <route53_domain> 1
```

- 1** For the **<route53\_domain>**, specify the Route 53 base domain that you used when you generated the **install-config.yaml** file for the cluster.

#### Example output

```
mycluster.example.com. False 100
HOSTEDZONES 65F8F38E-2268-B835-E15C-AB55336FCBFA
/hostedzone/Z21IXYZABCZ2A4 mycluster.example.com. 10
```

In the example output, the hosted zone ID is **Z21IXYZABCZ2A4**.

2. Create a JSON file that contains the parameter values that the template requires:

```
[
  {
    "ParameterKey": "ClusterName", 1
    "ParameterValue": "mycluster" 2
  }
]
```

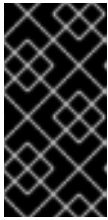
```

},
{
  "ParameterKey": "InfrastructureName", ❸
  "ParameterValue": "mycluster-<random_string>" ❹
},
{
  "ParameterKey": "HostedZoneId", ❺
  "ParameterValue": "<random_string>" ❻
},
{
  "ParameterKey": "HostedZoneName", ❼
  "ParameterValue": "example.com" ❽
},
{
  "ParameterKey": "PublicSubnets", ❾
  "ParameterValue": "subnet-<random_string>" ❿
},
{
  "ParameterKey": "PrivateSubnets", ⓫
  "ParameterValue": "subnet-<random_string>" ⓬
},
{
  "ParameterKey": "VpcId", ⓭
  "ParameterValue": "vpc-<random_string>" ⓮
}
]

```

- ❶ A short, representative cluster name to use for hostnames, etc.
- ❷ Specify the cluster name that you used when you generated the **install-config.yaml** file for the cluster.
- ❸ The name for your cluster infrastructure that is encoded in your Ignition config files for the cluster.
- ❹ Specify the infrastructure name that you extracted from the Ignition config file metadata, which has the format **<cluster-name>-<random-string>**.
- ❺ The Route 53 public zone ID to register the targets with.
- ❻ Specify the Route 53 public zone ID, which as a format similar to **Z21IXYZABCZ2A4**. You can obtain this value from the AWS console.
- ❼ The Route 53 zone to register the targets with.
- ❽ Specify the Route 53 base domain that you used when you generated the **install-config.yaml** file for the cluster. Do not include the trailing period (.) that is displayed in the AWS console.
- ❾ The public subnets that you created for your VPC.
- ❿ Specify the **PublicSubnetIds** value from the output of the CloudFormation template for the VPC.
- ⓫ The private subnets that you created for your VPC.

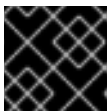
- 12 Specify the **PrivateSubnetIds** value from the output of the CloudFormation template for the VPC.
  - 13 The VPC that you created for the cluster.
  - 14 Specify the **VpcId** value from the output of the CloudFormation template for the VPC.
3. Copy the template from the **CloudFormation template for the network and load balancers** section of this topic and save it as a YAML file on your computer. This template describes the networking and load balancing objects that your cluster requires.



### IMPORTANT

If you are deploying your cluster to an AWS government or secret region, you must update the **InternalApiServerRecord** in the CloudFormation template to use **CNAME** records. Records of type **ALIAS** are not supported for AWS government regions.

4. Launch the CloudFormation template to create a stack of AWS resources that provide the networking and load balancing components:



### IMPORTANT

You must enter the command on a single line.

```
$ aws cloudformation create-stack --stack-name <name> 1
  --template-body file://<template>.yaml 2
  --parameters file://<parameters>.json 3
  --capabilities CAPABILITY_NAMED_IAM 4
```

- 1 **<name>** is the name for the CloudFormation stack, such as **cluster-dns**. You need the name of this stack if you remove the cluster.
- 2 **<template>** is the relative path to and name of the CloudFormation template YAML file that you saved.
- 3 **<parameters>** is the relative path to and name of the CloudFormation parameters JSON file.
- 4 You must explicitly declare the **CAPABILITY\_NAMED\_IAM** capability because the provided template creates some **AWS::IAM::Role** resources.

### Example output

```
arn:aws:cloudformation:us-east-1:269333783861:stack/cluster-dns/cd3e5de0-2fd4-11eb-5cf0-12be5c33a183
```

5. Confirm that the template components exist:

```
$ aws cloudformation describe-stacks --stack-name <name>
```

After the **StackStatus** displays **CREATE\_COMPLETE**, the output displays values for the following parameters. You must provide these parameter values to the other CloudFormation templates that you run to create your cluster:

<b>PrivateHostedZoneId</b>	Hosted zone ID for the private DNS.
<b>ExternalApiLoadBalancerName</b>	Full name of the external API load balancer.
<b>InternalApiLoadBalancerName</b>	Full name of the internal API load balancer.
<b>ApiServerDnsName</b>	Full hostname of the API server.
<b>RegisterNlbTargetLambda</b>	Lambda ARN useful to help register/deregister IP targets for these load balancers.
<b>ExternalApiTargetGroupArn</b>	ARN of external API target group.
<b>InternalApiTargetGroupArn</b>	ARN of internal API target group.
<b>InternalServiceTargetGroupArn</b>	ARN of internal service target group.

#### 4.13.10.1. CloudFormation template for the network and load balancers

You can use the following CloudFormation template to deploy the networking objects and load balancers that you need for your OpenShift Container Platform cluster.

##### Example 4.57. CloudFormation template for the network and load balancers

AWSTemplateFormatVersion: [2010-09-09](#)  
 Description: Template for OpenShift Cluster Network Elements (Route53 & LBs)

Parameters:

ClusterName:

AllowedPattern: `^[a-zA-Z][a-zA-Z0-9-]{0,26}$`

MaxLength: [27](#)

MinLength: [1](#)



ConstraintDescription: Cluster name must be alphanumeric, start with a letter, and have a maximum of 27 characters.

Description: A short, representative cluster name to use for host names and other identifying names.

Type: String

InfrastructureName:

AllowedPattern: ^([a-zA-Z][a-zA-Z0-9\-\\_]{0,26})\$

MaxLength: 27

MinLength: 1

ConstraintDescription: Infrastructure name must be alphanumeric, start with a letter, and have a maximum of 27 characters.

Description: A short, unique cluster ID used to tag cloud resources and identify items owned or used by the cluster.

Type: String

HostedZoneId:

Description: The Route53 public zone ID to register the targets with, such as Z21IXYZABCZ2A4.

Type: String

HostedZoneName:

Description: The Route53 zone to register the targets with, such as example.com. Omit the trailing period.

Type: String

Default: "example.com"

PublicSubnets:

Description: The internet-facing subnets.

Type: List<AWS::EC2::Subnet::Id>

PrivateSubnets:

Description: The internal subnets.

Type: List<AWS::EC2::Subnet::Id>

VpcId:

Description: The VPC-scoped resources will belong to this VPC.

Type: AWS::EC2::VPC::Id

Metadata:

AWS::CloudFormation::Interface:

ParameterGroups:

- Label:

default: "Cluster Information"

Parameters:

- ClusterName

- InfrastructureName

- Label:

default: "Network Configuration"

Parameters:

- VpcId

- PublicSubnets

- PrivateSubnets

- Label:

default: "DNS"

Parameters:

- HostedZoneName

- HostedZoneId

ParameterLabels:

ClusterName:

default: "Cluster Name"

InfrastructureName:

```

    default: "Infrastructure Name"
  VpcId:
    default: "VPC ID"
  PublicSubnets:
    default: "Public Subnets"
  PrivateSubnets:
    default: "Private Subnets"
  HostedZoneName:
    default: "Public Hosted Zone Name"
  HostedZoneId:
    default: "Public Hosted Zone ID"

```

## Resources:

## ExtApiElb:

```

Type: AWS::ElasticLoadBalancingV2::LoadBalancer
Properties:
  Name: !Join ["-", [!Ref InfrastructureName, "ext"]]
  IpAddressType: ipv4
  Subnets: !Ref PublicSubnets
  Type: network

```

## IntApiElb:

```

Type: AWS::ElasticLoadBalancingV2::LoadBalancer
Properties:
  Name: !Join ["-", [!Ref InfrastructureName, "int"]]
  Scheme: internal
  IpAddressType: ipv4
  Subnets: !Ref PrivateSubnets
  Type: network

```

## IntDns:

```

Type: "AWS::Route53::HostedZone"
Properties:
  HostedZoneConfig:
    Comment: "Managed by CloudFormation"
  Name: !Join [".", [!Ref ClusterName, !Ref HostedZoneName]]
  HostedZoneTags:
    - Key: Name
      Value: !Join ["-", [!Ref InfrastructureName, "int"]]
    - Key: !Join [ "", ["kubernetes.io/cluster/", !Ref InfrastructureName] ]
      Value: "owned"
  VPCs:
    - VPCId: !Ref VpcId
      VPCRegion: !Ref "AWS::Region"

```

## ExternalApiServerRecord:

```

Type: AWS::Route53::RecordSetGroup
Properties:
  Comment: Alias record for the API server
  HostedZoneId: !Ref HostedZoneId
  RecordSets:
    - Name:
      !Join [
        ".",
        ["api", !Ref ClusterName, !Join [ "", [!Ref HostedZoneName, "."] ]],
      ]

```

Type: A  
 AliasTarget:  
 HostedZoneId: !GetAtt ExtApiElb.CanonicalHostedZoneID  
 DNSName: !GetAtt ExtApiElb.DNSName

#### InternalApiServerRecord:

Type: AWS::Route53::RecordSetGroup  
 Properties:  
 Comment: Alias record for the API server  
 HostedZoneId: !Ref IntDns  
 RecordSets:  
 - Name:  
   !Join [  
     ".",  
     ["api", !Ref ClusterName, !Join ["", [!Ref HostedZoneName, "."]]],  
   ]  
 Type: A  
 AliasTarget:  
 HostedZoneId: !GetAtt IntApiElb.CanonicalHostedZoneID  
 DNSName: !GetAtt IntApiElb.DNSName  
 - Name:  
   !Join [  
     ".",  
     ["api-int", !Ref ClusterName, !Join ["", [!Ref HostedZoneName, "."]]],  
   ]  
 Type: A  
 AliasTarget:  
 HostedZoneId: !GetAtt IntApiElb.CanonicalHostedZoneID  
 DNSName: !GetAtt IntApiElb.DNSName

#### ExternalApiListener:

Type: AWS::ElasticLoadBalancingV2::Listener  
 Properties:  
 DefaultActions:  
 - Type: forward  
   TargetGroupArn:  
     Ref: ExternalApiTargetGroup  
 LoadBalancerArn:  
   Ref: ExtApiElb  
 Port: 6443  
 Protocol: TCP

#### ExternalApiTargetGroup:

Type: AWS::ElasticLoadBalancingV2::TargetGroup  
 Properties:  
 HealthCheckIntervalSeconds: 10  
 HealthCheckPath: "/readyz"  
 HealthCheckPort: 6443  
 HealthCheckProtocol: HTTPS  
 HealthyThresholdCount: 2  
 UnhealthyThresholdCount: 2  
 Port: 6443  
 Protocol: TCP  
 TargetType: ip  
 VpId:  
   Ref: VpId

## TargetGroupAttributes:

- Key: deregistration\_delay.timeout\_seconds  
Value: 60

## InternalApiListener:

Type: AWS::ElasticLoadBalancingV2::Listener

## Properties:

## DefaultActions:

- Type: forward

## TargetGroupArn:

Ref: InternalApiTargetGroup

## LoadBalancerArn:

Ref: IntApiElb

Port: 6443

Protocol: TCP

## InternalApiTargetGroup:

Type: AWS::ElasticLoadBalancingV2::TargetGroup

## Properties:

HealthCheckIntervalSeconds: 10

HealthCheckPath: "/readyz"

HealthCheckPort: 6443

HealthCheckProtocol: HTTPS

HealthyThresholdCount: 2

UnhealthyThresholdCount: 2

Port: 6443

Protocol: TCP

TargetType: ip

## VpcId:

Ref: VpcId

## TargetGroupAttributes:

- Key: deregistration\_delay.timeout\_seconds  
Value: 60

## InternalServiceInternalListener:

Type: AWS::ElasticLoadBalancingV2::Listener

## Properties:

## DefaultActions:

- Type: forward

## TargetGroupArn:

Ref: InternalServiceTargetGroup

## LoadBalancerArn:

Ref: IntApiElb

Port: 22623

Protocol: TCP

## InternalServiceTargetGroup:

Type: AWS::ElasticLoadBalancingV2::TargetGroup

## Properties:

HealthCheckIntervalSeconds: 10

HealthCheckPath: "/healthz"

HealthCheckPort: 22623

HealthCheckProtocol: HTTPS

HealthyThresholdCount: 2

UnhealthyThresholdCount: 2

Port: 22623

Protocol: TCP  
 TargetType: ip  
 Vpclid:  
 Ref: Vpclid  
 TargetGroupAttributes:  
 - Key: deregistration\_delay.timeout\_seconds  
 Value: 60

RegisterTargetLambdalamRole:

Type: AWS::IAM::Role

Properties:

RoleName: !Join ["-", [!Ref InfrastructureName, "nlb", "lambda", "role"]]

AssumeRolePolicyDocument:

Version: "2012-10-17"

Statement:

- Effect: "Allow"

Principal:

Service:

- "lambda.amazonaws.com"

Action:

- "sts:AssumeRole"

Path: "/"

Policies:

- PolicyName: !Join ["-", [!Ref InfrastructureName, "master", "policy"]]

PolicyDocument:

Version: "2012-10-17"

Statement:

- Effect: "Allow"

Action:

```
[
  "elasticloadbalancing:RegisterTargets",
  "elasticloadbalancing:DeregisterTargets",
]
```

Resource: !Ref InternalApiTargetGroup

- Effect: "Allow"

Action:

```
[
  "elasticloadbalancing:RegisterTargets",
  "elasticloadbalancing:DeregisterTargets",
]
```

Resource: !Ref InternalServiceTargetGroup

- Effect: "Allow"

Action:

```
[
  "elasticloadbalancing:RegisterTargets",
  "elasticloadbalancing:DeregisterTargets",
]
```

Resource: !Ref ExternalApiTargetGroup

RegisterNlbTargets:

Type: "AWS::Lambda::Function"

Properties:

Handler: "index.handler"

Role:

Fn::GetAtt:

- "RegisterTargetLambdalamRole"

```

- "Arn"
Code:
ZipFile: |
import json
import boto3
import cfnresponse
def handler(event, context):
    elb = boto3.client('elbv2')
    if event['RequestType'] == 'Delete':
        elb.deregister_targets(TargetGroupArn=event['ResourceProperties']
['TargetArn'],Targets=[{'Id': event['ResourceProperties']['TargetIp']})
    elif event['RequestType'] == 'Create':
        elb.register_targets(TargetGroupArn=event['ResourceProperties']['TargetArn'],Targets=
[{'Id': event['ResourceProperties']['TargetIp']})
    responseData = {}
    cfnresponse.send(event, context, cfnresponse.SUCCESS, responseData,
event['ResourceProperties']['TargetArn']+event['ResourceProperties']['TargetIp'])
Runtime: "python3.7"
Timeout: 120

```

RegisterSubnetTagsLambdaramRole:

Type: AWS::IAM::Role

Properties:

RoleName: !Join ["-", [!Ref InfrastructureName, "subnet-tags-lambda-role"]]

AssumeRolePolicyDocument:

Version: "2012-10-17"

Statement:

- Effect: "Allow"

Principal:

Service:

- "lambda.amazonaws.com"

Action:

- "sts:AssumeRole"

Path: "/"

Policies:

- PolicyName: !Join ["-", [!Ref InfrastructureName, "subnet-tagging-policy"]]

PolicyDocument:

Version: "2012-10-17"

Statement:

- Effect: "Allow"

Action:

```

[
  "ec2:DeleteTags",
  "ec2:CreateTags"
]

```

Resource: "arn:aws:ec2:\*:\*:subnet/\*"

- Effect: "Allow"

Action:

```

[
  "ec2:DescribeSubnets",
  "ec2:DescribeTags"
]

```

Resource: ""

RegisterSubnetTags:

Type: "AWS::Lambda::Function"

## Properties:

Handler: "index.handler"

Role:

Fn::GetAtt:

- "RegisterSubnetTagsLambdalamRole"

- "Arn"

## Code:

```

ZipFile: |
import json
import boto3
import cfnresponse
def handler(event, context):
    ec2_client = boto3.client('ec2')
    if event['RequestType'] == 'Delete':
        for subnet_id in event['ResourceProperties']['Subnets']:
            ec2_client.delete_tags(Resources=[subnet_id], Tags=[{'Key': 'kubernetes.io/cluster/' +
event['ResourceProperties']['InfrastructureName']}]);
    elif event['RequestType'] == 'Create':
        for subnet_id in event['ResourceProperties']['Subnets']:
            ec2_client.create_tags(Resources=[subnet_id], Tags=[{'Key': 'kubernetes.io/cluster/' +
event['ResourceProperties']['InfrastructureName'], 'Value': 'shared'}]);
        responseData = {}
        cfnresponse.send(event, context, cfnresponse.SUCCESS, responseData,
event['ResourceProperties']['InfrastructureName']+event['ResourceProperties']['Subnets'][:0])
Runtime: "python3.7"
Timeout: 120

```

## RegisterPublicSubnetTags:

Type: Custom::SubnetRegister

Properties:

ServiceToken: !GetAtt RegisterSubnetTags.Arn

InfrastructureName: !Ref InfrastructureName

Subnets: !Ref PublicSubnets

## RegisterPrivateSubnetTags:

Type: Custom::SubnetRegister

Properties:

ServiceToken: !GetAtt RegisterSubnetTags.Arn

InfrastructureName: !Ref InfrastructureName

Subnets: !Ref PrivateSubnets

## Outputs:

PrivateHostedZoneId:

Description: Hosted zone ID for the private DNS, which is required for private records.

Value: !Ref IntDns

ExternalApiLoadBalancerName:

Description: Full name of the external API load balancer.

Value: !GetAtt ExtApiElb.LoadBalancerFullName

InternalApiLoadBalancerName:

Description: Full name of the internal API load balancer.

Value: !GetAtt IntApiElb.LoadBalancerFullName

ApiServerDnsName:

Description: Full hostname of the API server, which is required for the Ignition config files.

Value: !Join [".", ["api-int", !Ref ClusterName, !Ref HostedZoneName]]

RegisterNlbIpTargetsLambda:

Description: Lambda ARN useful to help register or deregister IP targets for these load

balancers.

Value: !GetAtt RegisterNlbTargets.Arn

ExternalApiTargetGroupArn:

Description: ARN of the external API target group.

Value: !Ref ExternalApiTargetGroup

InternalApiTargetGroupArn:

Description: ARN of the internal API target group.

Value: !Ref InternalApiTargetGroup

InternalServiceTargetGroupArn:

Description: ARN of the internal service target group.

Value: !Ref InternalServiceTargetGroup

## IMPORTANT

If you are deploying your cluster to an AWS government or secret region, you must update the **InternalApiServerRecord** to use **CNAME** records. Records of type **ALIAS** are not supported for AWS government regions. For example:

Type: CNAME

TTL: 10

ResourceRecords:

- !GetAtt IntApiElb.DNSName

## Additional resources

- See [Listing public hosted zones](#) in the AWS documentation for more information about listing public hosted zones.

## 4.13.11. Creating security group and roles in AWS

You must create security groups and roles in Amazon Web Services (AWS) for your OpenShift Container Platform cluster to use.

You can use the provided CloudFormation template and a custom parameter file to create a stack of AWS resources. The stack represents the security groups and roles that your OpenShift Container Platform cluster requires.

## NOTE

If you do not use the provided CloudFormation template to create your AWS infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

## Prerequisites

- You configured an AWS account.
- You added your AWS keys and region to your local AWS profile by running **aws configure**.
- You generated the Ignition config files for your cluster.
- You created and configured a VPC and associated subnets in AWS.

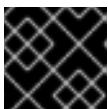


## Procedure

1. Create a JSON file that contains the parameter values that the template requires:

```
[
  {
    "ParameterKey": "InfrastructureName", ❶
    "ParameterValue": "mycluster-<random_string>" ❷
  },
  {
    "ParameterKey": "VpcCidr", ❸
    "ParameterValue": "10.0.0.0/16" ❹
  },
  {
    "ParameterKey": "PrivateSubnets", ❺
    "ParameterValue": "subnet-<random_string>" ❻
  },
  {
    "ParameterKey": "VpcId", ❼
    "ParameterValue": "vpc-<random_string>" ❽
  }
]
```

- ❶ The name for your cluster infrastructure that is encoded in your Ignition config files for the cluster.
  - ❷ Specify the infrastructure name that you extracted from the Ignition config file metadata, which has the format **<cluster-name>-<random-string>**.
  - ❸ The CIDR block for the VPC.
  - ❹ Specify the CIDR block parameter that you used for the VPC that you defined in the form **x.x.x.x/16-24**.
  - ❺ The private subnets that you created for your VPC.
  - ❻ Specify the **PrivateSubnetIds** value from the output of the CloudFormation template for the VPC.
  - ❼ The VPC that you created for the cluster.
  - ❽ Specify the **VpcId** value from the output of the CloudFormation template for the VPC.
2. Copy the template from the **CloudFormation template for security objects** section of this topic and save it as a YAML file on your computer. This template describes the security groups and roles that your cluster requires.
  3. Launch the CloudFormation template to create a stack of AWS resources that represent the security groups and roles:



### IMPORTANT

You must enter the command on a single line.



```
$ aws cloudformation create-stack --stack-name <name> ❶
  --template-body file://<template>.yaml ❷
  --parameters file://<parameters>.json ❸
  --capabilities CAPABILITY_NAMED_IAM ❹
```

- ❶ **<name>** is the name for the CloudFormation stack, such as **cluster-sec**. You need the name of this stack if you remove the cluster.
- ❷ **<template>** is the relative path to and name of the CloudFormation template YAML file that you saved.
- ❸ **<parameters>** is the relative path to and name of the CloudFormation parameters JSON file.
- ❹ You must explicitly declare the **CAPABILITY\_NAMED\_IAM** capability because the provided template creates some **AWS::IAM::Role** and **AWS::IAM::InstanceProfile** resources.

### Example output

```
arn:aws:cloudformation:us-east-1:269333783861:stack/cluster-sec/03bd4210-2ed7-11eb-6d7a-13fc0b61e9db
```

4. Confirm that the template components exist:

```
$ aws cloudformation describe-stacks --stack-name <name>
```

After the **StackStatus** displays **CREATE\_COMPLETE**, the output displays values for the following parameters. You must provide these parameter values to the other CloudFormation templates that you run to create your cluster:

<b>MasterSecurityGroupID</b>	Master Security Group ID
<b>WorkerSecurityGroupID</b>	Worker Security Group ID
<b>MasterInstanceProfile</b>	Master IAM Instance Profile
<b>WorkerInstanceProfile</b>	Worker IAM Instance Profile

#### 4.13.11.1. CloudFormation template for security objects

You can use the following CloudFormation template to deploy the security objects that you need for your OpenShift Container Platform cluster.

**Example 4.58. CloudFormation template for security objects**

```

AWSTemplateFormatVersion: 2010-09-09
Description: Template for OpenShift Cluster Security Elements (Security Groups & IAM)

Parameters:
  InfrastructureName:
    AllowedPattern: ^([a-zA-Z][a-zA-Z0-9\-\_]{0,26})$
    MaxLength: 27
    MinLength: 1
    ConstraintDescription: Infrastructure name must be alphanumeric, start with a letter, and have a
maximum of 27 characters.
    Description: A short, unique cluster ID used to tag cloud resources and identify items owned or
used by the cluster.
    Type: String
  VpcCidr:
    AllowedPattern: ^((([0-9]|[1-9][0-9]|1[0-9]{2}|2[0-4][0-9]|25[0-5])\.){3}([0-9]|[1-9][0-9]|1[0-9]{2}|2[0-
4][0-9]|25[0-5])|(1[6-9]|2[0-4]))$
    ConstraintDescription: CIDR block parameter must be in the form x.x.x.x/16-24.
    Default: 10.0.0/16
    Description: CIDR block for VPC.
    Type: String
  VpcId:
    Description: The VPC-scoped resources will belong to this VPC.
    Type: AWS::EC2::VPC::Id
  PrivateSubnets:
    Description: The internal subnets.
    Type: List<AWS::EC2::Subnet::Id>

Metadata:
  AWS::CloudFormation::Interface:
    ParameterGroups:
      - Label:
        default: "Cluster Information"
        Parameters:
          - InfrastructureName
      - Label:
        default: "Network Configuration"
        Parameters:
          - VpcId
          - VpcCidr
          - PrivateSubnets
    ParameterLabels:
      InfrastructureName:
        default: "Infrastructure Name"
      VpcId:
        default: "VPC ID"
      VpcCidr:
        default: "VPC CIDR"
      PrivateSubnets:
        default: "Private Subnets"

Resources:
  MasterSecurityGroup:
    Type: AWS::EC2::SecurityGroup
    Properties:

```

GroupDescription: Cluster Master Security Group

SecurityGroupIngress:

- IpProtocol: icmp  
FromPort: 0  
ToPort: 0  
CidrIp: !Ref VpcCidr
  - IpProtocol: tcp  
FromPort: 22  
ToPort: 22  
CidrIp: !Ref VpcCidr
  - IpProtocol: tcp  
ToPort: 6443  
FromPort: 6443  
CidrIp: !Ref VpcCidr
  - IpProtocol: tcp  
FromPort: 22623  
ToPort: 22623  
CidrIp: !Ref VpcCidr
- VpcId: !Ref VpcId

WorkerSecurityGroup:

Type: AWS::EC2::SecurityGroup

Properties:

GroupDescription: Cluster Worker Security Group

SecurityGroupIngress:

- IpProtocol: icmp  
FromPort: 0  
ToPort: 0  
CidrIp: !Ref VpcCidr
  - IpProtocol: tcp  
FromPort: 22  
ToPort: 22  
CidrIp: !Ref VpcCidr
- VpcId: !Ref VpcId

MasterIngressEtcD:

Type: AWS::EC2::SecurityGroupIngress

Properties:

GroupId: !GetAtt MasterSecurityGroup.GroupId  
SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId  
Description: etcd  
FromPort: 2379  
ToPort: 2380  
IpProtocol: tcp

MasterIngressVxlan:

Type: AWS::EC2::SecurityGroupIngress

Properties:

GroupId: !GetAtt MasterSecurityGroup.GroupId  
SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId  
Description: Vxlan packets  
FromPort: 4789  
ToPort: 4789  
IpProtocol: udp

MasterIngressWorkerVxlan:

Type: AWS::EC2::SecurityGroupIngress  
Properties:  
  GroupId: !GetAtt MasterSecurityGroup.GroupId  
  SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId  
  Description: Vxlan packets  
  FromPort: 4789  
  ToPort: 4789  
  IpProtocol: udp

MasterIngressGeneve:  
Type: AWS::EC2::SecurityGroupIngress  
Properties:  
  GroupId: !GetAtt MasterSecurityGroup.GroupId  
  SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId  
  Description: Geneve packets  
  FromPort: 6081  
  ToPort: 6081  
  IpProtocol: udp

MasterIngressWorkerGeneve:  
Type: AWS::EC2::SecurityGroupIngress  
Properties:  
  GroupId: !GetAtt MasterSecurityGroup.GroupId  
  SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId  
  Description: Geneve packets  
  FromPort: 6081  
  ToPort: 6081  
  IpProtocol: udp

MasterIngressIpsecIke:  
Type: AWS::EC2::SecurityGroupIngress  
Properties:  
  GroupId: !GetAtt MasterSecurityGroup.GroupId  
  SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId  
  Description: IPsec IKE packets  
  FromPort: 500  
  ToPort: 500  
  IpProtocol: udp

MasterIngressIpsecNat:  
Type: AWS::EC2::SecurityGroupIngress  
Properties:  
  GroupId: !GetAtt MasterSecurityGroup.GroupId  
  SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId  
  Description: IPsec NAT-T packets  
  FromPort: 4500  
  ToPort: 4500  
  IpProtocol: udp

MasterIngressIpsecEsp:  
Type: AWS::EC2::SecurityGroupIngress  
Properties:  
  GroupId: !GetAtt MasterSecurityGroup.GroupId  
  SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId  
  Description: IPsec ESP packets  
  IpProtocol: 50

**MasterIngressWorkerIpsecIke:**

Type: AWS::EC2::SecurityGroupIngress

## Properties:

GroupId: !GetAtt MasterSecurityGroup.GroupId

SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId

Description: IPsec IKE packets

FromPort: 500

ToPort: 500

IpProtocol: udp

**MasterIngressWorkerIpsecNat:**

Type: AWS::EC2::SecurityGroupIngress

## Properties:

GroupId: !GetAtt MasterSecurityGroup.GroupId

SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId

Description: IPsec NAT-T packets

FromPort: 4500

ToPort: 4500

IpProtocol: udp

**MasterIngressWorkerIpsecEsp:**

Type: AWS::EC2::SecurityGroupIngress

## Properties:

GroupId: !GetAtt MasterSecurityGroup.GroupId

SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId

Description: IPsec ESP packets

IpProtocol: 50

**MasterIngressInternal:**

Type: AWS::EC2::SecurityGroupIngress

## Properties:

GroupId: !GetAtt MasterSecurityGroup.GroupId

SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId

Description: Internal cluster communication

FromPort: 9000

ToPort: 9999

IpProtocol: tcp

**MasterIngressWorkerInternal:**

Type: AWS::EC2::SecurityGroupIngress

## Properties:

GroupId: !GetAtt MasterSecurityGroup.GroupId

SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId

Description: Internal cluster communication

FromPort: 9000

ToPort: 9999

IpProtocol: tcp

**MasterIngressInternalUDP:**

Type: AWS::EC2::SecurityGroupIngress

## Properties:

GroupId: !GetAtt MasterSecurityGroup.GroupId

SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId

Description: Internal cluster communication

FromPort: 9000

ToPort: 9999  
IpProtocol: udp

MasterIngressWorkerInternalUDP:

Type: AWS::EC2::SecurityGroupIngress  
Properties:  
GroupId: !GetAtt MasterSecurityGroup.GroupId  
SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId  
Description: Internal cluster communication  
FromPort: 9000  
ToPort: 9999  
IpProtocol: udp

MasterIngressKube:

Type: AWS::EC2::SecurityGroupIngress  
Properties:  
GroupId: !GetAtt MasterSecurityGroup.GroupId  
SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId  
Description: Kubernetes kubelet, scheduler and controller manager  
FromPort: 10250  
ToPort: 10259  
IpProtocol: tcp

MasterIngressWorkerKube:

Type: AWS::EC2::SecurityGroupIngress  
Properties:  
GroupId: !GetAtt MasterSecurityGroup.GroupId  
SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId  
Description: Kubernetes kubelet, scheduler and controller manager  
FromPort: 10250  
ToPort: 10259  
IpProtocol: tcp

MasterIngressIngressServices:

Type: AWS::EC2::SecurityGroupIngress  
Properties:  
GroupId: !GetAtt MasterSecurityGroup.GroupId  
SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId  
Description: Kubernetes ingress services  
FromPort: 30000  
ToPort: 32767  
IpProtocol: tcp

MasterIngressWorkerIngressServices:

Type: AWS::EC2::SecurityGroupIngress  
Properties:  
GroupId: !GetAtt MasterSecurityGroup.GroupId  
SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId  
Description: Kubernetes ingress services  
FromPort: 30000  
ToPort: 32767  
IpProtocol: tcp

MasterIngressIngressServicesUDP:

Type: AWS::EC2::SecurityGroupIngress  
Properties:

GroupId: !GetAtt MasterSecurityGroup.GroupId  
SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId  
Description: Kubernetes ingress services  
FromPort: 30000  
ToPort: 32767  
IpProtocol: udp

MasterIngressWorkerIngressServicesUDP:

Type: AWS::EC2::SecurityGroupIngress  
Properties:  
GroupId: !GetAtt MasterSecurityGroup.GroupId  
SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId  
Description: Kubernetes ingress services  
FromPort: 30000  
ToPort: 32767  
IpProtocol: udp

WorkerIngressVxlan:

Type: AWS::EC2::SecurityGroupIngress  
Properties:  
GroupId: !GetAtt WorkerSecurityGroup.GroupId  
SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId  
Description: Vxlan packets  
FromPort: 4789  
ToPort: 4789  
IpProtocol: udp

WorkerIngressMasterVxlan:

Type: AWS::EC2::SecurityGroupIngress  
Properties:  
GroupId: !GetAtt WorkerSecurityGroup.GroupId  
SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId  
Description: Vxlan packets  
FromPort: 4789  
ToPort: 4789  
IpProtocol: udp

WorkerIngressGeneve:

Type: AWS::EC2::SecurityGroupIngress  
Properties:  
GroupId: !GetAtt WorkerSecurityGroup.GroupId  
SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId  
Description: Geneve packets  
FromPort: 6081  
ToPort: 6081  
IpProtocol: udp

WorkerIngressMasterGeneve:

Type: AWS::EC2::SecurityGroupIngress  
Properties:  
GroupId: !GetAtt WorkerSecurityGroup.GroupId  
SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId  
Description: Geneve packets  
FromPort: 6081  
ToPort: 6081  
IpProtocol: udp



**WorkerIngressIpsecIke:**

Type: AWS::EC2::SecurityGroupIngress

Properties:

GroupId: !GetAtt WorkerSecurityGroup.GroupId

SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId

Description: IPsec IKE packets

FromPort: 500

ToPort: 500

IpProtocol: udp

**WorkerIngressIpsecNat:**

Type: AWS::EC2::SecurityGroupIngress

Properties:

GroupId: !GetAtt WorkerSecurityGroup.GroupId

SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId

Description: IPsec NAT-T packets

FromPort: 4500

ToPort: 4500

IpProtocol: udp

**WorkerIngressIpsecEsp:**

Type: AWS::EC2::SecurityGroupIngress

Properties:

GroupId: !GetAtt WorkerSecurityGroup.GroupId

SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId

Description: IPsec ESP packets

IpProtocol: 50

**WorkerIngressMasterIpsecIke:**

Type: AWS::EC2::SecurityGroupIngress

Properties:

GroupId: !GetAtt WorkerSecurityGroup.GroupId

SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId

Description: IPsec IKE packets

FromPort: 500

ToPort: 500

IpProtocol: udp

**WorkerIngressMasterIpsecNat:**

Type: AWS::EC2::SecurityGroupIngress

Properties:

GroupId: !GetAtt WorkerSecurityGroup.GroupId

SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId

Description: IPsec NAT-T packets

FromPort: 4500

ToPort: 4500

IpProtocol: udp

**WorkerIngressMasterIpsecEsp:**

Type: AWS::EC2::SecurityGroupIngress

Properties:

GroupId: !GetAtt WorkerSecurityGroup.GroupId

SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId

Description: IPsec ESP packets

IpProtocol: 50

**WorkerIngressInternal:**

Type: AWS::EC2::SecurityGroupIngress

## Properties:

GroupId: !GetAtt WorkerSecurityGroup.GroupId

SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId

Description: Internal cluster communication

FromPort: 9000

ToPort: 9999

IpProtocol: tcp

**WorkerIngressMasterInternal:**

Type: AWS::EC2::SecurityGroupIngress

## Properties:

GroupId: !GetAtt WorkerSecurityGroup.GroupId

SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId

Description: Internal cluster communication

FromPort: 9000

ToPort: 9999

IpProtocol: tcp

**WorkerIngressInternalUDP:**

Type: AWS::EC2::SecurityGroupIngress

## Properties:

GroupId: !GetAtt WorkerSecurityGroup.GroupId

SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId

Description: Internal cluster communication

FromPort: 9000

ToPort: 9999

IpProtocol: udp

**WorkerIngressMasterInternalUDP:**

Type: AWS::EC2::SecurityGroupIngress

## Properties:

GroupId: !GetAtt WorkerSecurityGroup.GroupId

SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId

Description: Internal cluster communication

FromPort: 9000

ToPort: 9999

IpProtocol: udp

**WorkerIngressKube:**

Type: AWS::EC2::SecurityGroupIngress

## Properties:

GroupId: !GetAtt WorkerSecurityGroup.GroupId

SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId

Description: Kubernetes secure kubelet port

FromPort: 10250

ToPort: 10250

IpProtocol: tcp

**WorkerIngressWorkerKube:**

Type: AWS::EC2::SecurityGroupIngress

## Properties:

GroupId: !GetAtt WorkerSecurityGroup.GroupId

SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId

Description: Internal Kubernetes communication  
 FromPort: 10250  
 ToPort: 10250  
 IpProtocol: tcp

WorkerIngressIngressServices:  
 Type: AWS::EC2::SecurityGroupIngress  
 Properties:  
 GroupId: !GetAtt WorkerSecurityGroup.GroupId  
 SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId  
 Description: Kubernetes ingress services  
 FromPort: 30000  
 ToPort: 32767  
 IpProtocol: tcp

WorkerIngressMasterIngressServices:  
 Type: AWS::EC2::SecurityGroupIngress  
 Properties:  
 GroupId: !GetAtt WorkerSecurityGroup.GroupId  
 SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId  
 Description: Kubernetes ingress services  
 FromPort: 30000  
 ToPort: 32767  
 IpProtocol: tcp

WorkerIngressIngressServicesUDP:  
 Type: AWS::EC2::SecurityGroupIngress  
 Properties:  
 GroupId: !GetAtt WorkerSecurityGroup.GroupId  
 SourceSecurityGroupId: !GetAtt WorkerSecurityGroup.GroupId  
 Description: Kubernetes ingress services  
 FromPort: 30000  
 ToPort: 32767  
 IpProtocol: udp

WorkerIngressMasterIngressServicesUDP:  
 Type: AWS::EC2::SecurityGroupIngress  
 Properties:  
 GroupId: !GetAtt WorkerSecurityGroup.GroupId  
 SourceSecurityGroupId: !GetAtt MasterSecurityGroup.GroupId  
 Description: Kubernetes ingress services  
 FromPort: 30000  
 ToPort: 32767  
 IpProtocol: udp

MasterIamRole:  
 Type: AWS::IAM::Role  
 Properties:  
 AssumeRolePolicyDocument:  
 Version: "2012-10-17"  
 Statement:  
 - Effect: "Allow"  
 Principal:  
 Service:  
 - "ec2.amazonaws.com"  
 Action:

- "sts:AssumeRole"

Policies:

- PolicyName: !Join ["-", [!Ref InfrastructureName, "master", "policy"]]

PolicyDocument:

Version: "2012-10-17"

Statement:

- Effect: "Allow"

Action:

- "ec2:AttachVolume"

- "ec2:AuthorizeSecurityGroupIngress"

- "ec2:CreateSecurityGroup"

- "ec2:CreateTags"

- "ec2:CreateVolume"

- "ec2>DeleteSecurityGroup"

- "ec2>DeleteVolume"

- "ec2:Describe\*"

- "ec2:DetachVolume"

- "ec2:ModifyInstanceAttribute"

- "ec2:ModifyVolume"

- "ec2:RevokeSecurityGroupIngress"

- "elasticloadbalancing:AddTags"

- "elasticloadbalancing:AttachLoadBalancerToSubnets"

- "elasticloadbalancing:ApplySecurityGroupsToLoadBalancer"

- "elasticloadbalancing:CreateListener"

- "elasticloadbalancing:CreateLoadBalancer"

- "elasticloadbalancing:CreateLoadBalancerPolicy"

- "elasticloadbalancing:CreateLoadBalancerListeners"

- "elasticloadbalancing:CreateTargetGroup"

- "elasticloadbalancing:ConfigureHealthCheck"

- "elasticloadbalancing>DeleteListener"

- "elasticloadbalancing>DeleteLoadBalancer"

- "elasticloadbalancing>DeleteLoadBalancerListeners"

- "elasticloadbalancing>DeleteTargetGroup"

- "elasticloadbalancing:DeregisterInstancesFromLoadBalancer"

- "elasticloadbalancing:DeregisterTargets"

- "elasticloadbalancing:Describe\*"

- "elasticloadbalancing:DetachLoadBalancerFromSubnets"

- "elasticloadbalancing:ModifyListener"

- "elasticloadbalancing:ModifyLoadBalancerAttributes"

- "elasticloadbalancing:ModifyTargetGroup"

- "elasticloadbalancing:ModifyTargetGroupAttributes"

- "elasticloadbalancing:RegisterInstancesWithLoadBalancer"

- "elasticloadbalancing:RegisterTargets"

- "elasticloadbalancing:SetLoadBalancerPoliciesForBackendServer"

- "elasticloadbalancing:SetLoadBalancerPoliciesOfListener"

- "kms:DescribeKey"

Resource: ""

MasterInstanceProfile:

Type: "AWS::IAM::InstanceProfile"

Properties:

Roles:

- Ref: "MasterIamRole"

WorkerIamRole:

Type: AWS::IAM::Role

```

Properties:
  AssumeRolePolicyDocument:
    Version: "2012-10-17"
    Statement:
      - Effect: "Allow"
        Principal:
          Service:
            - "ec2.amazonaws.com"
        Action:
          - "sts:AssumeRole"
  Policies:
    - PolicyName: !Join ["-", [!Ref InfrastructureName, "worker", "policy"]]
      PolicyDocument:
        Version: "2012-10-17"
        Statement:
          - Effect: "Allow"
            Action:
              - "ec2:DescribeInstances"
              - "ec2:DescribeRegions"
            Resource: "*"

WorkerInstanceProfile:
  Type: "AWS::IAM::InstanceProfile"
  Properties:
    Roles:
      - Ref: "WorkerIamRole"

Outputs:
  MasterSecurityGroupId:
    Description: Master Security Group ID
    Value: !GetAtt MasterSecurityGroup.GroupId

  WorkerSecurityGroupId:
    Description: Worker Security Group ID
    Value: !GetAtt WorkerSecurityGroup.GroupId

  MasterInstanceProfile:
    Description: Master IAM Instance Profile
    Value: !Ref MasterInstanceProfile

  WorkerInstanceProfile:
    Description: Worker IAM Instance Profile
    Value: !Ref WorkerInstanceProfile

```

#### 4.13.12. Accessing RHCOS AMIs with stream metadata

In OpenShift Container Platform, *stream metadata* provides standardized metadata about RHCOS in the JSON format and injects the metadata into the cluster. Stream metadata is a stable format that supports multiple architectures and is intended to be self-documenting for maintaining automation.

You can use the **coreos print-stream-json** sub-command of **openshift-install** to access information about the boot images in the stream metadata format. This command provides a method for printing stream metadata in a scriptable, machine-readable format.

For user-provisioned installations, the **openshift-install** binary contains references to the version of RHCOS boot images that are tested for use with OpenShift Container Platform, such as the AWS AMI.

## Procedure

To parse the stream metadata, use one of the following methods:

- From a Go program, use the official **stream-metadata-go** library at <https://github.com/coreos/stream-metadata-go>. You can also view example code in the library.
- From another programming language, such as Python or Ruby, use the JSON library of your preferred programming language.
- From a command-line utility that handles JSON data, such as **jq**:
  - Print the current **x86\_64** AMI for an AWS region, such as **us-west-1**:

```
$ openshift-install coreos print-stream-json | jq -r
'.architectures.x86_64.images.aws.regions["us-west-1"].image'
```

### Example output

```
ami-0d3e625f84626bbda
```

The output of this command is the AWS AMI ID for the **us-west-1** region. The AMI must belong to the same region as the cluster.

### 4.13.13. RHCOS AMIs for the AWS infrastructure

Red Hat provides Red Hat Enterprise Linux CoreOS (RHCOS) AMIs that are valid for the various AWS regions that you can manually specify for your OpenShift Container Platform nodes.



#### NOTE

By importing your own AMI, you can also install to regions that do not have a published RHCOS AMI.

Table 4.46. RHCOS AMIs

AWS zone	AWS AMI
<b>af-south-1</b>	<b>ami-0f3804f5a2f913dcc</b>
<b>ap-east-1</b>	<b>ami-0de1febb30a83da66</b>
<b>ap-northeast-1</b>	<b>ami-0183df96a3e002687</b>
<b>ap-northeast-2</b>	<b>ami-06b8798cd60242798</b>
<b>ap-northeast-3</b>	<b>ami-00b16b33aa0951016</b>
<b>ap-south-1</b>	<b>ami-007243f8ff78e8294</b>

AWS zone	AWS AMI
ap-southeast-1	ami-079dfdacb5ab5a0d1
ap-southeast-2	ami-03882e39cb7785c32
ca-central-1	ami-05cba1f80cc8b1dbe
eu-central-1	ami-073c775bbe9cd434e
eu-north-1	ami-0763e6e75b681acc5
eu-south-1	ami-00d023f19775fb64b
eu-west-1	ami-0033e3f2331a530c4
eu-west-2	ami-00d8a741ebe74f0c4
eu-west-3	ami-09b04e7f60e3374a7
me-south-1	ami-0f8039330b6e54010
sa-east-1	ami-01af22f821b470ad1
us-east-1	ami-0c72f473496a7b1c2
us-east-2	ami-09e637fc5885c13cc
us-west-1	ami-0fa0f6fce7e63dd26
us-west-2	ami-084fb1316cd1ed4cc

#### 4.13.14. Creating the bootstrap node in AWS

You must create the bootstrap node in Amazon Web Services (AWS) to use during OpenShift Container Platform cluster initialization.

You can use the provided CloudFormation template and a custom parameter file to create a stack of AWS resources. The stack represents the bootstrap node that your OpenShift Container Platform installation requires.



#### NOTE

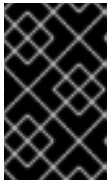
If you do not use the provided CloudFormation template to create your bootstrap node, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

## Prerequisites

- You configured an AWS account.
- You added your AWS keys and region to your local AWS profile by running **aws configure**.
- You generated the Ignition config files for your cluster.
- You created and configured a VPC and associated subnets in AWS.
- You created and configured DNS, load balancers, and listeners in AWS.
- You created the security groups and roles required for your cluster in AWS.

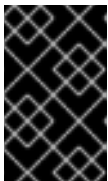
## Procedure

1. Provide a location to serve the **bootstrap.ign** Ignition config file to your cluster. This file is located in your installation directory. One way to do this is to create an S3 bucket in your cluster's region and upload the Ignition config file to it.



### IMPORTANT

The provided CloudFormation Template assumes that the Ignition config files for your cluster are served from an S3 bucket. If you choose to serve the files from another location, you must modify the templates.



### IMPORTANT

If you are deploying to a region that has endpoints that differ from the AWS SDK, or you are providing your own custom endpoints, you must use a presigned URL for your S3 bucket instead of the **s3://** schema.



### NOTE

The bootstrap Ignition config file does contain secrets, like X.509 keys. The following steps provide basic security for the S3 bucket. To provide additional security, you can enable an S3 bucket policy to allow only certain users, such as the OpenShift IAM user, to access objects that the bucket contains. You can avoid S3 entirely and serve your bootstrap Ignition config file from any address that the bootstrap machine can reach.

- a. Create the bucket:

```
$ aws s3 mb s3://<cluster-name>-infra 1
```

- 1** **<cluster-name>-infra** is the bucket name. When creating the **install-config.yaml** file, replace **<cluster-name>** with the name specified for the cluster.

- b. Upload the **bootstrap.ign** Ignition config file to the bucket:

```
$ aws s3 cp <installation_directory>/bootstrap.ign s3://<cluster-name>-infra/bootstrap.ign 1
```



- 1 For `<installation_directory>`, specify the path to the directory that you stored the installation files in.

c. Verify that the file uploaded:

```
$ aws s3 ls s3://<cluster-name>-infra/
```

### Example output

```
2019-04-03 16:15:16 314878 bootstrap.ign
```

2. Create a JSON file that contains the parameter values that the template requires:

```
[
  {
    "ParameterKey": "InfrastructureName", 1
    "ParameterValue": "mycluster-<random_string>" 2
  },
  {
    "ParameterKey": "RhcOsAmi", 3
    "ParameterValue": "ami-<random_string>" 4
  },
  {
    "ParameterKey": "AllowedBootstrapSshCidr", 5
    "ParameterValue": "0.0.0.0/0" 6
  },
  {
    "ParameterKey": "PublicSubnet", 7
    "ParameterValue": "subnet-<random_string>" 8
  },
  {
    "ParameterKey": "MasterSecurityGroupID", 9
    "ParameterValue": "sg-<random_string>" 10
  },
  {
    "ParameterKey": "VpcID", 11
    "ParameterValue": "vpc-<random_string>" 12
  },
  {
    "ParameterKey": "BootstrapIgnitionLocation", 13
    "ParameterValue": "s3://<bucket_name>/bootstrap.ign" 14
  },
  {
    "ParameterKey": "AutoRegisterELB", 15
    "ParameterValue": "yes" 16
  },
  {
    "ParameterKey": "RegisterNlbTargetsLambdaArn", 17
    "ParameterValue": "arn:aws:lambda:<region>:<account_number>:function:
<dns_stack_name>-RegisterNlbTargets-<random_string>" 18
  },
]
```

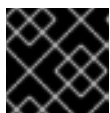
```

{
  "ParameterKey": "ExternalApiTargetGroupArn", 19
  "ParameterValue": "arn:aws:elasticloadbalancing:<region>:
<account_number>:targetgroup/<dns_stack_name>-Exter-<random_string>" 20
},
{
  "ParameterKey": "InternalApiTargetGroupArn", 21
  "ParameterValue": "arn:aws:elasticloadbalancing:<region>:
<account_number>:targetgroup/<dns_stack_name>-Inter-<random_string>" 22
},
{
  "ParameterKey": "InternalServiceTargetGroupArn", 23
  "ParameterValue": "arn:aws:elasticloadbalancing:<region>:
<account_number>:targetgroup/<dns_stack_name>-Inter-<random_string>" 24
}
]

```

- 1** The name for your cluster infrastructure that is encoded in your Ignition config files for the cluster.
- 2** Specify the infrastructure name that you extracted from the Ignition config file metadata, which has the format **<cluster-name>-<random-string>**.
- 3** Current Red Hat Enterprise Linux CoreOS (RHCOS) AMI to use for the bootstrap node.
- 4** Specify a valid **AWS::EC2::Image::Id** value.
- 5** CIDR block to allow SSH access to the bootstrap node.
- 6** Specify a CIDR block in the format **x.x.x.x/16-24**.
- 7** The public subnet that is associated with your VPC to launch the bootstrap node into.
- 8** Specify the **PublicSubnetIds** value from the output of the CloudFormation template for the VPC.
- 9** The master security group ID (for registering temporary rules)
- 10** Specify the **MasterSecurityGroupId** value from the output of the CloudFormation template for the security group and roles.
- 11** The VPC created resources will belong to.
- 12** Specify the **VpcId** value from the output of the CloudFormation template for the VPC.
- 13** Location to fetch bootstrap Ignition config file from.
- 14** Specify the S3 bucket and file name in the form **s3://<bucket\_name>/bootstrap.ign**.
- 15** Whether or not to register a network load balancer (NLB).
- 16** Specify **yes** or **no**. If you specify **yes**, you must provide a Lambda Amazon Resource Name (ARN) value.
- 17** The ARN for NLB IP target registration lambda group.

- 18 Specify the **RegisterNlbTargetsLambda** value from the output of the CloudFormation template for DNS and load balancing. Use **arn:aws-us-gov** if deploying the cluster to an
  - 19 The ARN for external API load balancer target group.
  - 20 Specify the **ExternalApiTargetGroupArn** value from the output of the CloudFormation template for DNS and load balancing. Use **arn:aws-us-gov** if deploying the cluster to an AWS GovCloud region.
  - 21 The ARN for internal API load balancer target group.
  - 22 Specify the **InternalApiTargetGroupArn** value from the output of the CloudFormation template for DNS and load balancing. Use **arn:aws-us-gov** if deploying the cluster to an AWS GovCloud region.
  - 23 The ARN for internal service load balancer target group.
  - 24 Specify the **InternalServiceTargetGroupArn** value from the output of the CloudFormation template for DNS and load balancing. Use **arn:aws-us-gov** if deploying the cluster to an AWS GovCloud region.
3. Copy the template from the **CloudFormation template for the bootstrap machines** section of this topic and save it as a YAML file on your computer. This template describes the bootstrap machine that your cluster requires.
  4. Launch the CloudFormation template to create a stack of AWS resources that represent the bootstrap node:



### IMPORTANT

You must enter the command on a single line.

```
$ aws cloudformation create-stack --stack-name <name> 1
  --template-body file://<template>.yaml 2
  --parameters file://<parameters>.json 3
  --capabilities CAPABILITY_NAMED_IAM 4
```

- 1 **<name>** is the name for the CloudFormation stack, such as **cluster-bootstrap**. You need the name of this stack if you remove the cluster.
- 2 **<template>** is the relative path to and name of the CloudFormation template YAML file that you saved.
- 3 **<parameters>** is the relative path to and name of the CloudFormation parameters JSON file.
- 4 You must explicitly declare the **CAPABILITY\_NAMED\_IAM** capability because the provided template creates some **AWS::IAM::Role** and **AWS::IAM::InstanceProfile** resources.

### Example output

```
arn:aws:cloudformation:us-east-1:269333783861:stack/cluster-bootstrap/12944486-2add-11eb-9dee-12dace8e3a83
```

5. Confirm that the template components exist:

```
$ aws cloudformation describe-stacks --stack-name <name>
```

After the **StackStatus** displays **CREATE\_COMPLETE**, the output displays values for the following parameters. You must provide these parameter values to the other CloudFormation templates that you run to create your cluster:

<b>Bootstrap InstanceId</b>	The bootstrap Instance ID.
<b>Bootstrap PublicIp</b>	The bootstrap node public IP address.
<b>Bootstrap PrivateIp</b>	The bootstrap node private IP address.

#### 4.13.14.1. CloudFormation template for the bootstrap machine

You can use the following CloudFormation template to deploy the bootstrap machine that you need for your OpenShift Container Platform cluster.

##### Example 4.59. CloudFormation template for the bootstrap machine

```
AWSTemplateFormatVersion: 2010-09-09
Description: Template for OpenShift Cluster Bootstrap (EC2 Instance, Security Groups and IAM)

Parameters:
  InfrastructureName:
    AllowedPattern: ^([a-zA-Z][a-zA-Z0-9\-\_]{0,26})$
    MaxLength: 27
    MinLength: 1
    ConstraintDescription: Infrastructure name must be alphanumeric, start with a letter, and have a maximum of 27 characters.
    Description: A short, unique cluster ID used to tag cloud resources and identify items owned or used by the cluster.
    Type: String
  RhcosAmi:
    Description: Current Red Hat Enterprise Linux CoreOS AMI to use for bootstrap.
    Type: AWS::EC2::Image::Id
  AllowedBootstrapSshCidr:
    AllowedPattern: ^((([0-9]{1,3}[0-9]{1,3}|[0-9]{1,3}[0-9]{1,3}|[0-9]{1,3}[0-9]{1,3}|[0-9]{1,3}[0-9]{1,3})\.){3}([0-9]{1,3}|[0-9]{1,3}|[0-9]{1,3}|[0-9]{1,3})\.[0-9]{1,3}|([0-9]{1,3}|[0-9]{1,3}|[0-9]{1,3}|[0-9]{1,3})\.[0-9]{1,3}|([0-9]{1,3}|[0-9]{1,3}|[0-9]{1,3}|[0-9]{1,3})\.[0-9]{1,3}|([0-9]{1,3}|[0-9]{1,3}|[0-9]{1,3}|[0-9]{1,3})\.[0-9]{1,3})$
    ConstraintDescription: CIDR block parameter must be in the form x.x.x.x/0-32.
    Default: 0.0.0.0/0
    Description: CIDR block to allow SSH access to the bootstrap node.
    Type: String
  PublicSubnet:
    Description: The public subnet to launch the bootstrap node into.
```

```

Type: AWS::EC2::Subnet::Id
MasterSecurityGroupId:
  Description: The master security group ID for registering temporary rules.
  Type: AWS::EC2::SecurityGroup::Id
VpcId:
  Description: The VPC-scoped resources will belong to this VPC.
  Type: AWS::EC2::VPC::Id
BootstrapIgnitionLocation:
  Default: s3://my-s3-bucket/bootstrap.ign
  Description: Ignition config file location.
  Type: String
AutoRegisterELB:
  Default: "yes"
  AllowedValues:
  - "yes"
  - "no"
  Description: Do you want to invoke NLB registration, which requires a Lambda ARN parameter?
  Type: String
RegisterNlbTargetsLambdaArn:
  Description: ARN for NLB IP target registration lambda.
  Type: String
ExternalApiTargetGroupArn:
  Description: ARN for external API load balancer target group.
  Type: String
InternalApiTargetGroupArn:
  Description: ARN for internal API load balancer target group.
  Type: String
InternalServiceTargetGroupArn:
  Description: ARN for internal service load balancer target group.
  Type: String

Metadata:
AWS::CloudFormation::Interface:
  ParameterGroups:
  - Label:
    default: "Cluster Information"
    Parameters:
    - InfrastructureName
  - Label:
    default: "Host Information"
    Parameters:
    - RhcosAmi
    - BootstrapIgnitionLocation
    - MasterSecurityGroupId
  - Label:
    default: "Network Configuration"
    Parameters:
    - VpcId
    - AllowedBootstrapSshCidr
    - PublicSubnet
  - Label:
    default: "Load Balancer Automation"
    Parameters:
    - AutoRegisterELB
    - RegisterNlbTargetsLambdaArn
    - ExternalApiTargetGroupArn

```

- InternalApiTargetGroupArn
- InternalServiceTargetGroupArn

ParameterLabels:

InfrastructureName:  
default: "Infrastructure Name"

VpcId:  
default: "VPC ID"

AllowedBootstrapSshCidr:  
default: "Allowed SSH Source"

PublicSubnet:  
default: "Public Subnet"

RhcosAmi:  
default: "Red Hat Enterprise Linux CoreOS AMI ID"

BootstrapIgnitionLocation:  
default: "Bootstrap Ignition Source"

MasterSecurityGroupId:  
default: "Master Security Group ID"

AutoRegisterELB:  
default: "Use Provided ELB Automation"

Conditions:

DoRegistration: !Equals ["yes", !Ref AutoRegisterELB]

Resources:

BootstrapIamRole:  
Type: AWS::IAM::Role  
Properties:  
AssumeRolePolicyDocument:  
Version: "2012-10-17"  
Statement:  
- Effect: "Allow"  
Principal:  
Service:  
- "ec2.amazonaws.com"  
Action:  
- "sts:AssumeRole"  
Path: "/"  
Policies:  
- PolicyName: !Join ["-", [!Ref InfrastructureName, "bootstrap", "policy"]]  
PolicyDocument:  
Version: "2012-10-17"  
Statement:  
- Effect: "Allow"  
Action: "ec2:Describe\*"   
Resource: "\*"   
- Effect: "Allow"  
Action: "ec2:AttachVolume"  
Resource: "\*"   
- Effect: "Allow"  
Action: "ec2:DetachVolume"  
Resource: "\*"   
- Effect: "Allow"  
Action: "s3:GetObject"  
Resource: "\*"

BootstrapInstanceProfile:

Type: "AWS::IAM::InstanceProfile"

Properties:

Path: "/"

Roles:

- Ref: "BootstrapIamRole"

BootstrapSecurityGroup:

Type: AWS::EC2::SecurityGroup

Properties:

GroupDescription: Cluster Bootstrap Security Group

SecurityGroupIngress:

- IpProtocol: tcp

FromPort: 22

ToPort: 22

CidrIp: !Ref AllowedBootstrapSshCidr

- IpProtocol: tcp

ToPort: 19531

FromPort: 19531

CidrIp: 0.0.0.0/0

VpcId: !Ref VpcId

BootstrapInstance:

Type: AWS::EC2::Instance

Properties:

ImageId: !Ref RhcosAmi

IamInstanceProfile: !Ref BootstrapInstanceProfile

InstanceType: "i3.large"

NetworkInterfaces:

- AssociatePublicIpAddress: "true"

DeviceIndex: "0"

GroupSet:

- !Ref "BootstrapSecurityGroup"

- !Ref "MasterSecurityGroupId"

SubnetId: !Ref "PublicSubnet"

UserData:

Fn::Base64: !Sub

- '{"ignition":{"config":{"replace":{"source":"\${S3Loc}}","version":"3.1.0"}}}'

- {

  S3Loc: !Ref BootstrapIgnitionLocation

}

RegisterBootstrapApiTarget:

Condition: DoRegistration

Type: Custom::NLBRegister

Properties:

ServiceToken: !Ref RegisterNlbTargetsLambdaArn

TargetArn: !Ref ExternalApiTargetGroupArn

TargetIp: !GetAtt BootstrapInstance.PrivateIp

RegisterBootstrapInternalApiTarget:

Condition: DoRegistration

Type: Custom::NLBRegister

Properties:

ServiceToken: !Ref RegisterNlbTargetsLambdaArn

TargetArn: !Ref InternalApiTargetGroupArn

TargetIp: !GetAtt BootstrapInstance.PrivateIp

```

RegisterBootstrapInternalServiceTarget:
  Condition: DoRegistration
  Type: Custom::NLBRegister
  Properties:
    ServiceToken: !Ref RegisterNlbTargetsLambdaArn
    TargetArn: !Ref InternalServiceTargetGroupArn
    TargetIp: !GetAtt BootstrapInstance.PrivateIp

```

#### Outputs:

```

BootstrapInstanceId:
  Description: Bootstrap Instance ID.
  Value: !Ref BootstrapInstance

```

#### BootstrapPublicIp:

```

Description: The bootstrap node public IP address.
Value: !GetAtt BootstrapInstance.PublicIp

```

#### BootstrapPrivateIp:

```

Description: The bootstrap node private IP address.
Value: !GetAtt BootstrapInstance.PrivateIp

```

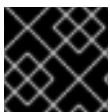
### Additional resources

- See [RHCOS AMIs for the AWS infrastructure](#) for details about the Red Hat Enterprise Linux CoreOS (RHCOS) AMIs for the AWS zones.

## 4.13.15. Creating the control plane machines in AWS

You must create the control plane machines in Amazon Web Services (AWS) that your cluster will use.

You can use the provided CloudFormation template and a custom parameter file to create a stack of AWS resources that represent the control plane nodes.



### IMPORTANT

The CloudFormation template creates a stack that represents three control plane nodes.



### NOTE

If you do not use the provided CloudFormation template to create your control plane nodes, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

### Prerequisites

- You configured an AWS account.
- You added your AWS keys and region to your local AWS profile by running **aws configure**.
- You generated the Ignition config files for your cluster.



- You created and configured a VPC and associated subnets in AWS.
- You created and configured DNS, load balancers, and listeners in AWS.
- You created the security groups and roles required for your cluster in AWS.
- You created the bootstrap machine.

## Procedure

1. Create a JSON file that contains the parameter values that the template requires:

```
[
  {
    "ParameterKey": "InfrastructureName", 1
    "ParameterValue": "mycluster-<random_string>" 2
  },
  {
    "ParameterKey": "RhcoshAmi", 3
    "ParameterValue": "ami-<random_string>" 4
  },
  {
    "ParameterKey": "AutoRegisterDNS", 5
    "ParameterValue": "yes" 6
  },
  {
    "ParameterKey": "PrivateHostedZoneId", 7
    "ParameterValue": "<random_string>" 8
  },
  {
    "ParameterKey": "PrivateHostedZoneName", 9
    "ParameterValue": "mycluster.example.com" 10
  },
  {
    "ParameterKey": "Master0Subnet", 11
    "ParameterValue": "subnet-<random_string>" 12
  },
  {
    "ParameterKey": "Master1Subnet", 13
    "ParameterValue": "subnet-<random_string>" 14
  },
  {
    "ParameterKey": "Master2Subnet", 15
    "ParameterValue": "subnet-<random_string>" 16
  },
  {
    "ParameterKey": "MasterSecurityGroupID", 17
    "ParameterValue": "sg-<random_string>" 18
  },
  {
    "ParameterKey": "IgnitionLocation", 19
    "ParameterValue": "https://api-int.<cluster_name>.<domain_name>:22623/config/master" 20
  }
]
```

```

},
{
  "ParameterKey": "CertificateAuthorities", 21
  "ParameterValue": "data:text/plain;charset=utf-8;base64,ABC...xYz==" 22
},
{
  "ParameterKey": "MasterInstanceProfileName", 23
  "ParameterValue": "<roles_stack>-MasterInstanceProfile-<random_string>" 24
},
{
  "ParameterKey": "MasterInstanceType", 25
  "ParameterValue": "m5.xlarge" 26
},
{
  "ParameterKey": "AutoRegisterELB", 27
  "ParameterValue": "yes" 28
},
{
  "ParameterKey": "RegisterNlbTargetsLambdaArn", 29
  "ParameterValue": "arn:aws:lambda:<region>:<account_number>:function:
<dns_stack_name>-RegisterNlbTargets-<random_string>" 30
},
{
  "ParameterKey": "ExternalApiTargetGroupArn", 31
  "ParameterValue": "arn:aws:elasticloadbalancing:<region>:
<account_number>:targetgroup/<dns_stack_name>-Exter-<random_string>" 32
},
{
  "ParameterKey": "InternalApiTargetGroupArn", 33
  "ParameterValue": "arn:aws:elasticloadbalancing:<region>:
<account_number>:targetgroup/<dns_stack_name>-Inter-<random_string>" 34
},
{
  "ParameterKey": "InternalServiceTargetGroupArn", 35
  "ParameterValue": "arn:aws:elasticloadbalancing:<region>:
<account_number>:targetgroup/<dns_stack_name>-Inter-<random_string>" 36
}
]

```

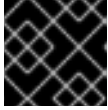
- 1 The name for your cluster infrastructure that is encoded in your Ignition config files for the cluster.
- 2 Specify the infrastructure name that you extracted from the Ignition config file metadata, which has the format **<cluster-name>-<random-string>**.
- 3 Current Red Hat Enterprise Linux CoreOS (RHCOS) AMI to use for the control plane machines.
- 4 Specify an **AWS::EC2::Image::Id** value.
- 5 Whether or not to perform DNS etcd registration.
- 6 Specify **yes** or **no**. If you specify **yes**, you must provide hosted zone information.

- 7 The Route 53 private zone ID to register the etcd targets with.
- 8 Specify the **PrivateHostedZoneId** value from the output of the CloudFormation template for DNS and load balancing.
- 9 The Route 53 zone to register the targets with.
- 10 Specify **<cluster\_name>.<domain\_name>** where **<domain\_name>** is the Route 53 base domain that you used when you generated **install-config.yaml** file for the cluster. Do not include the trailing period (.) that is displayed in the AWS console.
- 11 13 15 A subnet, preferably private, to launch the control plane machines on.
- 12 14 16 Specify a subnet from the **PrivateSubnets** value from the output of the CloudFormation template for DNS and load balancing.
- 17 The master security group ID to associate with control plane nodes.
- 18 Specify the **MasterSecurityGroupID** value from the output of the CloudFormation template for the security group and roles.
- 19 The location to fetch control plane Ignition config file from.
- 20 Specify the generated Ignition config file location, [https://api-int.<cluster\\_name>.<domain\\_name>:22623/config/master](https://api-int.<cluster_name>.<domain_name>:22623/config/master).
- 21 The base64 encoded certificate authority string to use.
- 22 Specify the value from the **master.ign** file that is in the installation directory. This value is the long string with the format **data:text/plain;charset=utf-8;base64,ABC...xYz==**.
- 23 The IAM profile to associate with control plane nodes.
- 24 Specify the **MasterInstanceProfile** parameter value from the output of the CloudFormation template for the security group and roles.
- 25 The type of AWS instance to use for the control plane machines.
- 26 Allowed values:
  - **m4.xlarge**
  - **m4.2xlarge**
  - **m4.4xlarge**
  - **m4.10xlarge**
  - **m4.16xlarge**
  - **m5.xlarge**
  - **m5.2xlarge**
  - **m5.4xlarge**
  - **m5.8xlarge**

- **m5.12xlarge**
- **m5.16xlarge**
- **m5a.xlarge**
- **m5a.2xlarge**
- **m5a.4xlarge**
- **m5a.8xlarge**
- **m5a.12xlarge**
- **m5a.16xlarge**
- **c4.2xlarge**
- **c4.4xlarge**
- **c4.8xlarge**
- **c5.2xlarge**
- **c5.4xlarge**
- **c5.9xlarge**
- **c5.12xlarge**
- **c5.18xlarge**
- **c5.24xlarge**
- **c5a.2xlarge**
- **c5a.4xlarge**
- **c5a.8xlarge**
- **c5a.12xlarge**
- **c5a.16xlarge**
- **c5a.24xlarge**
- **r4.xlarge**
- **r4.2xlarge**
- **r4.4xlarge**
- **r4.8xlarge**
- **r4.16xlarge**
- **r5.xlarge**

- **r5.2xlarge**
  - **r5.4xlarge**
  - **r5.8xlarge**
  - **r5.12xlarge**
  - **r5.16xlarge**
  - **r5.24xlarge**
  - **r5a.xlarge**
  - **r5a.2xlarge**
  - **r5a.4xlarge**
  - **r5a.8xlarge**
  - **r5a.12xlarge**
  - **r5a.16xlarge**
  - **r5a.24xlarge**
- 27** Whether or not to register a network load balancer (NLB).
- 28** Specify **yes** or **no**. If you specify **yes**, you must provide a Lambda Amazon Resource Name (ARN) value.
- 29** The ARN for NLB IP target registration lambda group.
- 30** Specify the **RegisterNlbTargetsLambda** value from the output of the CloudFormation template for DNS and load balancing. Use **arn:aws-us-gov** if deploying the cluster to an AWS GovCloud region.
- 31** The ARN for external API load balancer target group.
- 32** Specify the **ExternalApiTargetGroupArn** value from the output of the CloudFormation template for DNS and load balancing. Use **arn:aws-us-gov** if deploying the cluster to an AWS GovCloud region.
- 33** The ARN for internal API load balancer target group.
- 34** Specify the **InternalApiTargetGroupArn** value from the output of the CloudFormation template for DNS and load balancing. Use **arn:aws-us-gov** if deploying the cluster to an AWS GovCloud region.
- 35** The ARN for internal service load balancer target group.
- 36** Specify the **InternalServiceTargetGroupArn** value from the output of the CloudFormation template for DNS and load balancing. Use **arn:aws-us-gov** if deploying the cluster to an AWS GovCloud region.

- Copy the template from the **CloudFormation template for control plane machines** section of this topic and save it as a YAML file on your computer. This template describes the control plane machines that your cluster requires.
- If you specified an **m5** instance type as the value for **MasterInstanceType**, add that instance type to the **MasterInstanceType.AllowedValues** parameter in the CloudFormation template.
- Launch the CloudFormation template to create a stack of AWS resources that represent the control plane nodes:



### IMPORTANT

You must enter the command on a single line.

```
$ aws cloudformation create-stack --stack-name <name> 1
  --template-body file://<template>.yaml 2
  --parameters file://<parameters>.json 3
```

- <name>** is the name for the CloudFormation stack, such as **cluster-control-plane**. You need the name of this stack if you remove the cluster.
- <template>** is the relative path to and name of the CloudFormation template YAML file that you saved.
- <parameters>** is the relative path to and name of the CloudFormation parameters JSON file.

### Example output

```
arn:aws:cloudformation:us-east-1:269333783861:stack/cluster-control-plane/21c7e2b0-2ee2-11eb-c6f6-0aa34627df4b
```



### NOTE

The CloudFormation template creates a stack that represents three control plane nodes.

- Confirm that the template components exist:

```
$ aws cloudformation describe-stacks --stack-name <name>
```

#### 4.13.15.1. CloudFormation template for control plane machines

You can use the following CloudFormation template to deploy the control plane machines that you need for your OpenShift Container Platform cluster.

#### Example 4.60. CloudFormation template for control plane machines

```
AWSTemplateFormatVersion: 2010-09-09
Description: Template for OpenShift Cluster Node Launch (EC2 master instances)
```

## Parameters:

## InfrastructureName:

AllowedPattern: `^[a-zA-Z][a-zA-Z0-9\-\]{0,26}$`

MaxLength: `27`

MinLength: `1`

ConstraintDescription: Infrastructure name must be alphanumeric, start with a letter, and have a maximum of `27` characters.

Description: A short, unique cluster ID used to tag nodes for the kubelet cloud provider.

Type: String

## RhcOSAmi:

Description: Current Red Hat Enterprise Linux CoreOS AMI to use for bootstrap.

Type: `AWS::EC2::Image::Id`

## AutoRegisterDNS:

Default: `"yes"`

AllowedValues:

- `"yes"`

- `"no"`

Description: Do you want to invoke DNS etcd registration, which requires Hosted Zone information?

Type: String

## PrivateHostedZoneId:

Description: The Route53 private zone ID to register the etcd targets with, such as `Z21IXYZABCZ2A4`.

Type: String

## PrivateHostedZoneName:

Description: The Route53 zone to register the targets with, such as `cluster.example.com`. Omit the trailing period.

Type: String

## Master0Subnet:

Description: The subnets, recommend private, to launch the master nodes into.

Type: `AWS::EC2::Subnet::Id`

## Master1Subnet:

Description: The subnets, recommend private, to launch the master nodes into.

Type: `AWS::EC2::Subnet::Id`

## Master2Subnet:

Description: The subnets, recommend private, to launch the master nodes into.

Type: `AWS::EC2::Subnet::Id`

## MasterSecurityGroupId:

Description: The master security group ID to associate with master nodes.

Type: `AWS::EC2::SecurityGroup::Id`

## IgnitionLocation:

Default: `https://api-int.$CLUSTER_NAME.$DOMAIN:22623/config/master`

Description: Ignition config file location.

Type: String

## CertificateAuthorities:

Default: `data:text/plain;charset=utf-8;base64,ABC...xYz==`

Description: Base64 encoded certificate authority string to use.

Type: String

## MasterInstanceProfileName:

Description: IAM profile to associate with master nodes.

Type: String

## MasterInstanceType:

Default: `m5.xlarge`

Type: String

## AutoRegisterELB:

Default: "yes"

AllowedValues:

- "yes"
- "no"

Description: Do you want to invoke NLB registration, which requires a Lambda ARN parameter?

Type: String

RegisterNlbTargetsLambdaArn:

Description: ARN for NLB IP target registration lambda. Supply the value from the cluster infrastructure or select "no" for AutoRegisterELB.

Type: String

ExternalApiTargetGroupArn:

Description: ARN for external API load balancer target group. Supply the value from the cluster infrastructure or select "no" for AutoRegisterELB.

Type: String

InternalApiTargetGroupArn:

Description: ARN for internal API load balancer target group. Supply the value from the cluster infrastructure or select "no" for AutoRegisterELB.

Type: String

InternalServiceTargetGroupArn:

Description: ARN for internal service load balancer target group. Supply the value from the cluster infrastructure or select "no" for AutoRegisterELB.

Type: String

Metadata:

AWS::CloudFormation::Interface:

ParameterGroups:

- Label:

default: "Cluster Information"

Parameters:

- InfrastructureName

- Label:

default: "Host Information"

Parameters:

- MasterInstanceType

- RhcosAmi

- IgnitionLocation

- CertificateAuthorities

- MasterSecurityGroupId

- MasterInstanceProfileName

- Label:

default: "Network Configuration"

Parameters:

- VpcId

- AllowedBootstrapSshCidr

- Master0Subnet

- Master1Subnet

- Master2Subnet

- Label:

default: "DNS"

Parameters:

- AutoRegisterDNS

- PrivateHostedZoneName

- PrivateHostedZoneId

- Label:

default: "Load Balancer Automation"

Parameters:



- AutoRegisterELB
- RegisterNlbTargetsLambdaArn
- ExternalApiTargetGroupArn
- InternalApiTargetGroupArn
- InternalServiceTargetGroupArn

ParameterLabels:

InfrastructureName:  
 default: "Infrastructure Name"

VpcId:  
 default: "VPC ID"

Master0Subnet:  
 default: "Master-0 Subnet"

Master1Subnet:  
 default: "Master-1 Subnet"

Master2Subnet:  
 default: "Master-2 Subnet"

MasterInstanceType:  
 default: "Master Instance Type"

MasterInstanceProfileName:  
 default: "Master Instance Profile Name"

RhcosAmi:  
 default: "Red Hat Enterprise Linux CoreOS AMI ID"

BootstrapIgnitionLocation:  
 default: "Master Ignition Source"

CertificateAuthorities:  
 default: "Ignition CA String"

MasterSecurityGroupId:  
 default: "Master Security Group ID"

AutoRegisterDNS:  
 default: "Use Provided DNS Automation"

AutoRegisterELB:  
 default: "Use Provided ELB Automation"

PrivateHostedZoneName:  
 default: "Private Hosted Zone Name"

PrivateHostedZoneId:  
 default: "Private Hosted Zone ID"

Conditions:

DoRegistration: !Equals ["yes", !Ref AutoRegisterELB]  
 DoDns: !Equals ["yes", !Ref AutoRegisterDNS]

Resources:

Master0:  
 Type: AWS::EC2::Instance  
 Properties:  
 ImageId: !Ref RhcosAmi  
 BlockDeviceMappings:  
 - DeviceName: /dev/xvda  
 Ebs:  
 VolumeSize: "120"  
 VolumeType: "gp2"  
 IamInstanceProfile: !Ref MasterInstanceProfileName  
 InstanceType: !Ref MasterInstanceType  
 NetworkInterfaces:  
 - AssociatePublicIp: "false"  
 DeviceIndex: "0"

```

GroupSet:
- !Ref "MasterSecurityGroupId"
SubnetId: !Ref "Master0Subnet"
UserData:
  Fn::Base64: !Sub
    - '{"ignition":{"config":{"merge":{"source":"${SOURCE}"}}, "security":{"tls":
{"certificateAuthorities":[{"source":"${CA_BUNDLE}"}]}}, "version":"3.1.0"}}'
    - {
      SOURCE: !Ref IgnitionLocation,
      CA_BUNDLE: !Ref CertificateAuthorities,
    }
  Tags:
    - Key: !Join [ "", ["kubernetes.io/cluster/", !Ref InfrastructureName] ]
      Value: "shared"

```

```

RegisterMaster0:
Condition: DoRegistration
Type: Custom::NLBRegister
Properties:
  ServiceToken: !Ref RegisterNlbTargetsLambdaArn
  TargetArn: !Ref ExternalApiTargetGroupArn
  TargetIp: !GetAtt Master0.PrivateIp

```

```

RegisterMaster0InternalApiTarget:
Condition: DoRegistration
Type: Custom::NLBRegister
Properties:
  ServiceToken: !Ref RegisterNlbTargetsLambdaArn
  TargetArn: !Ref InternalApiTargetGroupArn
  TargetIp: !GetAtt Master0.PrivateIp

```

```

RegisterMaster0InternalServiceTarget:
Condition: DoRegistration
Type: Custom::NLBRegister
Properties:
  ServiceToken: !Ref RegisterNlbTargetsLambdaArn
  TargetArn: !Ref InternalServiceTargetGroupArn
  TargetIp: !GetAtt Master0.PrivateIp

```

```

Master1:
Type: AWS::EC2::Instance
Properties:
  ImageId: !Ref RhcosAmi
  BlockDeviceMappings:
    - DeviceName: /dev/xvda
      Ebs:
        VolumeSize: "120"
        VolumeType: "gp2"
  IamInstanceProfile: !Ref MasterInstanceProfileName
  InstanceType: !Ref MasterInstanceType
  NetworkInterfaces:
    - AssociatePublicIpAddress: "false"
      DeviceIndex: "0"
      GroupSet:
        - !Ref "MasterSecurityGroupId"
      SubnetId: !Ref "Master1Subnet"

```

```

UserData:
  Fn::Base64: !Sub
    - '{"ignition":{"config":{"merge":{"source":"${SOURCE}"}}, "security":{"tls":
{"certificateAuthorities":[{"source":"${CA_BUNDLE}"}]}, "version":"3.1.0"}}'
    - {
      SOURCE: !Ref IgnitionLocation,
      CA_BUNDLE: !Ref CertificateAuthorities,
    }
  Tags:
    - Key: !Join ["/"], ["kubernetes.io/cluster/", !Ref InfrastructureName]
      Value: "shared"

```

```

RegisterMaster1:
  Condition: DoRegistration
  Type: Custom::NLBRegister
  Properties:
    ServiceToken: !Ref RegisterNlbTargetsLambdaArn
    TargetArn: !Ref ExternalApiTargetGroupArn
    TargetIp: !GetAtt Master1.PrivateIp

```

```

RegisterMaster1InternalApiTarget:
  Condition: DoRegistration
  Type: Custom::NLBRegister
  Properties:
    ServiceToken: !Ref RegisterNlbTargetsLambdaArn
    TargetArn: !Ref InternalApiTargetGroupArn
    TargetIp: !GetAtt Master1.PrivateIp

```

```

RegisterMaster1InternalServiceTarget:
  Condition: DoRegistration
  Type: Custom::NLBRegister
  Properties:
    ServiceToken: !Ref RegisterNlbTargetsLambdaArn
    TargetArn: !Ref InternalServiceTargetGroupArn
    TargetIp: !GetAtt Master1.PrivateIp

```

```

Master2:
  Type: AWS::EC2::Instance
  Properties:
    ImageId: !Ref RhcosAmi
    BlockDeviceMappings:
      - DeviceName: /dev/xvda
        Ebs:
          VolumeSize: "120"
          VolumeType: "gp2"
    IamInstanceProfile: !Ref MasterInstanceProfileName
    InstanceType: !Ref MasterInstanceType
    NetworkInterfaces:
      - AssociatePublicIpAddress: "false"
        DeviceIndex: "0"
        GroupSet:
          - !Ref "MasterSecurityGroupId"
        SubnetId: !Ref "Master2Subnet"
  UserData:
    Fn::Base64: !Sub
      - '{"ignition":{"config":{"merge":{"source":"${SOURCE}"}}, "security":{"tls":

```

```

{"certificateAuthorities":[{"source":"${CA_BUNDLE}"}]}, {"version":"3.1.0"}]
- {
  SOURCE: !Ref IgnitionLocation,
  CA_BUNDLE: !Ref CertificateAuthorities,
}
Tags:
- Key: !Join ["", ["kubernetes.io/cluster/", !Ref InfrastructureName]]
  Value: "shared"

RegisterMaster2:
  Condition: DoRegistration
  Type: Custom::NLBRegister
  Properties:
    ServiceToken: !Ref RegisterNlbTargetsLambdaArn
    TargetArn: !Ref ExternalApiTargetGroupArn
    TargetIp: !GetAtt Master2.PrivateIp

RegisterMaster2InternalApiTarget:
  Condition: DoRegistration
  Type: Custom::NLBRegister
  Properties:
    ServiceToken: !Ref RegisterNlbTargetsLambdaArn
    TargetArn: !Ref InternalApiTargetGroupArn
    TargetIp: !GetAtt Master2.PrivateIp

RegisterMaster2InternalServiceTarget:
  Condition: DoRegistration
  Type: Custom::NLBRegister
  Properties:
    ServiceToken: !Ref RegisterNlbTargetsLambdaArn
    TargetArn: !Ref InternalServiceTargetGroupArn
    TargetIp: !GetAtt Master2.PrivateIp

EtcDsrvRecords:
  Condition: DoDns
  Type: AWS::Route53::RecordSet
  Properties:
    HostedZoneId: !Ref PrivateHostedZoneId
    Name: !Join [".", ["_etcd-server-ssl._tcp", !Ref PrivateHostedZoneName]]
    ResourceRecords:
    - !Join [
      " ",
      ["0 10 2380", !Join [".", ["etcd-0", !Ref PrivateHostedZoneName]]],
    ]
    - !Join [
      " ",
      ["0 10 2380", !Join [".", ["etcd-1", !Ref PrivateHostedZoneName]]],
    ]
    - !Join [
      " ",
      ["0 10 2380", !Join [".", ["etcd-2", !Ref PrivateHostedZoneName]]],
    ]
    TTL: 60
    Type: SRV

EtcD0Record:

```

```

Condition: DoDns
Type: AWS::Route53::RecordSet
Properties:
  HostedZoneId: !Ref PrivateHostedZoneId
  Name: !Join [".", ["etcd-0", !Ref PrivateHostedZoneName]]
  ResourceRecords:
    - !GetAtt Master0.PrivateIp
  TTL: 60
  Type: A

```

```

Etcd1Record:
Condition: DoDns
Type: AWS::Route53::RecordSet
Properties:
  HostedZoneId: !Ref PrivateHostedZoneId
  Name: !Join [".", ["etcd-1", !Ref PrivateHostedZoneName]]
  ResourceRecords:
    - !GetAtt Master1.PrivateIp
  TTL: 60
  Type: A

```

```

Etcd2Record:
Condition: DoDns
Type: AWS::Route53::RecordSet
Properties:
  HostedZoneId: !Ref PrivateHostedZoneId
  Name: !Join [".", ["etcd-2", !Ref PrivateHostedZoneName]]
  ResourceRecords:
    - !GetAtt Master2.PrivateIp
  TTL: 60
  Type: A

```

```

Outputs:
PrivateIPs:
  Description: The control-plane node private IP addresses.
  Value:
    !Join [
      ",",
      [!GetAtt Master0.PrivateIp, !GetAtt Master1.PrivateIp, !GetAtt Master2.PrivateIp]
    ]

```

#### 4.13.16. Creating the worker nodes in AWS

You can create worker nodes in Amazon Web Services (AWS) for your cluster to use.

You can use the provided CloudFormation template and a custom parameter file to create a stack of AWS resources that represent a worker node.



#### IMPORTANT

The CloudFormation template creates a stack that represents one worker node. You must create a stack for each worker node.



## NOTE

If you do not use the provided CloudFormation template to create your worker nodes, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

## Prerequisites

- You configured an AWS account.
- You added your AWS keys and region to your local AWS profile by running **aws configure**.
- You generated the Ignition config files for your cluster.
- You created and configured a VPC and associated subnets in AWS.
- You created and configured DNS, load balancers, and listeners in AWS.
- You created the security groups and roles required for your cluster in AWS.
- You created the bootstrap machine.
- You created the control plane machines.

## Procedure

1. Create a JSON file that contains the parameter values that the CloudFormation template requires:

```
[
  {
    "ParameterKey": "InfrastructureName", 1
    "ParameterValue": "mycluster-<random_string>" 2
  },
  {
    "ParameterKey": "RhcocAmi", 3
    "ParameterValue": "ami-<random_string>" 4
  },
  {
    "ParameterKey": "Subnet", 5
    "ParameterValue": "subnet-<random_string>" 6
  },
  {
    "ParameterKey": "WorkerSecurityGroupld", 7
    "ParameterValue": "sg-<random_string>" 8
  },
  {
    "ParameterKey": "IgnitionLocation", 9
    "ParameterValue": "https://api-int.<cluster_name>.<domain_name>:22623/config/worker"
  },
  {
    "ParameterKey": "CertificateAuthorities", 11
    "ParameterValue": "" 12
  }
]
```

```

    },
    {
      "ParameterKey": "WorkerInstanceProfileName", 13
      "ParameterValue": "" 14
    },
    {
      "ParameterKey": "WorkerInstanceType", 15
      "ParameterValue": "m4.2xlarge" 16
    }
  ]

```

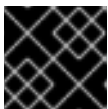
- 1 The name for your cluster infrastructure that is encoded in your Ignition config files for the cluster.
- 2 Specify the infrastructure name that you extracted from the Ignition config file metadata, which has the format **<cluster-name>-<random-string>**.
- 3 Current Red Hat Enterprise Linux CoreOS (RHCOS) AMI to use for the worker nodes.
- 4 Specify an **AWS::EC2::Image::Id** value.
- 5 A subnet, preferably private, to start the worker nodes on.
- 6 Specify a subnet from the **PrivateSubnets** value from the output of the CloudFormation template for DNS and load balancing.
- 7 The worker security group ID to associate with worker nodes.
- 8 Specify the **WorkerSecurityGroupID** value from the output of the CloudFormation template for the security group and roles.
- 9 The location to fetch the bootstrap Ignition config file from.
- 10 Specify the generated Ignition config location, [https://api-int.<cluster\\_name>.<domain\\_name>:22623/config/worker](https://api-int.<cluster_name>.<domain_name>:22623/config/worker).
- 11 Base64 encoded certificate authority string to use.
- 12 Specify the value from the **worker.ign** file that is in the installation directory. This value is the long string with the format **data:text/plain;charset=utf-8;base64,ABC...xYz==**.
- 13 The IAM profile to associate with worker nodes.
- 14 Specify the **WorkerInstanceProfile** parameter value from the output of the CloudFormation template for the security group and roles.
- 15 The type of AWS instance to use for the control plane machines.
- 16 Allowed values:
  - **m4.large**
  - **m4.xlarge**
  - **m4.2xlarge**
  - **m4.4xlarge**

- **m4.10xlarge**
- **m4.16xlarge**
- **m5.large**
- **m5.xlarge**
- **m5.2xlarge**
- **m5.4xlarge**
- **m5.8xlarge**
- **m5.12xlarge**
- **m5.16xlarge**
- **m5a.large**
- **m5a.xlarge**
- **m5a.2xlarge**
- **m5a.4xlarge**
- **m5a.8xlarge**
- **m5a.12xlarge**
- **m5a.16xlarge**
- **c4.large**
- **c4.xlarge**
- **c4.2xlarge**
- **c4.4xlarge**
- **c4.8xlarge**
- **c5.large**
- **c5.xlarge**
- **c5.2xlarge**
- **c5.4xlarge**
- **c5.9xlarge**
- **c5.12xlarge**
- **c5.18xlarge**
- **c5.24xlarge**



- **c5a.large**
- **c5a.xlarge**
- **c5a.2xlarge**
- **c5a.4xlarge**
- **c5a.8xlarge**
- **c5a.12xlarge**
- **c5a.16xlarge**
- **c5a.24xlarge**
- **r4.large**
- **r4.xlarge**
- **r4.2xlarge**
- **r4.4xlarge**
- **r4.8xlarge**
- **r4.16xlarge**
- **r5.large**
- **r5.xlarge**
- **r5.2xlarge**
- **r5.4xlarge**
- **r5.8xlarge**
- **r5.12xlarge**
- **r5.16xlarge**
- **r5.24xlarge**
- **r5a.large**
- **r5a.xlarge**
- **r5a.2xlarge**
- **r5a.4xlarge**
- **r5a.8xlarge**
- **r5a.12xlarge**
- **r5a.16xlarge**

- **r5a.24xlarge**
  - **t3.large**
  - **t3.xlarge**
  - **t3.2xlarge**
  - **t3a.large**
  - **t3a.xlarge**
  - **t3a.2xlarge**
2. Copy the template from the **CloudFormation template for worker machines** section of this topic and save it as a YAML file on your computer. This template describes the networking objects and load balancers that your cluster requires.
  3. Optional: If you specified an **m5** instance type as the value for **WorkerInstanceType**, add that instance type to the **WorkerInstanceType.AllowedValues** parameter in the CloudFormation template.
  4. Optional: If you are deploying with an AWS Marketplace image, update the **Worker0.type.properties.ImageID** parameter with the AMI ID that you obtained from your subscription.
  5. Use the CloudFormation template to create a stack of AWS resources that represent a worker node:



### IMPORTANT

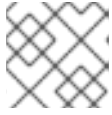
You must enter the command on a single line.

```
$ aws cloudformation create-stack --stack-name <name> 1
  --template-body file://<template>.yaml \ 2
  --parameters file://<parameters>.json 3
```

- 1** **<name>** is the name for the CloudFormation stack, such as **cluster-worker-1**. You need the name of this stack if you remove the cluster.
- 2** **<template>** is the relative path to and name of the CloudFormation template YAML file that you saved.
- 3** **<parameters>** is the relative path to and name of the CloudFormation parameters JSON file.

### Example output

```
arn:aws:cloudformation:us-east-1:269333783861:stack/cluster-worker-1/729ee301-1c2a-11eb-348f-sd9888c65b59
```

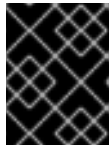
**NOTE**

The CloudFormation template creates a stack that represents one worker node.

- Confirm that the template components exist:

```
$ aws cloudformation describe-stacks --stack-name <name>
```

- Continue to create worker stacks until you have created enough worker machines for your cluster. You can create additional worker stacks by referencing the same template and parameter files and specifying a different stack name.

**IMPORTANT**

You must create at least two worker machines, so you must create at least two stacks that use this CloudFormation template.

#### 4.13.16.1. CloudFormation template for worker machines

You can use the following CloudFormation template to deploy the worker machines that you need for your OpenShift Container Platform cluster.

##### Example 4.61. CloudFormation template for worker machines

AWSTemplateFormatVersion: 2010-09-09

Description: Template for OpenShift Cluster Node Launch (EC2 worker instance)

Parameters:

InfrastructureName:

AllowedPattern: ^([a-zA-Z][a-zA-Z0-9\-\\_]{0,26})\$

MaxLength: 27

MinLength: 1

ConstraintDescription: Infrastructure name must be alphanumeric, start with a letter, and have a maximum of 27 characters.

Description: A short, unique cluster ID used to tag nodes for the kubelet cloud provider.

Type: String

RhcosAmi:

Description: Current Red Hat Enterprise Linux CoreOS AMI to use for bootstrap.

Type: AWS::EC2::Image::Id

Subnet:

Description: The subnets, recommend private, to launch the master nodes into.

Type: AWS::EC2::Subnet::Id

WorkerSecurityGroupId:

Description: The master security group ID to associate with master nodes.

Type: AWS::EC2::SecurityGroup::Id

IgnitionLocation:

Default: https://api-int.\$CLUSTER\_NAME.\$DOMAIN:22623/config/worker

Description: Ignition config file location.

Type: String

CertificateAuthorities:

Default: data:text/plain;charset=utf-8;base64,ABC...xYz==

Description: Base64 encoded certificate authority string to use.

Type: String

WorkerInstanceProfileName:

Description: IAM profile to associate with master nodes.

Type: String

WorkerInstanceType:

Default: m5.large

Type: String

Metadata:

AWS::CloudFormation::Interface:

ParameterGroups:

- Label:

default: "Cluster Information"

Parameters:

- InfrastructureName

- Label:

default: "Host Information"

Parameters:

- WorkerInstanceType

- RhcosAmi

- IgnitionLocation

- CertificateAuthorities

- WorkerSecurityGroupId

- WorkerInstanceProfileName

- Label:

default: "Network Configuration"

Parameters:

- Subnet

ParameterLabels:

Subnet:

default: "Subnet"

InfrastructureName:

default: "Infrastructure Name"

WorkerInstanceType:

default: "Worker Instance Type"

WorkerInstanceProfileName:

default: "Worker Instance Profile Name"

RhcosAmi:

default: "Red Hat Enterprise Linux CoreOS AMI ID"

IgnitionLocation:

default: "Worker Ignition Source"

CertificateAuthorities:

default: "Ignition CA String"

WorkerSecurityGroupId:

default: "Worker Security Group ID"

Resources:

Worker0:

Type: AWS::EC2::Instance

Properties:

ImageId: !Ref RhcosAmi

BlockDeviceMappings:

- DeviceName: /dev/xvda

Ebs:

VolumeSize: "120"

VolumeType: "gp2"

IamInstanceProfile: !Ref WorkerInstanceProfileName

InstanceType: !Ref WorkerInstanceType

```

NetworkInterfaces:
- AssociatePublicIpAddress: "false"
  DeviceIndex: "0"
  GroupSet:
- !Ref "WorkerSecurityGroup"
  SubnetId: !Ref "Subnet"
UserData:
  Fn::Base64: !Sub
- '{"ignition":{"config":{"merge":[{"source":"${SOURCE}"}]},"security":{"tls":
{"certificateAuthorities":[{"source":"${CA_BUNDLE}"}]},"version":"3.1.0"}}'
- {
  SOURCE: !Ref IgnitionLocation,
  CA_BUNDLE: !Ref CertificateAuthorities,
}
Tags:
- Key: !Join ["", ["kubernetes.io/cluster/", !Ref InfrastructureName]]
  Value: "shared"

Outputs:
PrivateIP:
  Description: The compute node private IP address.
  Value: !GetAtt Worker0.PrivateIp

```

#### 4.13.17. Initializing the bootstrap sequence on AWS with user-provisioned infrastructure

After you create all of the required infrastructure in Amazon Web Services (AWS), you can start the bootstrap sequence that initializes the OpenShift Container Platform control plane.

##### Prerequisites

- You configured an AWS account.
- You added your AWS keys and region to your local AWS profile by running **aws configure**.
- You generated the Ignition config files for your cluster.
- You created and configured a VPC and associated subnets in AWS.
- You created and configured DNS, load balancers, and listeners in AWS.
- You created the security groups and roles required for your cluster in AWS.
- You created the bootstrap machine.
- You created the control plane machines.
- You created the worker nodes.

##### Procedure

1. Change to the directory that contains the installation program and start the bootstrap process that initializes the OpenShift Container Platform control plane:

```

$ ./openshift-install wait-for bootstrap-complete --dir <installation_directory> \ 1
--log-level=info 2

```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.
- 2** To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

### Example output

```

INFO Waiting up to 20m0s for the Kubernetes API at
https://api.mycluster.example.com:6443...
INFO API v1.22.1 up
INFO Waiting up to 30m0s for bootstrapping to complete...
INFO It is now safe to remove the bootstrap resources
INFO Time elapsed: 1s

```

If the command exits without a **FATAL** warning, your OpenShift Container Platform control plane has initialized.



#### NOTE

After the control plane initializes, it sets up the compute nodes and installs additional services in the form of Operators.

### Additional resources

- See [Monitoring installation progress](#) for details about monitoring the installation, bootstrap, and control plane logs as an OpenShift Container Platform installation progresses.
- See [Gathering bootstrap node diagnostic data](#) for information about troubleshooting issues related to the bootstrap process.

### 4.13.18. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

#### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

#### Procedure

1. Export the **kubeadmin** credentials:

```

$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1

```

- 1 For `<installation_directory>`, specify the path to the directory that you stored the installation files in.

2. Verify you can run `oc` commands successfully using the exported configuration:

```
$ oc whoami
```

#### Example output

```
system:admin
```

### 4.13.19. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

#### Prerequisites

- You added machines to your cluster.

#### Procedure

1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

#### Example output

```
NAME      STATUS  ROLES  AGE  VERSION
master-0  Ready   master 63m  v1.22.1
master-1  Ready   master 63m  v1.22.1
master-2  Ready   master 64m  v1.22.1
```

The output lists all of the machines that you created.



#### NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

2. Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

#### Example output

```
NAME      AGE  REQUESTOR                                     CONDITION
csr-8b2br 15m  system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper Pending
```

```
csr-8vnps 15m system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper Pending
...
```

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

- If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:



#### NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.



#### NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{"\n"}
{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```



#### NOTE

Some Operators might not become available until some CSRs are approved.

- Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:



```
$ oc get csr
```

### Example output

```
NAME      AGE   REQUESTOR                                     CONDITION
csr-bfd72 5m26s system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv 5m26s system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

- If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{"\n"}\n{{end}}{{end}}' | xargs oc adm certificate approve
```

- After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

### Example output

```
NAME      STATUS   ROLES    AGE   VERSION
master-0  Ready    master   73m   v1.22.1
master-1  Ready    master   73m   v1.22.1
master-2  Ready    master   74m   v1.22.1
worker-0  Ready    worker   11m   v1.22.1
worker-1  Ready    worker   11m   v1.22.1
```



### NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

### Additional information

- For more information on CSRs, see [Certificate Signing Requests](#).

## 4.13.20. Initial Operator configuration

After the control plane initializes, you must immediately configure some Operators so that they all become available.

## Prerequisites

- Your control plane has initialized.

## Procedure

1. Watch the cluster components come online:

```
$ watch -n5 oc get clusteroperators
```

## Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
authentication	4.9.0	True	False	False	19m
baremetal	4.9.0	True	False	False	37m
cloud-credential	4.9.0	True	False	False	40m
cluster-autoscaler	4.9.0	True	False	False	37m
config-operator	4.9.0	True	False	False	38m
console	4.9.0	True	False	False	26m
csi-snapshot-controller	4.9.0	True	False	False	37m
dns	4.9.0	True	False	False	37m
etcd	4.9.0	True	False	False	36m
image-registry	4.9.0	True	False	False	31m
ingress	4.9.0	True	False	False	30m
insights	4.9.0	True	False	False	31m
kube-apiserver	4.9.0	True	False	False	26m
kube-controller-manager	4.9.0	True	False	False	36m
kube-scheduler	4.9.0	True	False	False	36m
kube-storage-version-migrator	4.9.0	True	False	False	37m
machine-api	4.9.0	True	False	False	29m
machine-approver	4.9.0	True	False	False	37m
machine-config	4.9.0	True	False	False	36m
marketplace	4.9.0	True	False	False	37m
monitoring	4.9.0	True	False	False	29m
network	4.9.0	True	False	False	38m
node-tuning	4.9.0	True	False	False	37m
openshift-apiserver	4.9.0	True	False	False	32m
openshift-controller-manager	4.9.0	True	False	False	30m
openshift-samples	4.9.0	True	False	False	32m
operator-lifecycle-manager	4.9.0	True	False	False	37m
operator-lifecycle-manager-catalog	4.9.0	True	False	False	37m
operator-lifecycle-manager-packageserver	4.9.0	True	False	False	32m
service-ca	4.9.0	True	False	False	38m
storage	4.9.0	True	False	False	37m

2. Configure the Operators that are not available.

### 4.13.20.1. Disabling the default OperatorHub sources

Operator catalogs that source content provided by Red Hat and community projects are configured for OperatorHub by default during an OpenShift Container Platform installation. In a restricted network environment, you must disable the default catalogs as a cluster administrator.

### Procedure

- Disable the sources for the default catalogs by adding **disableAllDefaultSources: true** to the **OperatorHub** object:

```
$ oc patch OperatorHub cluster --type json \
  -p '[{"op": "add", "path": "/spec/disableAllDefaultSources", "value": true}]'
```

### TIP

Alternatively, you can use the web console to manage catalog sources. From the **Administration** → **Cluster Settings** → **Configuration** → **OperatorHub** page, click the **Sources** tab, where you can create, delete, disable, and enable individual sources.

## 4.13.20.2. Image registry storage configuration

Amazon Web Services provides default storage, which means the Image Registry Operator is available after installation. However, if the Registry Operator cannot create an S3 bucket and automatically configure storage, you must manually configure registry storage.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

### 4.13.20.2.1. Configuring registry storage for AWS with user-provisioned infrastructure

During installation, your cloud credentials are sufficient to create an Amazon S3 bucket and the Registry Operator will automatically configure storage.

If the Registry Operator cannot create an S3 bucket and automatically configure storage, you can create an S3 bucket and configure storage with the following procedure.

### Prerequisites

- You have a cluster on AWS with user-provisioned infrastructure.
- For Amazon S3 storage, the secret is expected to contain two keys:
  - **REGISTRY\_STORAGE\_S3\_ACCESSKEY**
  - **REGISTRY\_STORAGE\_S3\_SECRETKEY**

### Procedure

Use the following procedure if the Registry Operator cannot create an S3 bucket and automatically configure storage.

1. Set up a [Bucket Lifecycle Policy](#) to abort incomplete multipart uploads that are one day old.

- Fill in the storage configuration in **configs.imageregistry.operator.openshift.io/cluster**:

```
$ oc edit configs.imageregistry.operator.openshift.io/cluster
```

### Example configuration

```
storage:
  s3:
    bucket: <bucket-name>
    region: <region-name>
```



#### WARNING

To secure your registry images in AWS, [block public access](#) to the S3 bucket.

#### 4.13.20.2.2. Configuring storage for the image registry in non-production clusters

You must configure storage for the Image Registry Operator. For non-production clusters, you can set the image registry to an empty directory. If you do so, all images are lost if you restart the registry.

#### Procedure

- To set the image registry storage to an empty directory:

```
$ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec": {"storage":{"emptyDir":{}}}'
```



#### WARNING

Configure this option for only non-production clusters.

If you run this command before the Image Registry Operator initializes its components, the **oc patch** command fails with the following error:

```
Error from server (NotFound): configs.imageregistry.operator.openshift.io "cluster" not found
```

Wait a few minutes and run the command again.

#### 4.13.21. Deleting the bootstrap resources

After you complete the initial Operator configuration for the cluster, remove the bootstrap resources from Amazon Web Services (AWS).

## Prerequisites

- You completed the initial Operator configuration for your cluster.

## Procedure

1. Delete the bootstrap resources. If you used the CloudFormation template, [delete its stack](#):

- Delete the stack by using the AWS CLI:

```
$ aws cloudformation delete-stack --stack-name <name> 1
```

- 1** **<name>** is the name of your bootstrap stack.

- Delete the stack by using the [AWS CloudFormation console](#).

### 4.13.22. Creating the Ingress DNS Records

If you removed the DNS Zone configuration, manually create DNS records that point to the Ingress load balancer. You can create either a wildcard record or specific records. While the following procedure uses A records, you can use other record types that you require, such as CNAME or alias.

## Prerequisites

- You deployed an OpenShift Container Platform cluster on Amazon Web Services (AWS) that uses infrastructure that you provisioned.
- You installed the OpenShift CLI (**oc**).
- You installed the **jq** package.
- You downloaded the AWS CLI and installed it on your computer. See [Install the AWS CLI Using the Bundled Installer \(Linux, macOS, or Unix\)](#).

## Procedure

1. Determine the routes to create.
  - To create a wildcard record, use **\*.apps.<cluster\_name>.<domain\_name>**, where **<cluster\_name>** is your cluster name, and **<domain\_name>** is the Route 53 base domain for your OpenShift Container Platform cluster.
  - To create specific records, you must create a record for each route that your cluster uses, as shown in the output of the following command:

```
$ oc get --all-namespaces -o jsonpath='{range .items[*]}{range .status.ingress[*]}{.host} {"\n"}{end}{end}' routes
```

### Example output

```
oauth-openshift.apps.<cluster_name>.<domain_name>
console-openshift-console.apps.<cluster_name>.<domain_name>
downloads-openshift-console.apps.<cluster_name>.<domain_name>
```

```

alertmanager-main-openshift-monitoring.apps.<cluster_name>.<domain_name>
grafana-openshift-monitoring.apps.<cluster_name>.<domain_name>
prometheus-k8s-openshift-monitoring.apps.<cluster_name>.<domain_name>

```

- Retrieve the Ingress Operator load balancer status and note the value of the external IP address that it uses, which is shown in the **EXTERNAL-IP** column:

```
$ oc -n openshift-ingress get service router-default
```

### Example output

```

NAME          TYPE          CLUSTER-IP    EXTERNAL-IP          PORT(S)
AGE
router-default LoadBalancer  172.30.62.215  ab3...28.us-east-2.elb.amazonaws.com
80:31499/TCP,443:30693/TCP  5m

```

- Locate the hosted zone ID for the load balancer:

```
$ aws elb describe-load-balancers | jq -r '.LoadBalancerDescriptions[] | select(.DNSName == "<external_ip>").CanonicalHostedZoneNameID' 1
```

- For **<external\_ip>**, specify the value of the external IP address of the Ingress Operator load balancer that you obtained.

### Example output

```
Z3AADJGX6KTTL2
```

The output of this command is the load balancer hosted zone ID.

- Obtain the public hosted zone ID for your cluster's domain:

```
$ aws route53 list-hosted-zones-by-name \
  --dns-name "<domain_name>" 1 \
  --query 'HostedZones[? Config.PrivateZone != `true` && Name == \
  `<domain_name>.`].Id' 2 \
  --output text
```

- For **<domain\_name>**, specify the Route 53 base domain for your OpenShift Container Platform cluster.

### Example output

```
/hostedzone/Z3URY6TWQ91KVV
```

The public hosted zone ID for your domain is shown in the command output. In this example, it is **Z3URY6TWQ91KVV**.

- Add the alias records to your private zone:

```
$ aws route53 change-resource-record-sets --hosted-zone-id "<private_hosted_zone_id>" --
```

```

change-batch '{ ❶
> "Changes": [
> {
>   "Action": "CREATE",
>   "ResourceRecordSet": {
>     "Name": "\\052.apps.<cluster_domain>", ❷
>     "Type": "A",
>     "AliasTarget":{
>       "HostedZoneId": "<hosted_zone_id>", ❸
>       "DNSName": "<external_ip>.", ❹
>       "EvaluateTargetHealth": false
>     }
>   }
> }
> ]
> }'

```

- ❶ For **<private\_hosted\_zone\_id>**, specify the value from the output of the CloudFormation template for DNS and load balancing.
- ❷ For **<cluster\_domain>**, specify the domain or subdomain that you use with your OpenShift Container Platform cluster.
- ❸ For **<hosted\_zone\_id>**, specify the public hosted zone ID for the load balancer that you obtained.
- ❹ For **<external\_ip>**, specify the value of the external IP address of the Ingress Operator load balancer. Ensure that you include the trailing period (.) in this parameter value.

6. Add the records to your public zone:

```

$ aws route53 change-resource-record-sets --hosted-zone-id "<public_hosted_zone_id>" --
change-batch '{ ❶
> "Changes": [
> {
>   "Action": "CREATE",
>   "ResourceRecordSet": {
>     "Name": "\\052.apps.<cluster_domain>", ❷
>     "Type": "A",
>     "AliasTarget":{
>       "HostedZoneId": "<hosted_zone_id>", ❸
>       "DNSName": "<external_ip>.", ❹
>       "EvaluateTargetHealth": false
>     }
>   }
> }
> ]
> }'

```

- ❶ For **<public\_hosted\_zone\_id>**, specify the public hosted zone for your domain.
- ❷ For **<cluster\_domain>**, specify the domain or subdomain that you use with your OpenShift Container Platform cluster.

- 3 For **<hosted\_zone\_id>**, specify the public hosted zone ID for the load balancer that you obtained.
- 4 For **<external\_ip>**, specify the value of the external IP address of the Ingress Operator load balancer. Ensure that you include the trailing period (.) in this parameter value.

### 4.13.23. Completing an AWS installation on user-provisioned infrastructure

After you start the OpenShift Container Platform installation on Amazon Web Service (AWS) user-provisioned infrastructure, monitor the deployment to completion.

#### Prerequisites

- You removed the bootstrap node for an OpenShift Container Platform cluster on user-provisioned AWS infrastructure.
- You installed the **oc** CLI.

#### Procedure

1. From the directory that contains the installation program, complete the cluster installation:

```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

- 1 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

#### Example output

```
INFO Waiting up to 40m0s for the cluster at https://api.mycluster.example.com:6443 to
initialize...
INFO Waiting up to 10m0s for the openshift-console route to be created...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Fe5en-ymBEc-
Wt6NL"
INFO Time elapsed: 1s
```





## IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Register your cluster on the [Cluster registration](#) page.

### 4.13.24. Logging in to the cluster by using the web console

The **kubeadmin** user exists by default after an OpenShift Container Platform installation. You can log in to your cluster as the **kubeadmin** user by using the OpenShift Container Platform web console.

#### Prerequisites

- You have access to the installation host.
- You completed a cluster installation and all cluster Operators are available.

#### Procedure

1. Obtain the password for the **kubeadmin** user from the **kubeadmin-password** file on the installation host:

```
$ cat <installation_directory>/auth/kubeadmin-password
```



#### NOTE

Alternatively, you can obtain the **kubeadmin** password from the **<installation\_directory>/openshift\_install.log** log file on the installation host.

2. List the OpenShift Container Platform web console route:

```
$ oc get routes -n openshift-console | grep 'console-openshift'
```



#### NOTE

Alternatively, you can obtain the OpenShift Container Platform route from the **<installation\_directory>/openshift\_install.log** log file on the installation host.

#### Example output

-

```
console console-openshift-console.apps.<cluster_name>.<base_domain> console
https reencrypt/Redirect None
```

3. Navigate to the route detailed in the output of the preceding command in a web browser and log in as the **kubeadmin** user.

#### Additional resources

- See [Accessing the web console](#) for more details about accessing and understanding the OpenShift Container Platform web console.

### 4.13.25. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

#### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

### 4.13.26. Additional resources

- See [Working with stacks](#) in the AWS documentation for more information about AWS CloudFormation stacks.

### 4.13.27. Next steps

- [Validate an installation.](#)
- [Customize your cluster.](#)
- [Configure image streams](#) for the Cluster Samples Operator and the **must-gather** tool.
- Learn how to [use Operator Lifecycle Manager \(OLM\) on restricted networks](#) .
- If the mirror registry that you used to install your cluster has a trusted CA, add it to the cluster by [configuring additional trust stores](#).
- If necessary, you can [opt out of remote health reporting](#) .
- If necessary, you can [remove cloud provider credentials](#).

## 4.14. UNINSTALLING A CLUSTER ON AWS

You can remove a cluster that you deployed to Amazon Web Services (AWS).

### 4.14.1. Removing a cluster that uses installer-provisioned infrastructure

You can remove a cluster that uses installer-provisioned infrastructure from your cloud.



## NOTE

After uninstallation, check your cloud provider for any resources not removed properly, especially with User Provisioned Infrastructure (UPI) clusters. There might be resources that the installer did not create or that the installer is unable to access.

### Prerequisites

- Have a copy of the installation program that you used to deploy the cluster.
- Have the files that the installation program generated when you created your cluster.

### Procedure

1. From the directory that contains the installation program on the computer that you used to install the cluster, run the following command:

```
$ ./openshift-install destroy cluster \
--dir <installation_directory> --log-level info 1 2
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.
- 2** To view different details, specify **warn**, **debug**, or **error** instead of **info**.



## NOTE

You must specify the directory that contains the cluster definition files for your cluster. The installation program requires the **metadata.json** file in this directory to delete the cluster.

2. Optional: Delete the **<installation\_directory>** directory and the OpenShift Container Platform installation program.

### 4.14.2. Deleting AWS resources with the Cloud Credential Operator utility

To clean up resources after uninstalling an OpenShift Container Platform cluster with the Cloud Credential Operator (CCO) in manual mode with STS, you can use the CCO utility (**ccoctl**) to remove the AWS resources that **ccoctl** created during installation.

### Prerequisites

- Extract and prepare the **ccoctl** binary.
- Install an OpenShift Container Platform cluster with the CCO in manual mode with STS.

### Procedure

- Delete the AWS resources that **ccoctl** created:

```
$ ccoctl aws delete --name=<name> --region=<aws_region>
```

where:

- **<name>** matches the name used to originally create and tag the cloud resources.
- **<aws-region>** is the AWS region in which cloud resources will be deleted.

### Example output:

```
2021/04/08 17:50:41 Identity Provider object .well-known/openid-configuration deleted
from the bucket <name>-oidc
2021/04/08 17:50:42 Identity Provider object keys.json deleted from the bucket <name>-
oidc
2021/04/08 17:50:43 Identity Provider bucket <name>-oidc deleted
2021/04/08 17:51:05 Policy <name>-openshift-cloud-credential-operator-cloud-
credential-o associated with IAM Role <name>-openshift-cloud-credential-operator-
cloud-credential-o deleted
2021/04/08 17:51:05 IAM Role <name>-openshift-cloud-credential-operator-cloud-
credential-o deleted
2021/04/08 17:51:07 Policy <name>-openshift-cluster-csi-drivers-ebs-cloud-credentials
associated with IAM Role <name>-openshift-cluster-csi-drivers-ebs-cloud-credentials
deleted
2021/04/08 17:51:07 IAM Role <name>-openshift-cluster-csi-drivers-ebs-cloud-
credentials deleted
2021/04/08 17:51:08 Policy <name>-openshift-image-registry-installer-cloud-credentials
associated with IAM Role <name>-openshift-image-registry-installer-cloud-credentials
deleted
2021/04/08 17:51:08 IAM Role <name>-openshift-image-registry-installer-cloud-
credentials deleted
2021/04/08 17:51:09 Policy <name>-openshift-ingress-operator-cloud-credentials
associated with IAM Role <name>-openshift-ingress-operator-cloud-credentials deleted
2021/04/08 17:51:10 IAM Role <name>-openshift-ingress-operator-cloud-credentials
deleted
2021/04/08 17:51:11 Policy <name>-openshift-machine-api-aws-cloud-credentials
associated with IAM Role <name>-openshift-machine-api-aws-cloud-credentials deleted
2021/04/08 17:51:11 IAM Role <name>-openshift-machine-api-aws-cloud-credentials
deleted
2021/04/08 17:51:39 Identity Provider with ARN arn:aws:iam::<aws_account_id>:oidc-
provider/<name>-oidc.s3.<aws_region>.amazonaws.com deleted
```

### Verification

You can verify that the resources are deleted by querying AWS. For more information, refer to AWS documentation.

## CHAPTER 5. INSTALLING ON AZURE

### 5.1. PREPARING TO INSTALL ON AZURE

#### 5.1.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).

#### 5.1.2. Requirements for installing OpenShift Container Platform on Azure

Before installing OpenShift Container Platform on Microsoft Azure, you must configure an Azure account. See [Configuring an Azure account](#) for details about account configuration, account limits, public DNS zone configuration, required roles, creating service principals, and supported Azure regions.

If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, see [Manually creating IAM for Azure](#) for other options.

#### 5.1.3. Choosing a method to install OpenShift Container Platform on Azure

You can install OpenShift Container Platform on installer-provisioned or user-provisioned infrastructure. The default installation type uses installer-provisioned infrastructure, where the installation program provisions the underlying infrastructure for the cluster. You can also install OpenShift Container Platform on infrastructure that you provision. If you do not use infrastructure that the installation program provisions, you must manage and maintain the cluster resources yourself.

See [Installation process](#) for more information about installer-provisioned and user-provisioned installation processes.

##### 5.1.3.1. Installing a cluster on installer-provisioned infrastructure

You can install a cluster on Azure infrastructure that is provisioned by the OpenShift Container Platform installation program, by using one of the following methods:

- **Installing a cluster quickly on Azure** You can install OpenShift Container Platform on Azure infrastructure that is provisioned by the OpenShift Container Platform installation program. You can install a cluster quickly by using the default configuration options.
- **Installing a customized cluster on Azure** You can install a customized cluster on Azure infrastructure that the installation program provisions. The installation program allows for some customization to be applied at the installation stage. Many other customization options are available [post-installation](#).
- **Installing a cluster on Azure with network customizations** You can customize your OpenShift Container Platform network configuration during installation, so that your cluster can coexist with your existing IP address allocations and adhere to your network requirements.
- **Installing a cluster on Azure into an existing VNet** You can install OpenShift Container Platform on an existing Azure Virtual Network (VNet) on Azure. You can use this installation method if you have constraints set by the guidelines of your company, such as limits when

creating new accounts or infrastructure.

- **Installing a private cluster on Azure** You can install a private cluster into an existing Azure Virtual Network (VNet) on Azure. You can use this method to deploy OpenShift Container Platform on an internal network that is not visible to the internet.
- **Installing a cluster on Azure into a government region** OpenShift Container Platform can be deployed into Microsoft Azure Government (MAG) regions that are specifically designed for US government agencies at the federal, state, and local level, as well as contractors, educational institutions, and other US customers that must run sensitive workloads on Azure.

### 5.1.3.2. Installing a cluster on user-provisioned infrastructure

You can install a cluster on Azure infrastructure that you provision, by using the following method:

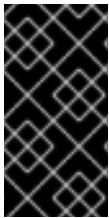
- **Installing a cluster on Azure using ARM templates** You can install OpenShift Container Platform on Azure by using infrastructure that you provide. You can use the provided Azure Resource Manager (ARM) templates to assist with an installation.

### 5.1.4. Next steps

- [Configuring an Azure account](#)

## 5.2. CONFIGURING AN AZURE ACCOUNT

Before you can install OpenShift Container Platform, you must configure a Microsoft Azure account.

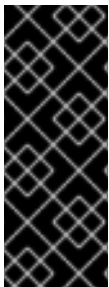


### IMPORTANT

All Azure resources that are available through public endpoints are subject to resource name restrictions, and you cannot create resources that use certain terms. For a list of terms that Azure restricts, see [Resolve reserved resource name errors](#) in the Azure documentation.

### 5.2.1. Azure account limits

The OpenShift Container Platform cluster uses a number of Microsoft Azure components, and the default [Azure subscription and service limits, quotas, and constraints](#) affect your ability to install OpenShift Container Platform clusters.



### IMPORTANT

Default limits vary by offer category types, such as Free Trial and Pay-As-You-Go, and by series, such as Dv2, F, and G. For example, the default for Enterprise Agreement subscriptions is 350 cores.


Check the limits for your subscription type and if necessary, increase quota limits for your account before you install a default cluster on Azure.

The following table summarizes the Azure components whose limits can impact your ability to install and run OpenShift Container Platform clusters.

Component	Number of components required by default	Default Azure limit	Description
vCPU	40	20 per region	<p>A default cluster requires 40 vCPUs, so you must increase the account limit.</p> <p>By default, each cluster creates the following instances:</p> <ul style="list-style-type: none"> <li>● One bootstrap machine, which is removed after installation</li> <li>● Three control plane machines</li> <li>● Three compute machines</li> </ul> <p>Because the bootstrap machine uses <b>Standard_D4s_v3</b> machines, which use 4 vCPUs, the control plane machines use <b>Standard_D8s_v3</b> virtual machines, which use 8 vCPUs, and the worker machines use <b>Standard_D4s_v3</b> virtual machines, which use 4 vCPUs, a default cluster requires 40 vCPUs. The bootstrap node VM, which uses 4 vCPUs, is used only during installation.</p> <p>To deploy more worker nodes, enable autoscaling, deploy large workloads, or use a different instance type, you must further increase the vCPU limit for your account to ensure that your cluster can deploy the machines that you require.</p> <p>By default, the installation program distributes control plane and compute machines across <a href="#">all availability zones</a> within a <a href="#">region</a>. To ensure high availability for your cluster, select a region with at least three availability zones. If your region contains fewer than three availability zones, the installation program places more than one control plane machine in the available zones.</p>

Component	Number of components required by default	Default Azure limit	Description				
OS Disk	7		<p>VM OS disk must be able to sustain a tested and recommended minimum throughput of 5000 IOPS / 200MBps for control plane machines. This throughput can be provided by having a minimum of 1 TiB Premium SSD (P30). In Azure, disk performance is directly dependent on SSD disk sizes, so to achieve the throughput supported by <b>Standard_D8s_v3</b>, or other similar machine types available, and the target of 5000 IOPS, at least a P30 disk is required.</p> <p>Host caching must be set to <b>ReadOnly</b> for low read latency and high read IOPS and throughput. The reads performed from the cache, which is present either in the VM memory or in the local SSD disk, are much faster than the reads from the data disk, which is in the blob storage.</p>				
VNet	1	1000 per region	Each default cluster requires one Virtual Network (VNet), which contains two subnets.				
Network interfaces	7	65,536 per region	Each default cluster requires seven network interfaces. If you create more machines or your deployed workloads create load balancers, your cluster uses more network interfaces.				
Network security groups	2	5000	<p>Each cluster creates network security groups for each subnet in the VNet. The default cluster creates network security groups for the control plane and for the compute node subnets:</p> <table border="1"> <tbody> <tr> <td><b>control plane</b></td> <td>Allows the control plane machines to be reached on port 6443 from anywhere</td> </tr> <tr> <td><b>node</b></td> <td>Allows worker nodes to be reached from the internet on ports 80 and 443</td> </tr> </tbody> </table>	<b>control plane</b>	Allows the control plane machines to be reached on port 6443 from anywhere	<b>node</b>	Allows worker nodes to be reached from the internet on ports 80 and 443
<b>control plane</b>	Allows the control plane machines to be reached on port 6443 from anywhere						
<b>node</b>	Allows worker nodes to be reached from the internet on ports 80 and 443						



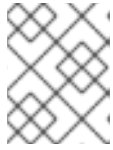
Component	Number of components required by default	Default Azure limit	Description						
Network load balancers	3	1000 per region	<p>Each cluster creates the following <a href="#">load balancers</a>:</p> <table border="1"> <tr> <td><b>default</b></td> <td>Public IP address that load balances requests to ports 80 and 443 across worker machines</td> </tr> <tr> <td><b>internal</b></td> <td>Private IP address that load balances requests to ports 6443 and 22623 across control plane machines</td> </tr> <tr> <td><b>external</b></td> <td>Public IP address that load balances requests to port 6443 across control plane machines</td> </tr> </table> <p>If your applications create more Kubernetes <b>LoadBalancer</b> service objects, your cluster uses more load balancers.</p>	<b>default</b>	Public IP address that load balances requests to ports 80 and 443 across worker machines	<b>internal</b>	Private IP address that load balances requests to ports 6443 and 22623 across control plane machines	<b>external</b>	Public IP address that load balances requests to port 6443 across control plane machines
<b>default</b>	Public IP address that load balances requests to ports 80 and 443 across worker machines								
<b>internal</b>	Private IP address that load balances requests to ports 6443 and 22623 across control plane machines								
<b>external</b>	Public IP address that load balances requests to port 6443 across control plane machines								
Public IP addresses	3		Each of the two public load balancers uses a public IP address. The bootstrap machine also uses a public IP address so that you can SSH into the machine to troubleshoot issues during installation. The IP address for the bootstrap node is used only during installation.						
Private IP addresses	7		The internal load balancer, each of the three control plane machines, and each of the three worker machines each use a private IP address.						
Spot VM vCPUs (optional)	0 If you configure spot VMs, your cluster must have two spot VM vCPUs for every compute node.	20 per region	<p>This is an optional component. To use spot VMs, you must increase the Azure default limit to at least twice the number of compute nodes in your cluster.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>Using spot VMs for control plane nodes is not recommended.</p> </div> </div>						

### 5.2.2. Configuring a public DNS zone in Azure

To install OpenShift Container Platform, the Microsoft Azure account you use must have a dedicated public hosted DNS zone in your account. This zone must be authoritative for the domain. This service provides cluster DNS resolution and name lookup for external connections to the cluster.

#### Procedure

1. Identify your domain, or subdomain, and registrar. You can transfer an existing domain and registrar or obtain a new one through Azure or another source.



#### NOTE

For more information about purchasing domains through Azure, see [Buy a custom domain name for Azure App Service](#) in the Azure documentation.

2. If you are using an existing domain and registrar, migrate its DNS to Azure. See [Migrate an active DNS name to Azure App Service](#) in the Azure documentation.
3. Configure DNS for your domain. Follow the steps in the [Tutorial: Host your domain in Azure DNS](#) in the Azure documentation to create a public hosted zone for your domain or subdomain, extract the new authoritative name servers, and update the registrar records for the name servers that your domain uses.  
Use an appropriate root domain, such as **openshiftcorp.com**, or subdomain, such as **clusters.openshiftcorp.com**.
4. If you use a subdomain, follow your company's procedures to add its delegation records to the parent domain.

### 5.2.3. Increasing Azure account limits

To increase an account limit, file a support request on the Azure portal.



#### NOTE

You can increase only one type of quota per support request.

#### Procedure

1. From the Azure portal, click **Help + support** in the lower left corner.
2. Click **New support request** and then select the required values:
  - a. From the **Issue type** list, select **Service and subscription limits (quotas)**
  - b. From the **Subscription** list, select the subscription to modify.
  - c. From the **Quota type** list, select the quota to increase. For example, select **Compute-VM (cores-vCPUs) subscription limit increases** to increase the number of vCPUs, which is required to install a cluster.
  - d. Click **Next: Solutions**.
3. On the **Problem Details** page, provide the required information for your quota increase:
  - a. Click **Provide details** and provide the required details in the **Quota details** window.
  - b. In the **SUPPORT METHOD** and **CONTACT INFO** sections, provide the issue severity and your contact details.
4. Click **Next: Review + create** and then click **Create**.

### 5.2.4. Required Azure roles

OpenShift Container Platform needs a service principal so it can manage Microsoft Azure resources. Before you can create a service principal, your Azure account subscription must have the following roles:

- **User Access Administrator**
- **Contributor**

To set roles on the Azure portal, see the [Manage access to Azure resources using RBAC and the Azure portal](#) in the Azure documentation.

## 5.2.5. Creating a service principal

Because OpenShift Container Platform and its installation program create Microsoft Azure resources by using the Azure Resource Manager, you must create a service principal to represent it.

### Prerequisites

- Install or update the [Azure CLI](#).
- Your Azure account has the required roles for the subscription that you use.

### Procedure

1. Log in to the Azure CLI:

```
$ az login
```

2. If your Azure account uses subscriptions, ensure that you are using the right subscription:
  - a. View the list of available accounts and record the **tenantId** value for the subscription you want to use for your cluster:

```
$ az account list --refresh
```

### Example output

```
[
  {
    "cloudName": "AzureCloud",
    "id": "9bab1460-96d5-40b3-a78e-17b15e978a80",
    "isDefault": true,
    "name": "Subscription Name",
    "state": "Enabled",
    "tenantId": "6057c7e9-b3ae-489d-a54e-de3f6bf6a8ee",
    "user": {
      "name": "you@example.com",
      "type": "user"
    }
  }
]
```

- b. View your active account details and confirm that the **tenantId** value matches the subscription you want to use:

```
$ az account show
```

### Example output

```
{
  "environmentName": "AzureCloud",
  "id": "9bab1460-96d5-40b3-a78e-17b15e978a80",
  "isDefault": true,
  "name": "Subscription Name",
  "state": "Enabled",
  "tenantId": "6057c7e9-b3ae-489d-a54e-de3f6bf6a8ee", 1
  "user": {
    "name": "you@example.com",
    "type": "user"
  }
}
```

**1** Ensure that the value of the **tenantId** parameter is the correct subscription ID.

- c. If you are not using the right subscription, change the active subscription:

```
$ az account set -s <subscription_id> 1
```

**1** Specify the subscription ID.

- d. Verify the subscription ID update:

```
$ az account show
```

### Example output

```
{
  "environmentName": "AzureCloud",
  "id": "33212d16-bdf6-45cb-b038-f6565b61edda",
  "isDefault": true,
  "name": "Subscription Name",
  "state": "Enabled",
  "tenantId": "8049c7e9-c3de-762d-a54e-dc3f6be6a7ee",
  "user": {
    "name": "you@example.com",
    "type": "user"
  }
}
```

- Record the **tenantId** and **id** parameter values from the output. You need these values during the OpenShift Container Platform installation.
- Create the service principal for your account:

```
$ az ad sp create-for-rbac --role Contributor --name <service_principal> \ 1
--scopes /subscriptions/<subscription_id> 2
--years <years> 3
```

- 1** Specify the service principal name.
- 2** Specify the subscription ID.
- 3** Specify the number of years. By default, a service principal expires in one year. By using the **--years** option you can extend the validity of your service principal.

### Example output

```
Creating 'Contributor' role assignment under scope '/subscriptions/<subscription_id>'
The output includes credentials that you must protect. Be sure that you do not
include these credentials in your code or check the credentials into your source
control. For more information, see https://aka.ms/azadsp-cli
{
  "appId": "ac461d78-bf4b-4387-ad16-7e32e328aec6",
  "displayName": <service_principal>,
  "password": "00000000-0000-0000-0000-000000000000",
  "tenantId": "8049c7e9-c3de-762d-a54e-dc3f6be6a7ee"
}
```

5. Record the values of the **appId** and **password** parameters from the previous output. You need these values during OpenShift Container Platform installation.
6. Assign the **User Access Administrator** role by running the following command:

```
$ az role assignment create --role "User Access Administrator" \
--assignee-object-id $(az ad sp show --id <appId> --query id -o tsv) 1
```

- 1** Specify the **appId** parameter value for your service principal.

### Additional resources

- For more information about CCO modes, see [About the Cloud Credential Operator](#).

### 5.2.6. Supported Azure Marketplace regions

Installing a cluster by using the Azure Marketplace image is available to customers who purchase the offer in North America and EMEA.

While the offer must be purchased in North America or EMEA, you can deploy the cluster to any of the Azure public partitions that OpenShift Container Platform supports.



#### NOTE

Deploying a cluster by using the Azure Marketplace image is not supported for the Azure Government regions.

## 5.2.7. Supported Azure regions

The installation program dynamically generates the list of available Microsoft Azure regions based on your subscription.

### Supported Azure public regions

- **australiacentral** (Australia Central)
- **australiaeast** (Australia East)
- **australiasoutheast** (Australia South East)
- **brazilsouth** (Brazil South)
- **canadacentral** (Canada Central)
- **canadaeast** (Canada East)
- **centralindia** (Central India)
- **centralus** (Central US)
- **eastasia** (East Asia)
- **eastus** (East US)
- **eastus2** (East US 2)
- **francecentral** (France Central)
- **germanywestcentral** (Germany West Central)
- **japaneast** (Japan East)
- **japanwest** (Japan West)
- **koreacentral** (Korea Central)
- **koreasouth** (Korea South)
- **northcentralus** (North Central US)
- **northeurope** (North Europe)
- **norwayeast** (Norway East)
- **qatarcentral** (Qatar Central)
- **southafricanorth** (South Africa North)
- **southcentralus** (South Central US)
- **southeastasia** (Southeast Asia)
- **southindia** (South India)
- **switzerlandnorth** (Switzerland North)

- **uaenorth** (UAE North)
- **uksouth** (UK South)
- **ukwest** (UK West)
- **westcentralus** (West Central US)
- **westeurope** (West Europe)
- **westindia** (West India)
- **westus** (West US)
- **westus2** (West US 2)

### Supported Azure Government regions

Support for the following Microsoft Azure Government (MAG) regions was added in OpenShift Container Platform version 4.6:

- **usgovtexas** (US Gov Texas)
- **usgovvirginia** (US Gov Virginia)

You can reference all available MAG regions in the [Azure documentation](#). Other provided MAG regions are expected to work with OpenShift Container Platform, but have not been tested.

### 5.2.8. Next steps

- Install an OpenShift Container Platform cluster on Azure. You can [install a customized cluster](#) or [quickly install a cluster](#) with default options.

## 5.3. MANUALLY CREATING IAM FOR AZURE

In environments where the cloud identity and access management (IAM) APIs are not reachable, or the administrator prefers not to store an administrator-level credential secret in the cluster **kube-system** namespace, you can put the Cloud Credential Operator (CCO) into manual mode before you install the cluster.

### 5.3.1. Alternatives to storing administrator-level secrets in the kube-system project

The Cloud Credential Operator (CCO) manages cloud provider credentials as Kubernetes custom resource definitions (CRDs). You can configure the CCO to suit the security requirements of your organization by setting different values for the **credentialsMode** parameter in the **install-config.yaml** file.

If you prefer not to store an administrator-level credential secret in the cluster **kube-system** project, you can set the **credentialsMode** parameter for the CCO to **Manual** when installing OpenShift Container Platform and manage your cloud credentials manually.

Using manual mode allows each cluster component to have only the permissions it requires, without storing an administrator-level credential in the cluster. You can also use this mode if your environment does not have connectivity to the cloud provider public IAM endpoint. However, you must manually reconcile permissions with new release images for every upgrade. You must also manually supply credentials for every component that requests them.

## Additional resources

- For a detailed description of all available CCO credential modes and their supported platforms, see [About the Cloud Credential Operator](#).

### 5.3.2. Manually create IAM

The Cloud Credential Operator (CCO) can be put into manual mode prior to installation in environments where the cloud identity and access management (IAM) APIs are not reachable, or the administrator prefers not to store an administrator-level credential secret in the cluster **kube-system** namespace.

#### Procedure

1. Change to the directory that contains the installation program and create the **install-config.yaml** file by running the following command:

```
$ openshift-install create install-config --dir <installation_directory>
```

where **<installation\_directory>** is the directory in which the installation program creates files.

2. Edit the **install-config.yaml** configuration file so that it contains the **credentialsMode** parameter set to **Manual**.

#### Example install-config.yaml configuration file

```
apiVersion: v1
baseDomain: cluster1.example.com
credentialsMode: Manual 1
compute:
- architecture: amd64
  hyperthreading: Enabled
...
```

- 1** This line is added to set the **credentialsMode** parameter to **Manual**.

3. To generate the manifests, run the following command from the directory that contains the installation program:

```
$ openshift-install create manifests --dir <installation_directory>
```

where **<installation\_directory>** is the directory in which the installation program creates files.

4. From the directory that contains the installation program, obtain details of the OpenShift Container Platform release image that your **openshift-install** binary is built to use by running the following command:

```
$ openshift-install version
```

#### Example output

```
release image quay.io/openshift-release-dev/ocp-release:4.y.z-x86_64
```



5. Locate all **CredentialsRequest** objects in this release image that target the cloud you are deploying on by running the following command:

```
$ oc adm release extract quay.io/openshift-release-dev/ocp-release:4.y.z-x86_64 \
  --credentials-requests \
  --cloud=azure
```

This command creates a YAML file for each **CredentialsRequest** object.

### Sample **CredentialsRequest** object

```
apiVersion: cloudcredential.openshift.io/v1
kind: CredentialsRequest
metadata:
  name: <component-credentials-request>
  namespace: openshift-cloud-credential-operator
  ...
spec:
  providerSpec:
    apiVersion: cloudcredential.openshift.io/v1
    kind: AzureProviderSpec
    roleBindings:
      - role: Contributor
    ...
```

6. Create YAML files for secrets in the **openshift-install** manifests directory that you generated previously. The secrets must be stored using the namespace and secret name defined in the **spec.secretRef** for each **CredentialsRequest** object.

### Sample **CredentialsRequest** object with secrets

```
apiVersion: cloudcredential.openshift.io/v1
kind: CredentialsRequest
metadata:
  name: <component-credentials-request>
  namespace: openshift-cloud-credential-operator
  ...
spec:
  providerSpec:
    apiVersion: cloudcredential.openshift.io/v1
    kind: AzureProviderSpec
    roleBindings:
      - role: Contributor
    ...
  secretRef:
    name: <component-secret>
    namespace: <component-namespace>
  ...
```

### Sample **Secret** object

```
apiVersion: v1
kind: Secret
metadata:
```

```

name: <component-secret>
namespace: <component-namespace>
data:
  azure_subscription_id: <base64_encoded_azure_subscription_id>
  azure_client_id: <base64_encoded_azure_client_id>
  azure_client_secret: <base64_encoded_azure_client_secret>
  azure_tenant_id: <base64_encoded_azure_tenant_id>
  azure_resource_prefix: <base64_encoded_azure_resource_prefix>
  azure_resourcegroup: <base64_encoded_azure_resourcegroup>
  azure_region: <base64_encoded_azure_region>

```



## IMPORTANT

Before upgrading a cluster that uses manually maintained credentials, you must ensure that the CCO is in an upgradeable state. For details, see the "Upgrading clusters with manually maintained credentials" section of the installation content for your cloud provider.

### 5.3.3. Upgrading clusters with manually maintained credentials

The Cloud Credential Operator (CCO) **Upgradable** status for a cluster with manually maintained credentials is **False** by default.

- For minor releases, for example, from 4.8 to 4.9, this status prevents you from upgrading until you have addressed any updated permissions and annotated the **CloudCredential** resource to indicate that the permissions are updated as needed for the next version. This annotation changes the **Upgradable** status to **True**.
- For z-stream releases, for example, from 4.9.0 to 4.9.1, no permissions are added or changed, so the upgrade is not blocked.

Before upgrading a cluster with manually maintained credentials, you must create any new credentials for the release image that you are upgrading to. Additionally, you must review the required permissions for existing credentials and accommodate any new permissions requirements in the new release for those components.

#### Procedure

1. Extract and examine the **CredentialsRequest** custom resource for the new release. The "Manually creating IAM" section of the installation content for your cloud provider explains how to obtain and use the credentials required for your cloud.
2. Update the manually maintained credentials on your cluster:
  - Create new secrets for any **CredentialsRequest** custom resources that are added by the new release image.
  - If the **CredentialsRequest** custom resources for any existing credentials that are stored in secrets have changed their permissions requirements, update the permissions as required.
3. When all of the secrets are correct for the new release, indicate that the cluster is ready to upgrade:
  - a. Log in to the OpenShift Container Platform CLI as a user with the **cluster-admin** role.

- b. Edit the **CloudCredential** resource to add an **upgradeable-to** annotation within the **metadata** field:

```
$ oc edit cloudcredential cluster
```

#### Text to add

```
...
metadata:
  annotations:
    cloudcredential.openshift.io/upgradeable-to: <version_number>
...
```

Where **<version\_number>** is the version you are upgrading to, in the format **x.y.z**. For example, **4.8.2** for OpenShift Container Platform 4.8.2.

It may take several minutes after adding the annotation for the upgradeable status to change.

4. Verify that the CCO is upgradeable:
  - a. In the **Administrator** perspective of the web console, navigate to **Administration** → **Cluster Settings**.
  - b. To view the CCO status details, click **cloud-credential** in the **Cluster Operators** list.
  - c. If the **Upgradeable** status in the **Conditions** section is **False**, verify that the **upgradeable-to** annotation is free of typographical errors.

When the **Upgradeable** status in the **Conditions** section is **True**, you can begin the OpenShift Container Platform upgrade.

### 5.3.4. Next steps

- Install an OpenShift Container Platform cluster:
  - [Installing a cluster quickly on Azure](#) with default options on installer-provisioned infrastructure
  - [Install a cluster with cloud customizations on installer-provisioned infrastructure](#)
  - [Install a cluster with network customizations on installer-provisioned infrastructure](#)

## 5.4. INSTALLING A CLUSTER QUICKLY ON AZURE

In OpenShift Container Platform version 4.9, you can install a cluster on Microsoft Azure that uses the default configuration options.

### 5.4.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).

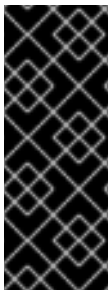
- You [configured an Azure account](#) to host the cluster and determined the tested and validated region to deploy the cluster to.
- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can [manually create and maintain IAM credentials](#).

### 5.4.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



#### IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

### 5.4.3. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.



#### IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

**NOTE**

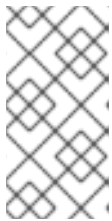
You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

**Procedure**

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.

**NOTE**

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.

**NOTE**

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

**Example output**

```
Agent pid 31874
```

**NOTE**

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1** Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

**Example output**

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

**Next steps**

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

**5.4.4. Obtaining the installation program**

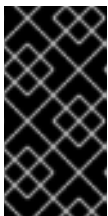
Before you install OpenShift Container Platform, download the installation file on a local computer.

**Prerequisites**

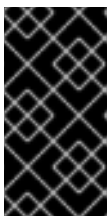
- You have a computer that runs Linux or macOS, with 500 MB of local disk space

**Procedure**

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.

**IMPORTANT**

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.

**IMPORTANT**

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

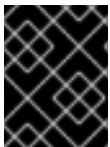
4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#) . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

### 5.4.5. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



#### IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

#### Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

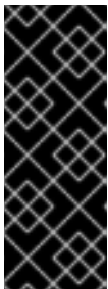
#### Procedure

1. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1  
--log-level=info 2
```

- 1** For **<installation\_directory>**, specify the directory name to store the files that the installation program creates.

- 2** To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.



#### IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

Provide values at the prompts:

- a. Optional: Select an SSH key to use to access your cluster machines.

**NOTE**

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

- b. Select **azure** as the platform to target.
- c. If you do not have a Microsoft Azure profile stored on your computer, specify the following Azure parameter values for your subscription and service principal:
  - **azure subscription id** The subscription ID to use for the cluster. Specify the **id** value in your account output.
  - **azure tenant id** The tenant ID. Specify the **tenantid** value in your account output.
  - **azure service principal client id** The value of the **appid** parameter for the service principal.
  - **azure service principal client secret** The value of the **password** parameter for the service principal.
- d. Select the region to deploy the cluster to.
- e. Select the base domain to deploy the cluster to. The base domain corresponds to the Azure DNS Zone that you created for your cluster.
- f. Enter a descriptive name for your cluster.

**IMPORTANT**

All Azure resources that are available through public endpoints are subject to resource name restrictions, and you cannot create resources that use certain terms. For a list of terms that Azure restricts, see [Resolve reserved resource name errors](#) in the Azure documentation.

- g. Paste the [pull secret from the Red Hat OpenShift Cluster Manager](#) .

**NOTE**

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

When the cluster deployment completes, directions for accessing your cluster, including a link to its web console and credentials for the **kubeadmin** user, display in your terminal.

**Example output**

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
```

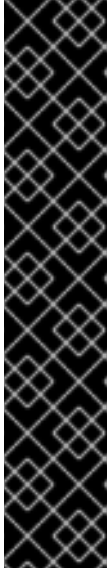


INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Ee6gm-ymBZj-Wt5AL"  
 INFO Time elapsed: 36m22s



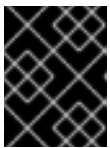
#### NOTE

The cluster access and credential information also outputs to `<installation_directory>/openshift_install.log` when an installation succeeds.



#### IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

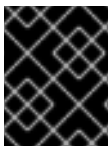


#### IMPORTANT

You must not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

### 5.4.6. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



#### IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

#### Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

```
$ tar xvf <file>
```

5. Place the **oc** binary in a directory that is on your **PATH**.  
To check your **PATH**, execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

### Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your **PATH**.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### 5.4.7. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

#### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

#### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

#### Example output

```
system:admin
```

#### Additional resources

- See [Accessing the web console](#) for more details about accessing and understanding the OpenShift Container Platform web console.

### 5.4.8. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

#### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

### 5.4.9. Next steps

- [Customize your cluster.](#)
- If necessary, you can [opt out of remote health reporting](#) .

## 5.5. INSTALLING A CLUSTER ON AZURE WITH CUSTOMIZATIONS

In OpenShift Container Platform version 4.9, you can install a customized cluster on infrastructure that the installation program provisions on Microsoft Azure. To customize the installation, you modify parameters in the **install-config.yaml** file before you install the cluster.

### 5.5.1. Prerequisites

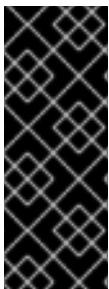
- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You [configured an Azure account](#) to host the cluster and determined the tested and validated region to deploy the cluster to.
- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can [manually create and maintain IAM credentials](#) .

### 5.5.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



#### IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

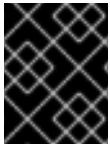
### 5.5.3. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the

installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.



### IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



### NOTE

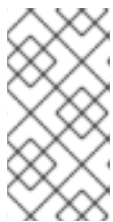
You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

## Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.



### NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.

**NOTE**

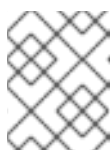
On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

**Example output**

```
Agent pid 31874
```

**NOTE**

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1** Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

**Example output**

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

**Next steps**

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

**5.5.4. Selecting an Azure Marketplace image**

If you are deploying an OpenShift Container Platform cluster using the Azure Marketplace offering, you must first obtain the Azure Marketplace image. The installation program uses this image to deploy worker nodes. When obtaining your image, consider the following:

- While the images are the same, the Azure Marketplace publisher is different depending on your region. If you are located in North America, specify **redhat** as the publisher. If you are located in EMEA, specify **redhat-limited** as the publisher.
- The offer includes a **rh-ocp-worker** SKU and a **rh-ocp-worker-gen1** SKU. The **rh-ocp-worker** SKU represents a Hyper-V generation version 2 VM image. The default instance types used in OpenShift Container Platform are version 2 compatible. If you are going to use an instance type that is only version 1 compatible, use the image associated with the **rh-ocp-worker-gen1** SKU. The **rh-ocp-worker-gen1** SKU represents a Hyper-V version 1 VM image.

**Prerequisites**

- You have installed the Azure CLI client (**az**).
- Your Azure account is entitled for the offer and you have logged into this account with the Azure CLI client.

## Procedure

1. Display all of the available OpenShift Container Platform images by running one of the following commands:

- North America:

```
$ az vm image list --all --offer rh-ocp-worker --publisher redhat -o table
```

### Example output

Offer	Publisher	Skus	Urn	Version
rh-ocp-worker-ocpworker:4.8.2021122100	RedHat	rh-ocp-worker	RedHat:rh-ocp-worker:rh-ocp-worker:4.8.2021122100	
rh-ocp-worker-gen1:4.8.2021122100	RedHat	rh-ocp-worker-gen1	RedHat:rh-ocp-worker:rh-ocp-worker-gen1:4.8.2021122100	

- EMEA:

```
$ az vm image list --all --offer rh-ocp-worker --publisher redhat-limited -o table
```

### Example output

Offer	Publisher	Skus	Urn	Version
rh-ocp-worker-worker:4.8.2021122100	redhat-limited	rh-ocp-worker	redhat-limited:rh-ocp-worker:rh-ocp-worker:4.8.2021122100	
rh-ocp-worker-gen1:4.8.2021122100	redhat-limited	rh-ocp-worker-gen1	redhat-limited:rh-ocp-worker:rh-ocp-worker-gen1:4.8.2021122100	



## NOTE

Regardless of the version of OpenShift Container Platform you are installing, the correct version of the Azure Marketplace image to use is 4.8.x. If required, as part of the installation process, your VMs are automatically upgraded.

2. Inspect the image for your offer by running one of the following commands:

- North America:

```
$ az vm image show --urn redhat:rh-ocp-worker:rh-ocp-worker:<version>
```

- EMEA:

```
$ az vm image show --urn redhat-limited:rh-ocp-worker:rh-ocp-worker:<version>
```

3. Review the terms of the offer by running one of the following commands:

- North America:

```
$ az vm image terms show --urn redhat:rh-ocp-worker:rh-ocp-worker:<version>
```

- EMEA:

```
$ az vm image terms show --urn redhat-limited:rh-ocp-worker:rh-ocp-worker:<version>
```

4. Accept the terms of the offering by running one of the following commands:

- North America:

```
$ az vm image terms accept --urn redhat:rh-ocp-worker:rh-ocp-worker:<version>
```

- EMEA:

```
$ az vm image terms accept --urn redhat-limited:rh-ocp-worker:rh-ocp-worker:<version>
```

5. Record the image details of your offer. You must update the **99\_openshift-cluster-api\_worker\_machineset-[0-2].yaml** files in the section titled "Updating Manifests for Marketplace Installation" before completing the installation.

### 5.5.5. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

#### Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space

#### Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



#### IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.





## IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#). This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

### 5.5.6. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Microsoft Azure.

#### Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

#### Procedure

1. Create the **install-config.yaml** file.
  - a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

- 1** For **<installation\_directory>**, specify the directory name to store the files that the installation program creates.



## IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

- b. At the prompts, provide the configuration details for your cloud:
  - i. Optional: Select an SSH key to use to access your cluster machines.

**NOTE**

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

- ii. Select **azure** as the platform to target.
- iii. If you do not have a Microsoft Azure profile stored on your computer, specify the following Azure parameter values for your subscription and service principal:
  - **azure subscription id** The subscription ID to use for the cluster. Specify the **id** value in your account output.
  - **azure tenant id** The tenant ID. Specify the **tenantId** value in your account output.
  - **azure service principal client id** The value of the **appId** parameter for the service principal.
  - **azure service principal client secret** The value of the **password** parameter for the service principal.
- iv. Select the region to deploy the cluster to.
- v. Select the base domain to deploy the cluster to. The base domain corresponds to the Azure DNS Zone that you created for your cluster.
- vi. Enter a descriptive name for your cluster.

**IMPORTANT**

All Azure resources that are available through public endpoints are subject to resource name restrictions, and you cannot create resources that use certain terms. For a list of terms that Azure restricts, see [Resolve reserved resource name errors](#) in the Azure documentation.

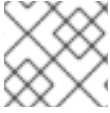
- vii. Paste the [pull secret from the Red Hat OpenShift Cluster Manager](#) .
2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.
3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

**IMPORTANT**

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

**5.5.6.1. Installation configuration parameters**

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.

**NOTE**

After installation, you cannot modify these parameters in the **install-config.yaml** file.

**IMPORTANT**

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

### 5.5.6.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

**Table 5.1. Required parameters**

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;</b> . <b>&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}</b> . <b>{{.baseDomain}}</b> .	String of lowercase letters, hyphens (-), and periods (.), such as <b>dev</b> .


Parameter	Description	Values
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws</b> , <b>baremetal</b> , <b>azure</b> , <b>gcp</b> , <b>openstack</b> , <b>ovirt</b> , <b>vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } }</pre>

#### 5.5.6.1.2. Network configuration parameters


You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

Table 5.2. Network parameters

Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	<p>Object</p>  <p><b>NOTE</b></p> <p>You cannot modify parameters specified by the <b>networking</b> object after installation.</p>

Parameter	Description	Values
<b>networking.networkType</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .
<b>networking.clusterNetwork</b>	The IP address blocks for pods.  The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b> .  If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example:  <pre>networking:   clusterNetwork:     - cidr: 10.128.0.0/14       hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	Required if you use <b>networking.clusterNetwork</b> . An IP address block.  An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b> .
<b>networking.clusterNetwork.hostPrefix</b>	The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b> . A <b>hostPrefix</b> value of <b>23</b> provides 510 ( $2^{(32 - 23)} - 2$ ) pod IP addresses.	A subnet prefix.  The default value is <b>23</b> .
<b>networking.serviceNetwork</b>	The IP address block for services. The default value is <b>172.30.0.0/16</b> .  The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example:  <pre>networking:   serviceNetwork:     - 172.30.0.0/16</pre>
<b>networking.machineNetwork</b>	The IP address blocks for machines.  If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example:  <pre>networking:   machineNetwork:     - cidr: 10.0.0.0/16</pre>


Parameter	Description	Values
<b>networking.machineNetwork.cidr</b>	Required if you use <b>networking.machineNetwork</b> . An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b> .	An IP network block in CIDR notation. For example, <b>10.0.0.0/16</b> .  <b>NOTE</b> Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.


### 5.5.6.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:



Table 5.3. Optional parameters

Parameter	Description	Values
<b>additionalTrustBundle</b>	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
<b>compute</b>	The configuration for the machines that comprise the compute nodes.	Array of <b>MachinePool</b> objects.
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String


Parameter	Description	Values
<b>compute.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b>
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String

Parameter	Description	Values
<b>controlPlane.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platform</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>controlPlane.replicas</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.



Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.</p> <div data-bbox="485 510 595 864" style="border: 1px solid black; padding: 5px; margin-bottom: 10px;">  </div> <p><b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators</i> reference content.</p> <div data-bbox="485 909 595 1263" style="border: 1px solid black; padding: 5px;">  </div> <p><b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p>	<b>Mint, Passthrough, Manual</b> or an empty string ("").

Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start;"> <div style="width: 60px; height: 60px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 60px; height: 60px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<b>Internal</b> or <b>External</b> . To deploy a private cluster, which cannot be accessed from the internet, set <b>publish</b> to <b>Internal</b> . The default value is <b>External</b> .

Parameter	Description	Values
<b>sshKey</b>	<p>The SSH key or keys to authenticate access your cluster machines.</p>  <p><b>NOTE</b></p> <p>For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.</p>	<p>One or more keys. For example:</p> <pre>sshKey:   &lt;key1&gt;   &lt;key2&gt;   &lt;key3&gt;</pre>

#### 5.5.6.1.4. Additional Azure configuration parameters

Additional Azure configuration parameters are described in the following table:

Table 5.4. Additional Azure parameters

Parameter	Description	Values
<b>compute.platform.azure.osDisk.diskSizeGB</b>	The Azure disk size for the VM.	Integer that represents the size of the disk in GB. The default is <b>128</b> .
<b>compute.platform.azure.osDisk.diskType</b>	Defines the type of disk.	<b>standard_LRS</b> , <b>premium_LRS</b> , or <b>standardSSD_LRS</b> . The default is <b>premium_LRS</b> .
<b>controlPlane.platform.azure.osDisk.diskSizeGB</b>	The Azure disk size for the VM.	Integer that represents the size of the disk in GB. The default is <b>1024</b> .
<b>controlPlane.platform.azure.osDisk.diskType</b>	Defines the type of disk.	<b>premium_LRS</b> or <b>standardSSD_LRS</b> . The default is <b>premium_LRS</b> .
<b>platform.azure.baseDomainResourceGroupName</b>	The name of the resource group that contains the DNS zone for your base domain.	String, for example <b>production_cluster</b> .

Parameter	Description	Values
<b>platform.azure.resourceGroupName</b>	The name of an already existing resource group to install your cluster to. This resource group must be empty and only used for this specific cluster; the cluster components assume ownership of all resources in the resource group. If you limit the service principal scope of the installation program to this resource group, you must ensure all other resources used by the installation program in your environment have the necessary permissions, such as the public DNS zone and virtual network. Destroying the cluster using the installation program deletes this resource group.	String, for example <b>existing_resource_group</b> .
<b>platform.azure.outboundType</b>	The outbound routing strategy used to connect your cluster to the internet. If you are using user-defined routing, you must have pre-existing networking available where the outbound routing has already been configured prior to installing a cluster. The installation program is not responsible for configuring user-defined routing.	<b>LoadBalancer</b> or <b>UserDefinedRouting</b> . The default is <b>LoadBalancer</b> .
<b>platform.azure.region</b>	The name of the Azure region that hosts your cluster.	Any valid region name, such as <b>centralus</b> .
<b>platform.azure.zone</b>	List of availability zones to place machines in. For high availability, specify at least two zones.	List of zones, for example <b>["1", "2", "3"]</b> .
<b>platform.azure.networkResourceGroupName</b>	The name of the resource group that contains the existing VNet that you want to deploy your cluster to. This name cannot be the same as the <b>platform.azure.baseDomainResourceGroupName</b> .	String.
<b>platform.azure.virtualNetwork</b>	The name of the existing VNet that you want to deploy your cluster to.	String.
<b>platform.azure.controlPlaneSubnet</b>	The name of the existing subnet in your VNet that you want to deploy your control plane machines to.	Valid CIDR, for example <b>10.0.0.0/16</b> .

Parameter	Description	Values
<b>platform.azure.computeSubnet</b>	The name of the existing subnet in your VNet that you want to deploy your compute machines to.	Valid CIDR, for example <b>10.0.0.0/16</b> .
<b>platform.azure.cloudName</b>	The name of the Azure cloud environment that is used to configure the Azure SDK with the appropriate Azure API endpoints. If empty, the default value <b>AzurePublicCloud</b> is used.	Any valid cloud environment, such as <b>AzurePublicCloud</b> or <b>AzureUSGovernmentCloud</b> .

**NOTE**

You cannot customize [Azure Availability Zones](#) or [Use tags to organize your Azure resources](#) with an Azure cluster.

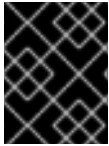
**5.5.6.2. Minimum resource requirements for cluster installation**

Each cluster machine must meet the following minimum requirements:

**Table 5.5. Minimum resource requirements**

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 7.9, or RHEL 8.4 [3]	2	8 GB	100 GB	300

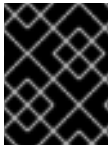
1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio:  $(\text{threads per core} \times \text{cores}) \times \text{sockets} = \text{vCPUs}$ .
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.

**IMPORTANT**

You are required to use Azure virtual machines with **premiumIO** set to **true**. The machines must also have the **hyperVGeneration** property contain **V1**.

**5.5.6.3. Sample customized install-config.yaml file for Azure**

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

**IMPORTANT**

This sample YAML file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program and modify it.

```

apiVersion: v1
baseDomain: example.com 1
controlPlane: 2
  hyperthreading: Enabled 3 4
  name: master
  platform:
    azure:
      osDisk:
        diskSizeGB: 1024 5
        diskType: Premium_LRS
        type: Standard_D8s_v3
      replicas: 3
compute: 6
- hyperthreading: Enabled 7
  name: worker
  platform:
    azure:
      type: Standard_D2s_v3
      osDisk:
        diskSizeGB: 512 8
        diskType: Standard_LRS
      zones: 9
      - "1"
      - "2"
      - "3"
    replicas: 5
metadata:
  name: test-cluster 10
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
  azure:

```

```

baseDomainResourceGroupName: resource_group 11
region: centralus 12
resourceGroupName: existing_resource_group 13
outboundType: Loadbalancer
cloudName: AzurePublicCloud
pullSecret: '{"auths": ...}' 14
fips: false 15
sshKey: ssh-ed25519 AAAA... 16

```

- 1 10 12 14 Required. The installation program prompts you for this value.
- 2 6 If you do not provide these parameters and values, the installation program provides the default value.
- 3 7 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. Only one control plane pool is used.
- 4 Whether to enable or disable simultaneous multithreading, or **hypertreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.



### IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger virtual machine types, such as **Standard\_D8s\_v3**, for your machines if you disable simultaneous multithreading.

- 5 8 You can specify the size of the disk to use in GB. Minimum recommendation for control plane nodes is 1024 GB.
- 9 Specify a list of zones to deploy your machines to. For high availability, specify at least two zones.
- 11 Specify the name of the resource group that contains the DNS zone for your base domain.
- 13 Specify the name of an already existing resource group to install your cluster to. If undefined, a new resource group is created for the cluster.
- 15 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.



### IMPORTANT

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

- 16 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.

**NOTE**

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

**5.5.6.4. Configuring the cluster-wide proxy during installation**

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

**Prerequisites**

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

**NOTE**

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

**Procedure**

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
  -----BEGIN CERTIFICATE-----
  <MY_TRUSTED_CA_CERT>
  -----END CERTIFICATE-----
...
```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.



- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with `.` to match subdomains only. For
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

**NOTE**

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

**NOTE**

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

### 5.5.7. Updating manifests for Marketplace installation

If you selected a Marketplace image for installation, you must create and modify the manifests to use the Marketplace image.

#### Prerequisites

- You have created the **install-config.yaml** file and completed any modifications to it.

#### Procedure

1. Change to the directory that contains the installation program and create the manifests by running the following command:

```
$ openshift-install create manifests --dir <installation_dir>
```

2. Edit the **.spec.template.spec.providerSpec.value.image** property of the compute machine set definitions, replacing the **offer**, **publisher**, **sku**, and **version** values with the details gathered in the section titled "Selecting an Azure Marketplace image". These are the three files that must be updated:

- **<installation\_dir>/openshift/99\_openshift-cluster-api\_worker-machineset-0.yaml**
- **<installation\_dir>/openshift/99\_openshift-cluster-api\_worker-machineset-1.yaml**
- **<installation\_dir>/openshift/99\_openshift-cluster-api\_worker-machineset-2.yaml**

- In each file, replace the value of the `.spec.template.spec.providerSpec.value.image.resourceID` property with an empty value (`""`).
- In each file, set the `type` property to `MarketplaceWithPlan`.
- Using the first machine set file as an example, the `.spec.template.spec.providerSpec.value.image` section must look like the following example:

```
image:
  offer: rh-ocp-worker
  publisher: redhat
  resourceID: ""
  sku: rh-ocp-worker
  version: 4.8.2021122100
  type: MarketplaceWithPlan
```

### 5.5.8. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



#### IMPORTANT

You can run the `create cluster` command of the installation program only once, during initial installation.

#### Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

#### Procedure

- Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
--log-level=info 2
```

- 1** For `<installation_directory>`, specify the location of your customized `./install-config.yaml` file.
- 2** To view different installation details, specify `warn`, `debug`, or `error` instead of `info`.



#### NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

When the cluster deployment completes, directions for accessing your cluster, including a link to its web console and credentials for the **kubeadmin** user, display in your terminal.

### Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Ee6gm-ymBZj-
Wt5AL"
INFO Time elapsed: 36m22s
```



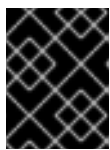
### NOTE

The cluster access and credential information also outputs to **<installation\_directory>/openshift\_install.log** when an installation succeeds.



### IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.



### IMPORTANT

You must not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

## 5.5.9. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



### IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

### Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

```
$ tar xvf <file>
```

5. Place the **oc** binary in a directory that is on your **PATH**.  
To check your **PATH**, execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

### Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### 5.5.10. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

#### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

#### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

#### Example output

```
system:admin
```

#### Additional resources

- See [Accessing the web console](#) for more details about accessing and understanding the OpenShift Container Platform web console.

### 5.5.11. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

#### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

### 5.5.12. Next steps

- [Customize your cluster](#).
- If necessary, you can [opt out of remote health reporting](#).

## 5.6. INSTALLING A CLUSTER ON AZURE WITH NETWORK CUSTOMIZATIONS

In OpenShift Container Platform version 4.9, you can install a cluster with a customized network configuration on infrastructure that the installation program provisions on Microsoft Azure. By customizing your network configuration, your cluster can coexist with existing IP address allocations in your environment and integrate with existing MTU and VXLAN configurations.

You must set most of the network configuration parameters during installation, and you can modify only **kubeProxy** configuration parameters in a running cluster.

### 5.6.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You [configured an Azure account](#) to host the cluster and determined the tested and validated region to deploy the cluster to.
- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can [manually create and maintain IAM credentials](#). Manual mode can also be used in environments where the cloud IAM APIs are not reachable.

### 5.6.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



### IMPORTANT

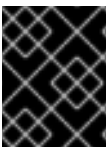
If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

### 5.6.3. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.



### IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



### NOTE

You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

#### Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.

**NOTE**

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

- View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

- Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.

**NOTE**

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

**Example output**

```
Agent pid 31874
```

**NOTE**

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

- Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1** Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

**Example output**

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

**Next steps**



- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

### 5.6.4. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

#### Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space

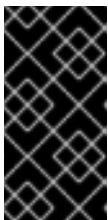
#### Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



#### IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



#### IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#). This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

### 5.6.5. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Microsoft Azure.

#### Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

## Procedure

1. Create the **install-config.yaml** file.
  - a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

- 1** For **<installation\_directory>**, specify the directory name to store the files that the installation program creates.



### IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

- b. At the prompts, provide the configuration details for your cloud:
  - i. Optional: Select an SSH key to use to access your cluster machines.



### NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

- ii. Select **azure** as the platform to target.
- iii. If you do not have a Microsoft Azure profile stored on your computer, specify the following Azure parameter values for your subscription and service principal:
  - **azure subscription id** The subscription ID to use for the cluster. Specify the **id** value in your account output.
  - **azure tenant id** The tenant ID. Specify the **tenantId** value in your account output.
  - **azure service principal client id** The value of the **appId** parameter for the service principal.
  - **azure service principal client secret** The value of the **password** parameter for the service principal.
- iv. Select the region to deploy the cluster to.

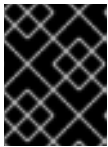
- v. Select the base domain to deploy the cluster to. The base domain corresponds to the Azure DNS Zone that you created for your cluster.
- vi. Enter a descriptive name for your cluster.



### IMPORTANT

All Azure resources that are available through public endpoints are subject to resource name restrictions, and you cannot create resources that use certain terms. For a list of terms that Azure restricts, see [Resolve reserved resource name errors](#) in the Azure documentation.

- vii. Paste the [pull secret from the Red Hat OpenShift Cluster Manager](#) .
2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.
  3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



### IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

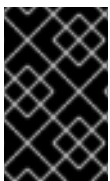
#### 5.6.5.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.



### NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.



### IMPORTANT

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

#### 5.6.5.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 5.6. Required parameters

Parameter	Description	Values
-----------	-------------	--------

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;.&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}.{{.baseDomain}}</b> .	String of lowercase letters, hyphens (-), and periods (.), such as <b>dev</b> .
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws, baremetal, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> , <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object


Parameter	Description	Values
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } }</pre>


### 5.6.5.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

Table 5.7. Network parameters


Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	Object  <div style="margin-left: 20px;"> <p><b>NOTE</b></p> <p>You cannot modify parameters specified by the <b>networking</b> object after installation.</p> </div>
<b>networking.networkType</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .


Parameter	Description	Values
<b>networking.clusterNetwork</b>	<p>The IP address blocks for pods.</p> <p>The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b>.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   clusterNetwork:     - cidr: 10.128.0.0/14       hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	<p>Required if you use <b>networking.clusterNetwork</b>. An IP address block.</p> <p>An IPv4 network.</p>	<p>An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b>.</p>
<b>networking.clusterNetwork.hostPrefix</b>	<p>The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b>. A <b>hostPrefix</b> value of <b>23</b> provides 510 (<math>2^{(32 - 23)} - 2</math>) pod IP addresses.</p>	<p>A subnet prefix.</p> <p>The default value is <b>23</b>.</p>
<b>networking.serviceNetwork</b>	<p>The IP address block for services. The default value is <b>172.30.0.0/16</b>.</p> <p>The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.</p>	<p>An array with an IP address block in CIDR format. For example:</p> <pre>networking:   serviceNetwork:     - 172.30.0.0/16</pre>
<b>networking.machineNetwork</b>	<p>The IP address blocks for machines.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   machineNetwork:     - cidr: 10.0.0.0/16</pre>
<b>networking.machineNetwork.cidr</b>	<p>Required if you use <b>networking.machineNetwork</b>. An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b>.</p>	<p>An IP network block in CIDR notation.</p> <p>For example, <b>10.0.0.0/16</b>.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p> </div> </div>

## 5.6.5.1.3. Optional configuration parameters



Optional installation configuration parameters are described in the following table:

Table 5.8. Optional parameters


Parameter	Description	Values
<b>additionalTrustBundle</b>	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
<b>compute</b>	The configuration for the machines that comprise the compute nodes.	Array of <b>MachinePool</b> objects.
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String
<b>compute.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b>

Parameter	Description	Values
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String
<b>controlPlane.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platform</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b>
<b>controlPlane.replicas</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.



Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.</p> <div data-bbox="485 510 595 862" style="border: 1px solid black; padding: 5px; margin-bottom: 10px;">  </div> <p><b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators reference content</i>.</p> <div data-bbox="485 909 595 1261" style="border: 1px solid black; padding: 5px;">  </div> <p><b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p>	<b>Mint, Passthrough, Manual</b> or an empty string ("").

Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start;"> <div style="width: 60px; height: 60px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 60px; height: 60px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<b>Internal</b> or <b>External</b> . To deploy a private cluster, which cannot be accessed from the internet, set <b>publish</b> to <b>Internal</b> . The default value is <b>External</b> .

Parameter	Description	Values
<b>sshKey</b>	<p>The SSH key or keys to authenticate access your cluster machines.</p>  <p><b>NOTE</b></p> <p>For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.</p>	<p>One or more keys. For example:</p> <pre>sshKey:   &lt;key1&gt;   &lt;key2&gt;   &lt;key3&gt;</pre>

#### 5.6.5.1.4. Additional Azure configuration parameters

Additional Azure configuration parameters are described in the following table:

Table 5.9. Additional Azure parameters

Parameter	Description	Values
<b>compute.platform.azure.osDisk.diskSizeGB</b>	The Azure disk size for the VM.	Integer that represents the size of the disk in GB. The default is <b>128</b> .
<b>compute.platform.azure.osDisk.diskType</b>	Defines the type of disk.	<b>standard_LRS</b> , <b>premium_LRS</b> , or <b>standardSSD_LRS</b> . The default is <b>premium_LRS</b> .
<b>controlPlane.platform.azure.osDisk.diskSizeGB</b>	The Azure disk size for the VM.	Integer that represents the size of the disk in GB. The default is <b>1024</b> .
<b>controlPlane.platform.azure.osDisk.diskType</b>	Defines the type of disk.	<b>premium_LRS</b> or <b>standardSSD_LRS</b> . The default is <b>premium_LRS</b> .
<b>platform.azure.baseDomainResourceGroupName</b>	The name of the resource group that contains the DNS zone for your base domain.	String, for example <b>production_cluster</b> .

Parameter	Description	Values
<b>platform.azure.resourceGroupName</b>	The name of an already existing resource group to install your cluster to. This resource group must be empty and only used for this specific cluster; the cluster components assume ownership of all resources in the resource group. If you limit the service principal scope of the installation program to this resource group, you must ensure all other resources used by the installation program in your environment have the necessary permissions, such as the public DNS zone and virtual network. Destroying the cluster using the installation program deletes this resource group.	String, for example <b>existing_resource_group</b> .
<b>platform.azure.outboundType</b>	The outbound routing strategy used to connect your cluster to the internet. If you are using user-defined routing, you must have pre-existing networking available where the outbound routing has already been configured prior to installing a cluster. The installation program is not responsible for configuring user-defined routing.	<b>LoadBalancer</b> or <b>UserDefinedRouting</b> . The default is <b>LoadBalancer</b> .
<b>platform.azure.region</b>	The name of the Azure region that hosts your cluster.	Any valid region name, such as <b>centralus</b> .
<b>platform.azure.zones</b>	List of availability zones to place machines in. For high availability, specify at least two zones.	List of zones, for example <b>["1", "2", "3"]</b> .
<b>platform.azure.networkResourceGroupName</b>	The name of the resource group that contains the existing VNet that you want to deploy your cluster to. This name cannot be the same as the <b>platform.azure.baseDomainResourceGroupName</b> .	String.
<b>platform.azure.virtualNetwork</b>	The name of the existing VNet that you want to deploy your cluster to.	String.
<b>platform.azure.controlPlaneSubnet</b>	The name of the existing subnet in your VNet that you want to deploy your control plane machines to.	Valid CIDR, for example <b>10.0.0.0/16</b> .

Parameter	Description	Values
<b>platform.azure.computeSubnet</b>	The name of the existing subnet in your VNet that you want to deploy your compute machines to.	Valid CIDR, for example <b>10.0.0.0/16</b> .
<b>platform.azure.cloudName</b>	The name of the Azure cloud environment that is used to configure the Azure SDK with the appropriate Azure API endpoints. If empty, the default value <b>AzurePublicCloud</b> is used.	Any valid cloud environment, such as <b>AzurePublicCloud</b> or <b>AzureUSGovernmentCloud</b> .

**NOTE**

You cannot customize [Azure Availability Zones](#) or [Use tags to organize your Azure resources](#) with an Azure cluster.

### 5.6.5.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

**Table 5.10. Minimum resource requirements**

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 7.9, or RHEL 8.4 [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.

**IMPORTANT**

You are required to use Azure virtual machines with **premiumIO** set to **true**. The machines must also have the **hyperVGeneration** property contain **V1**.

**5.6.5.3. Sample customized install-config.yaml file for Azure**

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

**IMPORTANT**

This sample YAML file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program and modify it.

```

apiVersion: v1
baseDomain: example.com 1
controlPlane: 2
  hyperthreading: Enabled 3 4
  name: master
  platform:
    azure:
      osDisk:
        diskSizeGB: 1024 5
        diskType: Premium_LRS
        type: Standard_D8s_v3
      replicas: 3
compute: 6
- hyperthreading: Enabled 7
  name: worker
  platform:
    azure:
      type: Standard_D2s_v3
      osDisk:
        diskSizeGB: 512 8
        diskType: Standard_LRS
      zones: 9
      - "1"
      - "2"
      - "3"
    replicas: 5
metadata:
  name: test-cluster 10
networking: 11
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:

```

```

azure:
  baseDomainResourceGroupName: resource_group 12
  region: centralus 13
  resourceGroupName: existing_resource_group 14
  outboundType: Loadbalancer
  cloudName: AzurePublicCloud
pullSecret: '{"auths": ...}' 15
fips: false 16
sshKey: ssh-ed25519 AAAA... 17

```

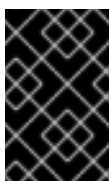
- 1 10 13 15 Required. The installation program prompts you for this value.
- 2 6 11 If you do not provide these parameters and values, the installation program provides the default value.
- 3 7 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. Only one control plane pool is used.
- 4 Whether to enable or disable simultaneous multithreading, or **hypertreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.



### IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger virtual machine types, such as **Standard\_D8s\_v3**, for your machines if you disable simultaneous multithreading.

- 5 8 You can specify the size of the disk to use in GB. Minimum recommendation for control plane nodes is 1024 GB.
- 9 Specify a list of zones to deploy your machines to. For high availability, specify at least two zones.
- 12 Specify the name of the resource group that contains the DNS zone for your base domain.
- 14 Specify the name of an already existing resource group to install your cluster to. If undefined, a new resource group is created for the cluster.
- 16 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.



### IMPORTANT

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

- 17 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.

**NOTE**

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

**5.6.5.4. Configuring the cluster-wide proxy during installation**

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

**Prerequisites**

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

**NOTE**

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

**Procedure**

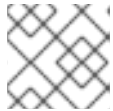
1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
  additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
  ...
```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.



- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with `.` to match subdomains only. For
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

**NOTE**

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

**NOTE**

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

### 5.6.6. Network configuration phases

There are two phases prior to OpenShift Container Platform installation where you can customize the network configuration.

#### Phase 1

You can customize the following network-related fields in the **install-config.yaml** file before you create the manifest files:

- **networking.networkType**
- **networking.clusterNetwork**
- **networking.serviceNetwork**
- **networking.machineNetwork**

For more information on these fields, refer to *Installation configuration parameters*.

**NOTE**

Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

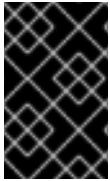
#### Phase 2

After creating the manifest files by running **openshift-install create manifests**, you can define a customized Cluster Network Operator manifest with only the fields you want to modify. You can use the manifest to specify advanced network configuration.

You cannot override the values specified in phase 1 in the **install-config.yaml** file during phase 2. However, you can further customize the cluster network provider during phase 2.

### 5.6.7. Specifying advanced network configuration

You can use advanced network configuration for your cluster network provider to integrate your cluster into your existing network environment. You can specify advanced network configuration only before you install the cluster.



#### IMPORTANT

Customizing your network configuration by modifying the OpenShift Container Platform manifest files created by the installation program is not supported. Applying a manifest file that you create, as in the following procedure, is supported.

#### Prerequisites

- You have created the **install-config.yaml** file and completed any modifications to it.

#### Procedure

- Change to the directory that contains the installation program and create the manifests:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

- 1** **<installation\_directory>** specifies the name of the directory that contains the **install-config.yaml** file for your cluster.

- Create a stub manifest file for the advanced network configuration that is named **cluster-network-03-config.yml** in the **<installation\_directory>/manifests/** directory:

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
```

- Specify the advanced network configuration for your cluster in the **cluster-network-03-config.yml** file, such as in the following examples:

#### Specify a different VXLAN port for the OpenShift SDN network provider

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
```

```

defaultNetwork:
  openshiftSDNConfig:
    vxlanPort: 4800

```

### Enable IPsec for the OVN-Kubernetes network provider

```

apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    ovnKubernetesConfig:
      ipsecConfig: {}

```

- Optional: Back up the **manifests/cluster-network-03-config.yml** file. The installation program consumes the **manifests/** directory when you create the Ignition config files.

## 5.6.8. Cluster Network Operator configuration

The configuration for the cluster network is specified as part of the Cluster Network Operator (CNO) configuration and stored in a custom resource (CR) object that is named **cluster**. The CR specifies the fields for the **Network** API in the **operator.openshift.io** API group.

The CNO configuration inherits the following fields during cluster installation from the **Network** API in the **Network.config.openshift.io** API group and these fields cannot be changed:

### **clusterNetwork**

IP address pools from which pod IP addresses are allocated.

### **serviceNetwork**

IP address pool for services.

### **defaultNetwork.type**

Cluster network provider, such as OpenShift SDN or OVN-Kubernetes.

You can specify the cluster network provider configuration for your cluster by setting the fields for the **defaultNetwork** object in the CNO object named **cluster**.

### 5.6.8.1. Cluster Network Operator configuration object

The fields for the Cluster Network Operator (CNO) are described in the following table:

**Table 5.11. Cluster Network Operator configuration object**

Field	Type	Description
<b>metadata.name</b>	<b>string</b>	The name of the CNO object. This name is always <b>cluster</b> .


Field	Type	Description
<b>spec.clusterNetwork</b>	<b>array</b>	<p>A list specifying the blocks of IP addresses from which pod IP addresses are allocated and the subnet prefix length assigned to each individual node in the cluster. For example:</p> <pre>spec:   clusterNetwork:   - cidr: 10.128.0.0/19     hostPrefix: 23   - cidr: 10.128.32.0/19     hostPrefix: 23</pre> <p>You can customize this field only in the <b>install-config.yaml</b> file before you create the manifests. The value is read-only in the manifest file.</p>
<b>spec.serviceNetwork</b>	<b>array</b>	<p>A block of IP addresses for services. The OpenShift SDN and OVN-Kubernetes Container Network Interface (CNI) network providers support only a single IP address block for the service network. For example:</p> <pre>spec:   serviceNetwork:   - 172.30.0.0/14</pre> <p>You can customize this field only in the <b>install-config.yaml</b> file before you create the manifests. The value is read-only in the manifest file.</p>
<b>spec.defaultNetwork</b>	<b>object</b>	Configures the Container Network Interface (CNI) cluster network provider for the cluster network.
<b>spec.kubeProxy Config</b>	<b>object</b>	The fields for this object specify the kube-proxy configuration. If you are using the OVN-Kubernetes cluster network provider, the kube-proxy configuration has no effect.

### defaultNetwork object configuration

The values for the **defaultNetwork** object are defined in the following table:

Table 5.12. **defaultNetwork** object

Field	Type	Description
-------	------	-------------

Field	Type	Description
<b>type</b>	<b>string</b>	<p>Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b>. The cluster network provider is selected during installation. This value cannot be changed after cluster installation.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>OpenShift Container Platform uses the OpenShift SDN Container Network Interface (CNI) cluster network provider by default.</p> </div> </div>
<b>openshiftSDNConfig</b>	<b>object</b>	This object is only valid for the OpenShift SDN cluster network provider.
<b>ovnKubernetesConfig</b>	<b>object</b>	This object is only valid for the OVN-Kubernetes cluster network provider.

#### Configuration for the OpenShift SDN CNI cluster network provider

The following table describes the configuration fields for the OpenShift SDN Container Network Interface (CNI) cluster network provider.

**Table 5.13. openshiftSDNConfig object**

Field	Type	Description
<b>mode</b>	<b>string</b>	<p>Configures the network isolation mode for OpenShift SDN. The default value is <b>NetworkPolicy</b>.</p> <p>The values <b>Multitenant</b> and <b>Subnet</b> are available for backwards compatibility with OpenShift Container Platform 3.x but are not recommended. This value cannot be changed after cluster installation.</p>

Field	Type	Description
<b>mtu</b>	<b>integer</b>	<p>The maximum transmission unit (MTU) for the VXLAN overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU.</p> <p>If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes.</p> <p>If your cluster requires different MTU values for different nodes, you must set this value to <b>50</b> less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of <b>9001</b>, and some have an MTU of <b>1500</b>, you must set this value to <b>1450</b>.</p> <p>This value cannot be changed after cluster installation.</p>
<b>vxlanPort</b>	<b>integer</b>	<p>The port to use for all VXLAN packets. The default value is <b>4789</b>. This value cannot be changed after cluster installation.</p> <p>If you are running in a virtualized environment with existing nodes that are part of another VXLAN network, then you might be required to change this. For example, when running an OpenShift SDN overlay on top of VMware NSX-T, you must select an alternate port for the VXLAN, because both SDNs use the same default VXLAN port number.</p> <p>On Amazon Web Services (AWS), you can select an alternate port for the VXLAN between port <b>9000</b> and port <b>9999</b>.</p>

### Example OpenShift SDN configuration

```
defaultNetwork:
  type: OpenShiftSDN
  openshiftSDNConfig:
    mode: NetworkPolicy
    mtu: 1450
    vxlanPort: 4789
```

### Configuration for the OVN-Kubernetes CNI cluster network provider

The following table describes the configuration fields for the OVN-Kubernetes CNI cluster network provider.

Table 5.14. `ovnKubernetesConfig` object

Field	Type	Description
-------	------	-------------

Field	Type	Description
<b>mtu</b>	<b>integer</b>	<p>The maximum transmission unit (MTU) for the Geneve (Generic Network Virtualization Encapsulation) overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU.</p> <p>If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes.</p> <p>If your cluster requires different MTU values for different nodes, you must set this value to <b>100</b> less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of <b>9001</b>, and some have an MTU of <b>1500</b>, you must set this value to <b>1400</b>.</p> <p>This value cannot be changed after cluster installation.</p>
<b>genevePort</b>	<b>integer</b>	The port to use for all Geneve packets. The default value is <b>6081</b> . This value cannot be changed after cluster installation.
<b>ipsecConfig</b>	<b>object</b>	Specify an empty object to enable IPsec encryption. This value cannot be changed after cluster installation.
<b>policyAuditConfig</b>	<b>object</b>	Specify a configuration object for customizing network policy audit logging. If unset, the defaults audit log settings are used.

Table 5.15. **policyAuditConfig** object

Field	Type	Description
<b>rateLimit</b>	integer	The maximum number of messages to generate every second per node. The default value is <b>20</b> messages per second.
<b>maxFileSize</b>	integer	The maximum size for the audit log in bytes. The default value is <b>50000000</b> or 50 MB.

Field	Type	Description
<b>destination</b>	string	<p>One of the following additional audit log targets:</p> <p><b>libc</b> The libc <b>syslog()</b> function of the journald process on the host.</p> <p><b>udp:&lt;host&gt;:&lt;port&gt;</b> A syslog server. Replace <b>&lt;host&gt;:&lt;port&gt;</b> with the host and port of the syslog server.</p> <p><b>unix:&lt;file&gt;</b> A Unix Domain Socket file specified by <b>&lt;file&gt;</b>.</p> <p><b>null</b> Do not send the audit logs to any additional target.</p>
<b>syslogFacility</b>	string	The syslog facility, such as <b>kern</b> , as defined by RFC5424. The default value is <b>local0</b> .


### Example OVN-Kubernetes configuration

```
defaultNetwork:
  type: OVNKubernetes
  ovnKubernetesConfig:
    mtu: 1400
    genevePort: 6081
    ipsecConfig: {}
```

### kubeProxyConfig object configuration

The values for the **kubeProxyConfig** object are defined in the following table:

Table 5.16. **kubeProxyConfig** object

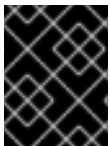
Field	Type	Description
<b>iptablesSyncPeriod</b>	<b>string</b>	<p>The refresh period for <b>iptables</b> rules. The default value is <b>30s</b>. Valid suffixes include <b>s</b>, <b>m</b>, and <b>h</b> and are described in the <a href="#">Go time package</a> documentation.</p> <div style="display: flex; align-items: flex-start;"> <div style="flex: 1;">  </div> <div style="flex: 2;"> <p><b>NOTE</b></p> <p>Because of performance improvements introduced in OpenShift Container Platform 4.3 and greater, adjusting the <b>iptablesSyncPeriod</b> parameter is no longer necessary.</p> </div> </div>



Field	Type	Description
<b>proxyArguments.iptables-min-sync-period</b>	<b>array</b>	<p>The minimum duration before refreshing <b>iptables</b> rules. This field ensures that the refresh does not happen too frequently. Valid suffixes include <b>s</b>, <b>m</b>, and <b>h</b> and are described in the <a href="#">Go time package</a>. The default value is:</p> <pre>kubeProxyConfig:   proxyArguments:     iptables-min-sync-period:       - 0s</pre>

### 5.6.9. Configuring hybrid networking with OVN-Kubernetes

You can configure your cluster to use hybrid networking with OVN-Kubernetes. This allows a hybrid cluster that supports different node networking configurations. For example, this is necessary to run both Linux and Windows nodes in a cluster.



#### IMPORTANT

You must configure hybrid networking with OVN-Kubernetes during the installation of your cluster. You cannot switch to hybrid networking after the installation process.

#### Prerequisites

- You defined **OVNKubernetes** for the **networking.networkType** parameter in the **install-config.yaml** file. See the installation documentation for configuring OpenShift Container Platform network customizations on your chosen cloud provider for more information.

#### Procedure

- Change to the directory that contains the installation program and create the manifests:

```
$ ./openshift-install create manifests --dir <installation_directory>
```

where:

**<installation\_directory>**

Specifies the name of the directory that contains the **install-config.yaml** file for your cluster.

- Create a stub manifest file for the advanced network configuration that is named **cluster-network-03-config.yml** in the **<installation\_directory>/manifests/** directory:

```
$ cat <<EOF > <installation_directory>/manifests/cluster-network-03-config.yml
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
EOF
```

■

where:

**<installation\_directory>**

Specifies the directory name that contains the **manifests/** directory for your cluster.

- Open the **cluster-network-03-config.yml** file in an editor and configure OVN-Kubernetes with hybrid networking, such as in the following example:

### Specify a hybrid networking configuration

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    ovnKubernetesConfig:
      hybridOverlayConfig:
        hybridClusterNetwork: 1
        - cidr: 10.132.0.0/14
        hostPrefix: 23
        hybridOverlayVXLANPort: 9898 2
```

- Specify the CIDR configuration used for nodes on the additional overlay network. The **hybridClusterNetwork** CIDR cannot overlap with the **clusterNetwork** CIDR.
- Specify a custom VXLAN port for the additional overlay network. This is required for running Windows nodes in a cluster installed on vSphere, and must not be configured for any other cloud provider. The custom port can be any open port excluding the default **4789** port. For more information on this requirement, see the Microsoft documentation on [Pod-to-pod connectivity between hosts is broken](#).



#### NOTE

Windows Server Long-Term Servicing Channel (LTSC): Windows Server 2019 is not supported on clusters with a custom **hybridOverlayVXLANPort** value because this Windows server version does not support selecting a custom VXLAN port.

- Save the **cluster-network-03-config.yml** file and quit the text editor.
- Optional: Back up the **manifests/cluster-network-03-config.yml** file. The installation program deletes the **manifests/** directory when creating the cluster.

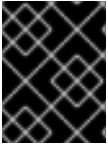


#### NOTE

For more information on using Linux and Windows nodes in the same cluster, see [Understanding Windows container workloads](#).

## 5.6.10. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



## IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

### Prerequisites

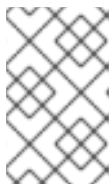
- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

### Procedure

1. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
--log-level=info 2
```

- 1 For **<installation\_directory>**, specify the location of your customized **./install-config.yaml** file.
- 2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.



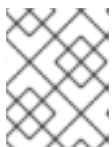
## NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

When the cluster deployment completes, directions for accessing your cluster, including a link to its web console and credentials for the **kubeadmin** user, display in your terminal.

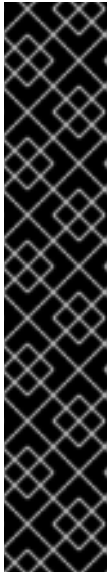
### Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Ee6gm-ymBZj-
Wt5AL"
INFO Time elapsed: 36m22s
```



## NOTE

The cluster access and credential information also outputs to **<installation\_directory>/openshift\_install.log** when an installation succeeds.

**IMPORTANT**

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

**IMPORTANT**

You must not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

### 5.6.11. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

**IMPORTANT**

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

#### Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

```
$ tar xvf <file>
```

5. Place the **oc** binary in a directory that is on your **PATH**. To check your **PATH**, execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

### Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your **PATH**.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### 5.6.12. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container

Platform installation.

### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

#### Example output

```
system:admin
```

### Additional resources

- See [Accessing the web console](#) for more details about accessing and understanding the OpenShift Container Platform web console.

## 5.6.13. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

## 5.6.14. Next steps

- [Customize your cluster](#).
- If necessary, you can [opt out of remote health reporting](#) .

## 5.7. INSTALLING A CLUSTER ON AZURE INTO AN EXISTING VNET

In OpenShift Container Platform version 4.9, you can install a cluster into an existing Azure Virtual Network (VNet) on Microsoft Azure. The installation program provisions the rest of the required infrastructure, which you can further customize. To customize the installation, you modify parameters in the **install-config.yaml** file before you install the cluster.

### 5.7.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You [configured an Azure account](#) to host the cluster and determined the tested and validated region to deploy the cluster to.
- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can [manually create and maintain IAM credentials](#).

### 5.7.2. About reusing a VNet for your OpenShift Container Platform cluster

In OpenShift Container Platform 4.9, you can deploy a cluster into an existing Azure Virtual Network (VNet) in Microsoft Azure. If you do, you must also use existing subnets within the VNet and routing rules.

By deploying OpenShift Container Platform into an existing Azure VNet, you might be able to avoid service limit constraints in new accounts or more easily abide by the operational constraints that your company's guidelines set. This is a good option to use if you cannot obtain the infrastructure creation permissions that are required to create the VNet.

#### 5.7.2.1. Requirements for using your VNet

When you deploy a cluster by using an existing VNet, you must perform additional network configuration before you install the cluster. In installer-provisioned infrastructure clusters, the installer usually creates the following components, but it does not create them when you install into an existing VNet:

- Subnets
- Route tables
- VNets
- Network Security Groups



#### NOTE

The installation program requires that you use the cloud-provided DNS server. Using a custom DNS server is not supported and causes the installation to fail.

If you use a custom VNet, you must correctly configure it and its subnets for the installation program and the cluster to use. The installation program cannot subdivide network ranges for the cluster to use, set route tables for the subnets, or set VNet options like DHCP, so you must do so before you install the

cluster.

The cluster must be able to access the resource group that contains the existing VNet and subnets. While all of the resources that the cluster creates are placed in a separate resource group that it creates, some network resources are used from a separate group. Some cluster Operators must be able to access resources in both resource groups. For example, the Machine API controller attaches NICS for the virtual machines that it creates to subnets from the networking resource group.

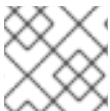
Your VNet must meet the following characteristics:

- The VNet's CIDR block must contain the **Networking.MachineCIDR** range, which is the IP address pool for cluster machines.
- The VNet and its subnets must belong to the same resource group, and the subnets must be configured to use Azure-assigned DHCP IP addresses instead of static IP addresses.

You must provide two subnets within your VNet, one for the control plane machines and one for the compute machines. Because Azure distributes machines in different availability zones within the region that you specify, your cluster will have high availability by default.

To ensure that the subnets that you provide are suitable, the installation program confirms the following data:

- All the specified subnets exist.
- There are two private subnets, one for the control plane machines and one for the compute machines.
- The subnet CIDRs belong to the machine CIDR that you specified. Machines are not provisioned in availability zones that you do not provide private subnets for. If required, the installation program creates public load balancers that manage the control plane and worker nodes, and Azure allocates a public IP address to them.



#### NOTE

If you destroy a cluster that uses an existing VNet, the VNet is not deleted.

#### 5.7.2.1.1. Network security group requirements

The network security groups for the subnets that host the compute and control plane machines require specific access to ensure that the cluster communication is correct. You must create rules to allow access to the required cluster communication ports.



#### IMPORTANT

The network security group rules must be in place before you install the cluster. If you attempt to install a cluster without the required access, the installation program cannot reach the Azure APIs, and installation fails.

Table 5.17. Required ports

Port	Description	Control plane	Compute
80	Allows HTTP traffic		x



Port	Description	Control plane	Compute
443	Allows HTTPS traffic		x
6443	Allows communication to the control plane machines	x	
22623	Allows internal communication to the machine config server for provisioning machines	x	



## IMPORTANT

Currently, there is no supported way to block or restrict the machine config server endpoint. The machine config server must be exposed to the network so that newly-provisioned machines, which have no existing configuration or state, are able to fetch their configuration. In this model, the root of trust is the certificate signing requests (CSR) endpoint, which is where the kubelet sends its certificate signing request for approval to join the cluster. Because of this, machine configs should not be used to distribute sensitive information, such as secrets and certificates.

To ensure that the machine config server endpoints, ports 22623 and 22624, are secured in bare metal scenarios, customers must configure proper network policies.

Because cluster components do not modify the user-provided network security groups, which the Kubernetes controllers update, a pseudo-network security group is created for the Kubernetes controller to modify without impacting the rest of the environment.

### Additional resources

- [About the OpenShift SDN network plugin](#)

### 5.7.2.2. Division of permissions

Starting with OpenShift Container Platform 4.3, you do not need all of the permissions that are required for an installation program-provisioned infrastructure cluster to deploy a cluster. This change mimics the division of permissions that you might have at your company: some individuals can create different resources in your clouds than others. For example, you might be able to create application-specific items, like instances, storage, and load balancers, but not networking-related components such as VNets, subnet, or ingress rules.

The Azure credentials that you use when you create your cluster do not need the networking permissions that are required to make VNets and core networking components within the VNet, such as subnets, routing tables, internet gateways, NAT, and VPN. You still need permission to make the application resources that the machines within the cluster require, such as load balancers, security groups, storage accounts, and nodes.

### 5.7.2.3. Isolation between clusters

Because the cluster is unable to modify network security groups in an existing subnet, there is no way to isolate clusters from each other on the VNet.

## 5.7.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



### IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

## 5.7.4. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.



### IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



### NOTE

You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

### Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.



#### NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

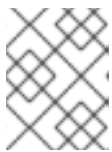
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.



#### NOTE

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

#### Example output

```
Agent pid 31874
```



#### NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1 Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

#### Example output

Identity added: /home/<you>/<path>/<file\_name> (<computer\_name>)

### Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

## 5.7.5. Obtaining the installation program

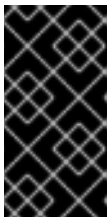
Before you install OpenShift Container Platform, download the installation file on a local computer.

### Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space

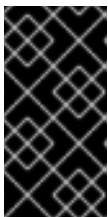
### Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



#### IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



#### IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#) . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

## 5.7.6. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Microsoft Azure.

## Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

## Procedure

1. Create the **install-config.yaml** file.
  - a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

- 1** For **<installation\_directory>**, specify the directory name to store the files that the installation program creates.



### IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

- b. At the prompts, provide the configuration details for your cloud:
  - i. Optional: Select an SSH key to use to access your cluster machines.



### NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

- ii. Select **azure** as the platform to target.
- iii. If you do not have a Microsoft Azure profile stored on your computer, specify the following Azure parameter values for your subscription and service principal:
  - **azure subscription id** The subscription ID to use for the cluster. Specify the **id** value in your account output.
  - **azure tenant id** The tenant ID. Specify the **tenantId** value in your account output.
  - **azure service principal client id** The value of the **appId** parameter for the service principal.
  - **azure service principal client secret** The value of the **password** parameter for the service principal.

- iv. Select the region to deploy the cluster to.
- v. Select the base domain to deploy the cluster to. The base domain corresponds to the Azure DNS Zone that you created for your cluster.
- vi. Enter a descriptive name for your cluster.



### IMPORTANT

All Azure resources that are available through public endpoints are subject to resource name restrictions, and you cannot create resources that use certain terms. For a list of terms that Azure restricts, see [Resolve reserved resource name errors](#) in the Azure documentation.

- vii. Paste the [pull secret from the Red Hat OpenShift Cluster Manager](#) .
2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.
  3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

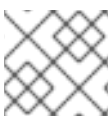


### IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

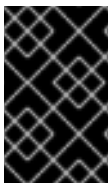
#### 5.7.6.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.



### NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.



### IMPORTANT

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

#### 5.7.6.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 5.18. Required parameters

Parameter	Description	Values
-----------	-------------	--------

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;.&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}.{{.baseDomain}}</b> .	String of lowercase letters, hyphens (-), and periods (.), such as <b>dev</b> .
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws, baremetal, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object


Parameter	Description	Values
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } }</pre>

### 5.7.6.1.2. Network configuration parameters


You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

Table 5.19. Network parameters

Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	Object <div style="display: flex; align-items: center; margin-top: 10px;">  <div> <p><b>NOTE</b></p> <p>You cannot modify parameters specified by the <b>networking</b> object after installation.</p> </div> </div>
<b>networking.networkType</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .




Parameter	Description	Values
<b>networking.clusterNetwork</b>	<p>The IP address blocks for pods.</p> <p>The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b>.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   clusterNetwork:     - cidr: 10.128.0.0/14       hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	<p>Required if you use <b>networking.clusterNetwork</b>. An IP address block.</p> <p>An IPv4 network.</p>	<p>An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b>.</p>
<b>networking.clusterNetwork.hostPrefix</b>	<p>The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b>. A <b>hostPrefix</b> value of <b>23</b> provides 510 (<math>2^{(32 - 23)} - 2</math>) pod IP addresses.</p>	<p>A subnet prefix.</p> <p>The default value is <b>23</b>.</p>
<b>networking.serviceNetwork</b>	<p>The IP address block for services. The default value is <b>172.30.0.0/16</b>.</p> <p>The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.</p>	<p>An array with an IP address block in CIDR format. For example:</p> <pre>networking:   serviceNetwork:     - 172.30.0.0/16</pre>
<b>networking.machineNetwork</b>	<p>The IP address blocks for machines.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   machineNetwork:     - cidr: 10.0.0.0/16</pre>
<b>networking.machineNetwork.cidr</b>	<p>Required if you use <b>networking.machineNetwork</b>. An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b>.</p>	<p>An IP network block in CIDR notation.</p> <p>For example, <b>10.0.0.0/16</b>.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p> </div> </div>



## 5.7.6.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

Table 5.20. Optional parameters

Parameter	Description	Values
<b>additionalTrustBundle</b>	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
<b>compute</b>	The configuration for the machines that comprise the compute nodes.	Array of <b>MachinePool</b> objects.
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String
<b>compute.hyperthreading</b>	Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b> , on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.   <b>IMPORTANT</b>  If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>

Parameter	Description	Values
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String
<b>controlPlane.hypertreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div data-bbox="485 1093 592 1411" style="background-color: black; width: 67px; height: 142px; margin-bottom: 10px;"></div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platform</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>controlPlane.replicas</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.

Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.</p> <p> <b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators</i> reference content.</p> <p> <b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p>	<b>Mint, Passthrough, Manual</b> or an empty string ("").

Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start; gap: 10px;"> <div style="width: 60px; height: 150px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px);"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; gap: 10px; margin-top: 10px;"> <div style="width: 60px; height: 80px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px);"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<b>Internal</b> or <b>External</b> . To deploy a private cluster, which cannot be accessed from the internet, set <b>publish</b> to <b>Internal</b> . The default value is <b>External</b> .

Parameter	Description	Values
<b>sshKey</b>	<p>The SSH key or keys to authenticate access your cluster machines.</p>  <p><b>NOTE</b></p> <p>For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.</p>	<p>One or more keys. For example:</p> <pre>sshKey:   &lt;key1&gt;   &lt;key2&gt;   &lt;key3&gt;</pre>

#### 5.7.6.1.4. Additional Azure configuration parameters

Additional Azure configuration parameters are described in the following table:

Table 5.21. Additional Azure parameters

Parameter	Description	Values
<b>compute.platform.azure.osDisk.diskSizeGB</b>	The Azure disk size for the VM.	Integer that represents the size of the disk in GB. The default is <b>128</b> .
<b>compute.platform.azure.osDisk.diskType</b>	Defines the type of disk.	<b>standard_LRS</b> , <b>premium_LRS</b> , or <b>standardSSD_LRS</b> . The default is <b>premium_LRS</b> .
<b>controlPlane.platform.azure.osDisk.diskSizeGB</b>	The Azure disk size for the VM.	Integer that represents the size of the disk in GB. The default is <b>1024</b> .
<b>controlPlane.platform.azure.osDisk.diskType</b>	Defines the type of disk.	<b>premium_LRS</b> or <b>standardSSD_LRS</b> . The default is <b>premium_LRS</b> .
<b>platform.azure.baseDomainResourceGroupName</b>	The name of the resource group that contains the DNS zone for your base domain.	String, for example <b>production_cluster</b> .

Parameter	Description	Values
<b>platform.azure.resourceGroupName</b>	The name of an already existing resource group to install your cluster to. This resource group must be empty and only used for this specific cluster; the cluster components assume ownership of all resources in the resource group. If you limit the service principal scope of the installation program to this resource group, you must ensure all other resources used by the installation program in your environment have the necessary permissions, such as the public DNS zone and virtual network. Destroying the cluster using the installation program deletes this resource group.	String, for example <b>existing_resource_group</b> .
<b>platform.azure.outboundType</b>	The outbound routing strategy used to connect your cluster to the internet. If you are using user-defined routing, you must have pre-existing networking available where the outbound routing has already been configured prior to installing a cluster. The installation program is not responsible for configuring user-defined routing.	<b>LoadBalancer</b> or <b>UserDefinedRouting</b> . The default is <b>LoadBalancer</b> .
<b>platform.azure.region</b>	The name of the Azure region that hosts your cluster.	Any valid region name, such as <b>centralus</b> .
<b>platform.azure.zone</b>	List of availability zones to place machines in. For high availability, specify at least two zones.	List of zones, for example <b>["1", "2", "3"]</b> .
<b>platform.azure.networkResourceGroupName</b>	The name of the resource group that contains the existing VNet that you want to deploy your cluster to. This name cannot be the same as the <b>platform.azure.baseDomainResourceGroupName</b> .	String.
<b>platform.azure.virtualNetwork</b>	The name of the existing VNet that you want to deploy your cluster to.	String.
<b>platform.azure.controlPlaneSubnet</b>	The name of the existing subnet in your VNet that you want to deploy your control plane machines to.	Valid CIDR, for example <b>10.0.0.0/16</b> .

Parameter	Description	Values
<b>platform.azure.computeSubnet</b>	The name of the existing subnet in your VNet that you want to deploy your compute machines to.	Valid CIDR, for example <b>10.0.0.0/16</b> .
<b>platform.azure.cloudName</b>	The name of the Azure cloud environment that is used to configure the Azure SDK with the appropriate Azure API endpoints. If empty, the default value <b>AzurePublicCloud</b> is used.	Any valid cloud environment, such as <b>AzurePublicCloud</b> or <b>AzureUSGovernmentCloud</b> .

**NOTE**

You cannot customize [Azure Availability Zones](#) or [Use tags to organize your Azure resources](#) with an Azure cluster.

**5.7.6.2. Minimum resource requirements for cluster installation**

Each cluster machine must meet the following minimum requirements:

**Table 5.22. Minimum resource requirements**

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 7.9, or RHEL 8.4 [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.



**IMPORTANT**

You are required to use Azure virtual machines with **premiumIO** set to **true**. The machines must also have the **hyperVGeneration** property contain **V1**.

**5.7.6.3. Sample customized install-config.yaml file for Azure**

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

**IMPORTANT**

This sample YAML file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program and modify it.

```

apiVersion: v1
baseDomain: example.com 1
controlPlane: 2
  hyperthreading: Enabled 3 4
  name: master
  platform:
    azure:
      osDisk:
        diskSizeGB: 1024 5
        diskType: Premium_LRS
        type: Standard_D8s_v3
      replicas: 3
compute: 6
- hyperthreading: Enabled 7
  name: worker
  platform:
    azure:
      type: Standard_D2s_v3
      osDisk:
        diskSizeGB: 512 8
        diskType: Standard_LRS
      zones: 9
      - "1"
      - "2"
      - "3"
    replicas: 5
metadata:
  name: test-cluster 10
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
  azure:

```

```

baseDomainResourceGroupName: resource_group 11
region: centralus 12
resourceGroupName: existing_resource_group 13
networkResourceGroupName: vnet_resource_group 14
virtualNetwork: vnet 15
controlPlaneSubnet: control_plane_subnet 16
computeSubnet: compute_subnet 17
outboundType: Loadbalancer
cloudName: AzurePublicCloud
pullSecret: '{"auths": ...}' 18
fips: false 19
sshKey: ssh-ed25519 AAAA... 20

```

- 1 10 12 18 Required. The installation program prompts you for this value.
- 2 6 If you do not provide these parameters and values, the installation program provides the default value.
- 3 7 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. Only one control plane pool is used.
- 4 Whether to enable or disable simultaneous multithreading, or **hypertreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.



### IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger virtual machine types, such as **Standard\_D8s\_v3**, for your machines if you disable simultaneous multithreading.

- 5 8 You can specify the size of the disk to use in GB. Minimum recommendation for control plane nodes is 1024 GB.
- 9 Specify a list of zones to deploy your machines to. For high availability, specify at least two zones.
- 11 Specify the name of the resource group that contains the DNS zone for your base domain.
- 13 Specify the name of an already existing resource group to install your cluster to. If undefined, a new resource group is created for the cluster.
- 14 If you use an existing VNet, specify the name of the resource group that contains it.
- 15 If you use an existing VNet, specify its name.
- 16 If you use an existing VNet, specify the name of the subnet to host the control plane machines.
- 17 If you use an existing VNet, specify the name of the subnet to host the compute machines.
- 19 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container

Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

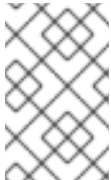


### IMPORTANT

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

20

You can optionally provide the **sshKey** value that you use to access the machines in your cluster.



### NOTE

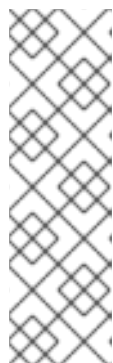
For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

#### 5.7.6.4. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

#### Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



### NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

#### Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
```

```

noProxy: example.com 3
additionalTrustBundle: | 4
  -----BEGIN CERTIFICATE-----
  <MY_TRUSTED_CA_CERT>
  -----END CERTIFICATE-----
...

```

- 1** A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2** A proxy URL to use for creating HTTPS connections outside the cluster.
- 3** A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations.
- 4** If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.



#### NOTE

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



#### NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

### 5.7.7. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



#### IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

#### Prerequisites

- Configure an account with the cloud platform that hosts your cluster.

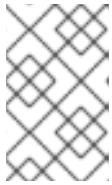
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

## Procedure

1. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
--log-level=info 2
```

- 1 For **<installation\_directory>**, specify the location of your customized **./install-config.yaml** file.
- 2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.



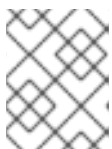
### NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

When the cluster deployment completes, directions for accessing your cluster, including a link to its web console and credentials for the **kubeadmin** user, display in your terminal.

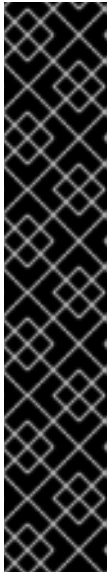
## Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Ee6gm-ymBZj-
Wt5AL"
INFO Time elapsed: 36m22s
```



### NOTE

The cluster access and credential information also outputs to **<installation\_directory>/./openshift\_install.log** when an installation succeeds.

**IMPORTANT**

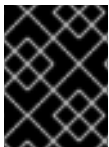
- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

**IMPORTANT**

You must not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

### 5.7.8. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

**IMPORTANT**

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

#### Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

**Procedure**

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

```
$ tar xvf <file>
```

5. Place the **oc** binary in a directory that is on your **PATH**.  
To check your **PATH**, execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

### Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your **PATH**.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### 5.7.9. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container

Platform installation.

### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

#### Example output

```
system:admin
```

### Additional resources

- See [Accessing the web console](#) for more details about accessing and understanding the OpenShift Container Platform web console.

## 5.7.10. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

## 5.7.11. Next steps

- [Customize your cluster](#).
- If necessary, you can [opt out of remote health reporting](#) .

## 5.8. INSTALLING A PRIVATE CLUSTER ON AZURE



In OpenShift Container Platform version 4.9, you can install a private cluster into an existing Azure Virtual Network (VNet) on Microsoft Azure. The installation program provisions the rest of the required infrastructure, which you can further customize. To customize the installation, you modify parameters in the **install-config.yaml** file before you install the cluster.

### 5.8.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You [configured an Azure account](#) to host the cluster and determined the tested and validated region to deploy the cluster to.
- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can [manually create and maintain IAM credentials](#).

### 5.8.2. Private clusters

You can deploy a private OpenShift Container Platform cluster that does not expose external endpoints. Private clusters are accessible from only an internal network and are not visible to the internet.

By default, OpenShift Container Platform is provisioned to use publicly-accessible DNS and endpoints. A private cluster sets the DNS, Ingress Controller, and API server to private when you deploy your cluster. This means that the cluster resources are only accessible from your internal network and are not visible to the internet.



#### IMPORTANT

If the cluster has any public subnets, load balancer services created by administrators might be publicly accessible. To ensure cluster security, verify that these services are explicitly annotated as private.

To deploy a private cluster, you must:

- Use existing networking that meets your requirements. Your cluster resources might be shared between other clusters on the network.
- Deploy from a machine that has access to:
  - The API services for the cloud to which you provision.
  - The hosts on the network that you provision.
  - The internet to obtain installation media.

You can use any machine that meets these access requirements and follows your company's guidelines. For example, this machine can be a bastion host on your cloud network or a machine that has access to the network through a VPN.

### 5.8.2.1. Private clusters in Azure

To create a private cluster on Microsoft Azure, you must provide an existing private VNet and subnets to host the cluster. The installation program must also be able to resolve the DNS records that the cluster requires. The installation program configures the Ingress Operator and API server for only internal traffic.

Depending how your network connects to the private VNET, you might need to use a DNS forwarder to resolve the cluster's private DNS records. The cluster's machines use **168.63.129.16** internally for DNS resolution. For more information, see [What is Azure Private DNS?](#) and [What is IP address 168.63.129.16?](#) in the Azure documentation.

The cluster still requires access to internet to access the Azure APIs.

The following items are not required or created when you install a private cluster:

- A **BaseDomainResourceGroup**, since the cluster does not create public records
- Public IP addresses
- Public DNS records
- Public endpoints

The cluster is configured so that the Operators do not create public records for the cluster and all cluster machines are placed in the private subnets that you specify.

#### 5.8.2.1.1. Limitations

Private clusters on Azure are subject to only the limitations that are associated with the use of an existing VNet.

#### 5.8.2.2. User-defined outbound routing

In OpenShift Container Platform, you can choose your own outbound routing for a cluster to connect to the internet. This allows you to skip the creation of public IP addresses and the public load balancer.

You can configure user-defined routing by modifying parameters in the **install-config.yaml** file before installing your cluster. A pre-existing VNet is required to use outbound routing when installing a cluster; the installation program is not responsible for configuring this.

When configuring a cluster to use user-defined routing, the installation program does not create the following resources:

- Outbound rules for access to the internet.
- Public IPs for the public load balancer.
- Kubernetes Service object to add the cluster machines to the public load balancer for outbound requests.

You must ensure the following items are available before setting user-defined routing:

- Egress to the internet is possible to pull container images, unless using an internal registry mirror.

- The cluster can access Azure APIs.
- Various allowlist endpoints are configured. You can reference these endpoints in the *Configuring your firewall* section.

There are several pre-existing networking setups that are supported for internet access using user-defined routing.

#### Private cluster with network address translation

You can use [Azure VNET network address translation \(NAT\)](#) to provide outbound internet access for the subnets in your cluster. You can reference [Create a NAT gateway using Azure CLI](#) in the Azure documentation for configuration instructions.

When using a VNet setup with Azure NAT and user-defined routing configured, you can create a private cluster with no public endpoints.

#### Private cluster with Azure Firewall

You can use Azure Firewall to provide outbound routing for the VNet used to install the cluster. You can learn more about [providing user-defined routing with Azure Firewall](#) in the Azure documentation.

When using a VNet setup with Azure Firewall and user-defined routing configured, you can create a private cluster with no public endpoints.

#### Private cluster with a proxy configuration

You can use a proxy with user-defined routing to allow egress to the internet. You must ensure that cluster Operators do not access Azure APIs using a proxy; Operators must have access to Azure APIs outside of the proxy.

When using the default route table for subnets, with **0.0.0.0/0** populated automatically by Azure, all Azure API requests are routed over Azure's internal network even though the IP addresses are public. As long as the Network Security Group rules allow egress to Azure API endpoints, proxies with user-defined routing configured allow you to create private clusters with no public endpoints.

#### Private cluster with no internet access

You can install a private network that restricts all access to the internet, except the Azure API. This is accomplished by mirroring the release image registry locally. Your cluster must have access to the following:

- An internal registry mirror that allows for pulling container images
- Access to Azure APIs

With these requirements available, you can use user-defined routing to create private clusters with no public endpoints.

### 5.8.3. About reusing a VNet for your OpenShift Container Platform cluster

In OpenShift Container Platform 4.9, you can deploy a cluster into an existing Azure Virtual Network (VNet) in Microsoft Azure. If you do, you must also use existing subnets within the VNet and routing rules.

By deploying OpenShift Container Platform into an existing Azure VNet, you might be able to avoid service limit constraints in new accounts or more easily abide by the operational constraints that your company's guidelines set. This is a good option to use if you cannot obtain the infrastructure creation permissions that are required to create the VNet.

### 5.8.3.1. Requirements for using your VNet

When you deploy a cluster by using an existing VNet, you must perform additional network configuration before you install the cluster. In installer-provisioned infrastructure clusters, the installer usually creates the following components, but it does not create them when you install into an existing VNet:

- Subnets
- Route tables
- VNets
- Network Security Groups



#### NOTE

The installation program requires that you use the cloud-provided DNS server. Using a custom DNS server is not supported and causes the installation to fail.

If you use a custom VNet, you must correctly configure it and its subnets for the installation program and the cluster to use. The installation program cannot subdivide network ranges for the cluster to use, set route tables for the subnets, or set VNet options like DHCP, so you must do so before you install the cluster.

The cluster must be able to access the resource group that contains the existing VNet and subnets. While all of the resources that the cluster creates are placed in a separate resource group that it creates, some network resources are used from a separate group. Some cluster Operators must be able to access resources in both resource groups. For example, the Machine API controller attaches NICS for the virtual machines that it creates to subnets from the networking resource group.

Your VNet must meet the following characteristics:

- The VNet's CIDR block must contain the **Networking.MachineCIDR** range, which is the IP address pool for cluster machines.
- The VNet and its subnets must belong to the same resource group, and the subnets must be configured to use Azure-assigned DHCP IP addresses instead of static IP addresses.

You must provide two subnets within your VNet, one for the control plane machines and one for the compute machines. Because Azure distributes machines in different availability zones within the region that you specify, your cluster will have high availability by default.

To ensure that the subnets that you provide are suitable, the installation program confirms the following data:

- All the specified subnets exist.
- There are two private subnets, one for the control plane machines and one for the compute machines.
- The subnet CIDRs belong to the machine CIDR that you specified. Machines are not provisioned in availability zones that you do not provide private subnets for.

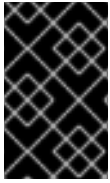


#### NOTE

If you destroy a cluster that uses an existing VNet, the VNet is not deleted.

### 5.8.3.1.1. Network security group requirements

The network security groups for the subnets that host the compute and control plane machines require specific access to ensure that the cluster communication is correct. You must create rules to allow access to the required cluster communication ports.



#### IMPORTANT

The network security group rules must be in place before you install the cluster. If you attempt to install a cluster without the required access, the installation program cannot reach the Azure APIs, and installation fails.

Table 5.23. Required ports

Port	Description	Control plane	Compute
80	Allows HTTP traffic		x
443	Allows HTTPS traffic		x
6443	Allows communication to the control plane machines	x	
22623	Allows internal communication to the machine config server for provisioning machines	x	



#### IMPORTANT

Currently, there is no supported way to block or restrict the machine config server endpoint. The machine config server must be exposed to the network so that newly-provisioned machines, which have no existing configuration or state, are able to fetch their configuration. In this model, the root of trust is the certificate signing requests (CSR) endpoint, which is where the kubelet sends its certificate signing request for approval to join the cluster. Because of this, machine configs should not be used to distribute sensitive information, such as secrets and certificates.

To ensure that the machine config server endpoints, ports 22623 and 22624, are secured in bare metal scenarios, customers must configure proper network policies.

Because cluster components do not modify the user-provided network security groups, which the Kubernetes controllers update, a pseudo-network security group is created for the Kubernetes controller to modify without impacting the rest of the environment.

#### Additional resources

- [About the OpenShift SDN network plugin](#)

### 5.8.3.2. Division of permissions

Starting with OpenShift Container Platform 4.3, you do not need all of the permissions that are required for an installation program-provisioned infrastructure cluster to deploy a cluster. This change mimics the division of permissions that you might have at your company: some individuals can create different

resources in your clouds than others. For example, you might be able to create application-specific items, like instances, storage, and load balancers, but not networking-related components such as VNets, subnet, or ingress rules.

The Azure credentials that you use when you create your cluster do not need the networking permissions that are required to make VNets and core networking components within the VNet, such as subnets, routing tables, internet gateways, NAT, and VPN. You still need permission to make the application resources that the machines within the cluster require, such as load balancers, security groups, storage accounts, and nodes.

### 5.8.3.3. Isolation between clusters

Because the cluster is unable to modify network security groups in an existing subnet, there is no way to isolate clusters from each other on the VNet.

### 5.8.4. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



#### IMPORTANT

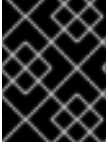
If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

### 5.8.5. Generating a key pair for cluster node SSH access

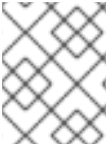
During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.

**IMPORTANT**

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

**NOTE**

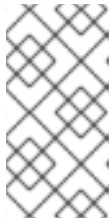
You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

**Procedure**

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.

**NOTE**

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.


**NOTE**

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

**Example output**




```
Agent pid 31874
```

**NOTE**


If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:



```
$ ssh-add <path>/<file_name> 1
```

- 1** Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

**Example output**

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

**Next steps**

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

**5.8.6. Obtaining the installation program**

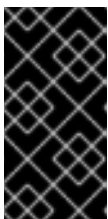
Before you install OpenShift Container Platform, download the installation file on a local computer.

**Prerequisites**

- You have a computer that runs Linux or macOS, with 500 MB of local disk space

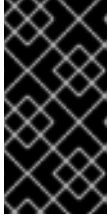
**Procedure**

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.

**IMPORTANT**

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.





## IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#). This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

### 5.8.7. Manually creating the installation configuration file

For installations of a private OpenShift Container Platform cluster that are only accessible from an internal network and are not visible to the internet, you must manually generate your installation configuration file.

#### Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

#### Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```



## IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation\_directory>**.



## NOTE

You must name this configuration file **install-config.yaml**.

**NOTE**

For some platform types, you can alternatively run `./openshift-install create install-config --dir <installation_directory>` to generate an `install-config.yaml` file. You can provide details about your cluster configuration at the prompts.

3. Back up the `install-config.yaml` file so that you can use it to install multiple clusters.

**IMPORTANT**

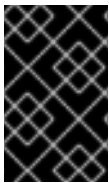
The `install-config.yaml` file is consumed during the next step of the installation process. You must back it up now.

**5.8.7.1. Installation configuration parameters**

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the `install-config.yaml` installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the `install-config.yaml` file to provide more details about the platform.

**NOTE**

After installation, you cannot modify these parameters in the `install-config.yaml` file.

**IMPORTANT**

The `openshift-install` command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

**5.8.7.1.1. Required configuration parameters**

Required installation configuration parameters are described in the following table:

**Table 5.24. Required parameters**

Parameter	Description	Values
<code>apiVersion</code>	The API version for the <code>install-config.yaml</code> content. The current version is <b>v1</b> . The installer may also support older API versions.	String



Parameter	Description	Values
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;</b> . <b>&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}</b> . <b>{{.baseDomain}}</b> .	String of lowercase letters, hyphens (-), and periods (.), such as <b>dev</b> .
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws, baremetal, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre> {   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } } </pre>


### 5.8.7.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

Table 5.25. Network parameters

Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	Object   <b>NOTE</b> You cannot modify parameters specified by the <b>networking</b> object after installation.
<b>networking.network Type</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .
<b>networking.clusterNetwork</b>	The IP address blocks for pods.  The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b> .  If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example:   networking: clusterNetwork: - cidr: <b>10.128.0.0/14</b> hostPrefix: <b>23</b>
<b>networking.clusterNetwork.cidr</b>	Required if you use <b>networking.clusterNetwork</b> . An IP address block.  An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b> .
<b>networking.clusterNetwork.hostPrefix</b>	The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b> . A <b>hostPrefix</b> value of <b>23</b> provides 510 ( $2^{(32 - 23)} - 2$ ) pod IP addresses.	A subnet prefix.  The default value is <b>23</b> .


Parameter	Description	Values
<b>networking.serviceNetwork</b>	<p>The IP address block for services. The default value is <b>172.30.0.0/16</b>.</p> <p>The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.</p>	<p>An array with an IP address block in CIDR format. For example:</p> <pre>networking:   serviceNetwork:     - 172.30.0.0/16</pre>
<b>networking.machineNetwork</b>	<p>The IP address blocks for machines.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   machineNetwork:     - cidr: 10.0.0.0/16</pre>
<b>networking.machineNetwork.cidr</b>	<p>Required if you use <b>networking.machineNetwork</b>. An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b>.</p>	<p>An IP network block in CIDR notation.</p> <p>For example, <b>10.0.0.0/16</b>.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p> </div> </div>

### 5.8.7.1.3. Optional configuration parameters



Optional installation configuration parameters are described in the following table:

Table 5.26. Optional parameters

Parameter	Description	Values
<b>additionalTrustBundle</b>	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
<b>compute</b>	The configuration for the machines that comprise the compute nodes.	Array of <b>MachinePool</b> objects.


Parameter	Description	Values
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String
<b>compute.hyperthreading</b>	Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b> , on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.   <b>IMPORTANT</b> If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b>
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String

Parameter	Description	Values
<b>controlPlane.hypert hreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p>  <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platfor m</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>controlPlane.replica s</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.

Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.</p> <p> <b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators reference content</i>.</p> <p> <b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p>	<b>Mint, Passthrough, Manual</b> or an empty string ("").



Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start;"> <div style="width: 60px; height: 60px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 60px; height: 60px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<b>Internal</b> or <b>External</b> . To deploy a private cluster, which cannot be accessed from the internet, set <b>publish</b> to <b>Internal</b> . The default value is <b>External</b> .

Parameter	Description	Values
<b>sshKey</b>	<p>The SSH key or keys to authenticate access your cluster machines.</p>  <p><b>NOTE</b></p> <p>For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.</p>	<p>One or more keys. For example:</p> <pre>sshKey:   &lt;key1&gt;   &lt;key2&gt;   &lt;key3&gt;</pre>

#### 5.8.7.1.4. Additional Azure configuration parameters

Additional Azure configuration parameters are described in the following table:

Table 5.27. Additional Azure parameters

Parameter	Description	Values
<b>compute.platform.azure.osDisk.diskSizeGB</b>	The Azure disk size for the VM.	Integer that represents the size of the disk in GB. The default is <b>128</b> .
<b>compute.platform.azure.osDisk.diskType</b>	Defines the type of disk.	<b>standard_LRS</b> , <b>premium_LRS</b> , or <b>standardSSD_LRS</b> . The default is <b>premium_LRS</b> .
<b>controlPlane.platform.azure.osDisk.diskSizeGB</b>	The Azure disk size for the VM.	Integer that represents the size of the disk in GB. The default is <b>1024</b> .
<b>controlPlane.platform.azure.osDisk.diskType</b>	Defines the type of disk.	<b>premium_LRS</b> or <b>standardSSD_LRS</b> . The default is <b>premium_LRS</b> .
<b>platform.azure.baseDomainResourceGroupName</b>	The name of the resource group that contains the DNS zone for your base domain.	String, for example <b>production_cluster</b> .

Parameter	Description	Values
<b>platform.azure.resourceGroupName</b>	The name of an already existing resource group to install your cluster to. This resource group must be empty and only used for this specific cluster; the cluster components assume ownership of all resources in the resource group. If you limit the service principal scope of the installation program to this resource group, you must ensure all other resources used by the installation program in your environment have the necessary permissions, such as the public DNS zone and virtual network. Destroying the cluster using the installation program deletes this resource group.	String, for example <b>existing_resource_group</b> .
<b>platform.azure.outboundType</b>	The outbound routing strategy used to connect your cluster to the internet. If you are using user-defined routing, you must have pre-existing networking available where the outbound routing has already been configured prior to installing a cluster. The installation program is not responsible for configuring user-defined routing.	<b>LoadBalancer</b> or <b>UserDefinedRouting</b> . The default is <b>LoadBalancer</b> .
<b>platform.azure.region</b>	The name of the Azure region that hosts your cluster.	Any valid region name, such as <b>centralus</b> .
<b>platform.azure.zones</b>	List of availability zones to place machines in. For high availability, specify at least two zones.	List of zones, for example <b>["1", "2", "3"]</b> .
<b>platform.azure.networkResourceGroupName</b>	The name of the resource group that contains the existing VNet that you want to deploy your cluster to. This name cannot be the same as the <b>platform.azure.baseDomainResourceGroupName</b> .	String.
<b>platform.azure.virtualNetwork</b>	The name of the existing VNet that you want to deploy your cluster to.	String.
<b>platform.azure.controlPlaneSubnet</b>	The name of the existing subnet in your VNet that you want to deploy your control plane machines to.	Valid CIDR, for example <b>10.0.0.0/16</b> .

Parameter	Description	Values
<b>platform.azure.computeSubnet</b>	The name of the existing subnet in your VNet that you want to deploy your compute machines to.	Valid CIDR, for example <b>10.0.0.0/16</b> .
<b>platform.azure.cloudName</b>	The name of the Azure cloud environment that is used to configure the Azure SDK with the appropriate Azure API endpoints. If empty, the default value <b>AzurePublicCloud</b> is used.	Any valid cloud environment, such as <b>AzurePublicCloud</b> or <b>AzureUSGovernmentCloud</b> .

**NOTE**

You cannot customize [Azure Availability Zones](#) or [Use tags to organize your Azure resources](#) with an Azure cluster.

### 5.8.7.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

**Table 5.28. Minimum resource requirements**

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 7.9, or RHEL 8.4 [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.

**IMPORTANT**

You are required to use Azure virtual machines with **premiumIO** set to **true**. The machines must also have the **hyperVGeneration** property contain **V1**.

**5.8.7.3. Sample customized install-config.yaml file for Azure**

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

**IMPORTANT**

This sample YAML file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program and modify it.

```

apiVersion: v1
baseDomain: example.com 1
controlPlane: 2
  hyperthreading: Enabled 3 4
  name: master
  platform:
    azure:
      osDisk:
        diskSizeGB: 1024 5
        diskType: Premium_LRS
        type: Standard_D8s_v3
      replicas: 3
compute: 6
- hyperthreading: Enabled 7
  name: worker
  platform:
    azure:
      type: Standard_D2s_v3
      osDisk:
        diskSizeGB: 512 8
        diskType: Standard_LRS
      zones: 9
      - "1"
      - "2"
      - "3"
    replicas: 5
metadata:
  name: test-cluster 10
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
  azure:

```

```

baseDomainResourceGroupName: resource_group 11
region: centralus 12
resourceGroupName: existing_resource_group 13
networkResourceGroupName: vnet_resource_group 14
virtualNetwork: vnet 15
controlPlaneSubnet: control_plane_subnet 16
computeSubnet: compute_subnet 17
outboundType: UserDefinedRouting 18
cloudName: AzurePublicCloud
pullSecret: '{"auths": ...}' 19
fips: false 20
sshKey: ssh-ed25519 AAAA... 21
publish: Internal 22

```

1 10 12 19 Required. The installation program prompts you for this value.

2 6 If you do not provide these parameters and values, the installation program provides the default value.

3 7 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

4 Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.



### IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger virtual machine types, such as **Standard\_D8s\_v3**, for your machines if you disable simultaneous multithreading.

5 8 You can specify the size of the disk to use in GB. Minimum recommendation for control plane nodes is 1024 GB.

9 Specify a list of zones to deploy your machines to. For high availability, specify at least two zones.

11 Specify the name of the resource group that contains the DNS zone for your base domain.

13 Specify the name of an already existing resource group to install your cluster to. If undefined, a new resource group is created for the cluster.

14 If you use an existing VNet, specify the name of the resource group that contains it.

15 If you use an existing VNet, specify its name.

16 If you use an existing VNet, specify the name of the subnet to host the control plane machines.

17 If you use an existing VNet, specify the name of the subnet to host the compute machines.

- 18 You can customize your own outbound routing. Configuring user-defined routing prevents exposing external endpoints in your cluster. User-defined routing for egress requires deploying
- 20 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.



### IMPORTANT

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

- 21 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.



### NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

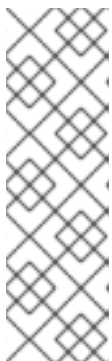
- 22 How to publish the user-facing endpoints of your cluster. Set **publish** to **Internal** to deploy a private cluster, which cannot be accessed from the internet. The default value is **External**.

#### 5.8.7.4. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

#### Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



### NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

#### Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```

apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
  -----BEGIN CERTIFICATE-----
  <MY_TRUSTED_CA_CERT>
  -----END CERTIFICATE-----
...

```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations.
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.



#### NOTE

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



#### NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

### 5.8.8. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.





## IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

### Prerequisites

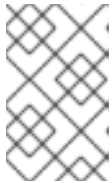
- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

### Procedure

1. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
--log-level=info 2
```

- 1 For **<installation\_directory>**, specify the
- 2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.



## NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

When the cluster deployment completes, directions for accessing your cluster, including a link to its web console and credentials for the **kubeadmin** user, display in your terminal.

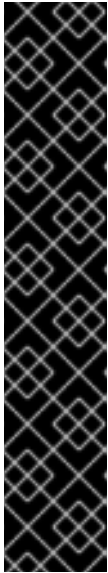
### Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Ee6gm-ymBZj-
Wt5AL"
INFO Time elapsed: 36m22s
```

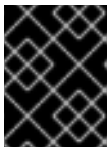


## NOTE

The cluster access and credential information also outputs to **<installation\_directory>/openshift\_install.log** when an installation succeeds.

**IMPORTANT**

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

**IMPORTANT**

You must not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

**5.8.9. Installing the OpenShift CLI by downloading the binary**

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

**IMPORTANT**

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

**Installing the OpenShift CLI on Linux**

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

**Procedure**

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

```
$ tar xvf <file>
```

5. Place the **oc** binary in a directory that is on your **PATH**.  
To check your **PATH**, execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

### Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your **PATH**.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### 5.8.10. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container

Platform installation.

### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

#### Example output

```
system:admin
```

### Additional resources

- See [Accessing the web console](#) for more details about accessing and understanding the OpenShift Container Platform web console.

## 5.8.11. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

## 5.8.12. Next steps

- [Customize your cluster](#).
- If necessary, you can [opt out of remote health reporting](#) .

## 5.9. INSTALLING A CLUSTER ON AZURE INTO A GOVERNMENT REGION

In OpenShift Container Platform version 4.9, you can install a cluster on Microsoft Azure into a government region. To configure the government region, you modify parameters in the **install-config.yaml** file before you install the cluster.

### 5.9.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You [configured an Azure account](#) to host the cluster and determined the tested and validated government region to deploy the cluster to.
- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can [manually create and maintain IAM credentials](#).

### 5.9.2. Azure government regions

OpenShift Container Platform supports deploying a cluster to [Microsoft Azure Government \(MAG\)](#) regions. MAG is specifically designed for US government agencies at the federal, state, and local level, as well as contractors, educational institutions, and other US customers that must run sensitive workloads on Azure. MAG is composed of government-only data center regions, all granted an [Impact Level 5 Provisional Authorization](#).

Installing to a MAG region requires manually configuring the Azure Government dedicated cloud instance and region in the **install-config.yaml** file. You must also update your service principal to reference the appropriate government environment.



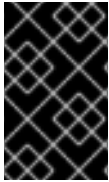
#### NOTE

The Azure government region cannot be selected using the guided terminal prompts from the installation program. You must define the region manually in the **install-config.yaml** file. Remember to also set the dedicated cloud instance, like **AzureUSGovernmentCloud**, based on the region specified.

### 5.9.3. Private clusters

You can deploy a private OpenShift Container Platform cluster that does not expose external endpoints. Private clusters are accessible from only an internal network and are not visible to the internet.

By default, OpenShift Container Platform is provisioned to use publicly-accessible DNS and endpoints. A private cluster sets the DNS, Ingress Controller, and API server to private when you deploy your cluster. This means that the cluster resources are only accessible from your internal network and are not visible to the internet.



## IMPORTANT

If the cluster has any public subnets, load balancer services created by administrators might be publicly accessible. To ensure cluster security, verify that these services are explicitly annotated as private.

To deploy a private cluster, you must:

- Use existing networking that meets your requirements. Your cluster resources might be shared between other clusters on the network.
- Deploy from a machine that has access to:
  - The API services for the cloud to which you provision.
  - The hosts on the network that you provision.
  - The internet to obtain installation media.

You can use any machine that meets these access requirements and follows your company's guidelines. For example, this machine can be a bastion host on your cloud network or a machine that has access to the network through a VPN.

### 5.9.3.1. Private clusters in Azure

To create a private cluster on Microsoft Azure, you must provide an existing private VNet and subnets to host the cluster. The installation program must also be able to resolve the DNS records that the cluster requires. The installation program configures the Ingress Operator and API server for only internal traffic.

Depending how your network connects to the private VNET, you might need to use a DNS forwarder to resolve the cluster's private DNS records. The cluster's machines use **168.63.129.16** internally for DNS resolution. For more information, see [What is Azure Private DNS?](#) and [What is IP address 168.63.129.16?](#) in the Azure documentation.

The cluster still requires access to internet to access the Azure APIs.

The following items are not required or created when you install a private cluster:

- A **BaseDomainResourceGroup**, since the cluster does not create public records
- Public IP addresses
- Public DNS records
- Public endpoints

The cluster is configured so that the Operators do not create public records for the cluster and all cluster machines are placed in the private subnets that you specify.

#### 5.9.3.1.1. Limitations

Private clusters on Azure are subject to only the limitations that are associated with the use of an existing VNet.

### 5.9.3.2. User-defined outbound routing

In OpenShift Container Platform, you can choose your own outbound routing for a cluster to connect to the internet. This allows you to skip the creation of public IP addresses and the public load balancer.

You can configure user-defined routing by modifying parameters in the **install-config.yaml** file before installing your cluster. A pre-existing VNet is required to use outbound routing when installing a cluster; the installation program is not responsible for configuring this.

When configuring a cluster to use user-defined routing, the installation program does not create the following resources:

- Outbound rules for access to the internet.
- Public IPs for the public load balancer.
- Kubernetes Service object to add the cluster machines to the public load balancer for outbound requests.

You must ensure the following items are available before setting user-defined routing:

- Egress to the internet is possible to pull container images, unless using an internal registry mirror.
- The cluster can access Azure APIs.
- Various allowlist endpoints are configured. You can reference these endpoints in the *Configuring your firewall* section.

There are several pre-existing networking setups that are supported for internet access using user-defined routing.

#### Private cluster with network address translation

You can use [Azure VNET network address translation \(NAT\)](#) to provide outbound internet access for the subnets in your cluster. You can reference [Create a NAT gateway using Azure CLI](#) in the Azure documentation for configuration instructions.

When using a VNet setup with Azure NAT and user-defined routing configured, you can create a private cluster with no public endpoints.

#### Private cluster with Azure Firewall

You can use Azure Firewall to provide outbound routing for the VNet used to install the cluster. You can learn more about [providing user-defined routing with Azure Firewall](#) in the Azure documentation.

When using a VNet setup with Azure Firewall and user-defined routing configured, you can create a private cluster with no public endpoints.

#### Private cluster with a proxy configuration

You can use a proxy with user-defined routing to allow egress to the internet. You must ensure that cluster Operators do not access Azure APIs using a proxy; Operators must have access to Azure APIs outside of the proxy.

When using the default route table for subnets, with **0.0.0.0/0** populated automatically by Azure, all Azure API requests are routed over Azure's internal network even though the IP addresses are public. As long as the Network Security Group rules allow egress to Azure API endpoints, proxies with user-defined routing configured allow you to create private clusters with no public endpoints.

### Private cluster with no internet access

You can install a private network that restricts all access to the internet, except the Azure API. This is accomplished by mirroring the release image registry locally. Your cluster must have access to the following:

- An internal registry mirror that allows for pulling container images
- Access to Azure APIs

With these requirements available, you can use user-defined routing to create private clusters with no public endpoints.

## 5.9.4. About reusing a VNet for your OpenShift Container Platform cluster

In OpenShift Container Platform 4.9, you can deploy a cluster into an existing Azure Virtual Network (VNet) in Microsoft Azure. If you do, you must also use existing subnets within the VNet and routing rules.

By deploying OpenShift Container Platform into an existing Azure VNet, you might be able to avoid service limit constraints in new accounts or more easily abide by the operational constraints that your company's guidelines set. This is a good option to use if you cannot obtain the infrastructure creation permissions that are required to create the VNet.

### 5.9.4.1. Requirements for using your VNet

When you deploy a cluster by using an existing VNet, you must perform additional network configuration before you install the cluster. In installer-provisioned infrastructure clusters, the installer usually creates the following components, but it does not create them when you install into an existing VNet:

- Subnets
- Route tables
- VNets
- Network Security Groups



#### NOTE

The installation program requires that you use the cloud-provided DNS server. Using a custom DNS server is not supported and causes the installation to fail.

If you use a custom VNet, you must correctly configure it and its subnets for the installation program and the cluster to use. The installation program cannot subdivide network ranges for the cluster to use, set route tables for the subnets, or set VNet options like DHCP, so you must do so before you install the cluster.

The cluster must be able to access the resource group that contains the existing VNet and subnets. While all of the resources that the cluster creates are placed in a separate resource group that it creates, some network resources are used from a separate group. Some cluster Operators must be able to access resources in both resource groups. For example, the Machine API controller attaches NICS for the virtual machines that it creates to subnets from the networking resource group.

Your VNet must meet the following characteristics:

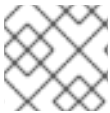


- The VNet's CIDR block must contain the **Networking.MachineCIDR** range, which is the IP address pool for cluster machines.
- The VNet and its subnets must belong to the same resource group, and the subnets must be configured to use Azure-assigned DHCP IP addresses instead of static IP addresses.

You must provide two subnets within your VNet, one for the control plane machines and one for the compute machines. Because Azure distributes machines in different availability zones within the region that you specify, your cluster will have high availability by default.

To ensure that the subnets that you provide are suitable, the installation program confirms the following data:

- All the specified subnets exist.
- There are two private subnets, one for the control plane machines and one for the compute machines.
- The subnet CIDRs belong to the machine CIDR that you specified. Machines are not provisioned in availability zones that you do not provide private subnets for. If required, the installation program creates public load balancers that manage the control plane and worker nodes, and Azure allocates a public IP address to them.

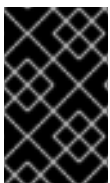


#### NOTE

If you destroy a cluster that uses an existing VNet, the VNet is not deleted.

#### 5.9.4.1.1. Network security group requirements

The network security groups for the subnets that host the compute and control plane machines require specific access to ensure that the cluster communication is correct. You must create rules to allow access to the required cluster communication ports.

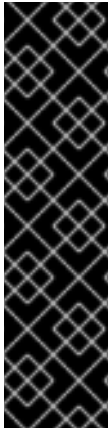


#### IMPORTANT

The network security group rules must be in place before you install the cluster. If you attempt to install a cluster without the required access, the installation program cannot reach the Azure APIs, and installation fails.

Table 5.29. Required ports

Port	Description	Control plane	Compute
80	Allows HTTP traffic		x
443	Allows HTTPS traffic		x
6443	Allows communication to the control plane machines	x	
22623	Allows internal communication to the machine config server for provisioning machines	x	



## IMPORTANT

Currently, there is no supported way to block or restrict the machine config server endpoint. The machine config server must be exposed to the network so that newly-provisioned machines, which have no existing configuration or state, are able to fetch their configuration. In this model, the root of trust is the certificate signing requests (CSR) endpoint, which is where the kubelet sends its certificate signing request for approval to join the cluster. Because of this, machine configs should not be used to distribute sensitive information, such as secrets and certificates.

To ensure that the machine config server endpoints, ports 22623 and 22624, are secured in bare metal scenarios, customers must configure proper network policies.

Because cluster components do not modify the user-provided network security groups, which the Kubernetes controllers update, a pseudo-network security group is created for the Kubernetes controller to modify without impacting the rest of the environment.

### Additional resources

- [About the OpenShift SDN network plugin](#)

#### 5.9.4.2. Division of permissions

Starting with OpenShift Container Platform 4.3, you do not need all of the permissions that are required for an installation program-provisioned infrastructure cluster to deploy a cluster. This change mimics the division of permissions that you might have at your company: some individuals can create different resources in your clouds than others. For example, you might be able to create application-specific items, like instances, storage, and load balancers, but not networking-related components such as VNets, subnet, or ingress rules.

The Azure credentials that you use when you create your cluster do not need the networking permissions that are required to make VNets and core networking components within the VNet, such as subnets, routing tables, internet gateways, NAT, and VPN. You still need permission to make the application resources that the machines within the cluster require, such as load balancers, security groups, storage accounts, and nodes.

#### 5.9.4.3. Isolation between clusters

Because the cluster is unable to modify network security groups in an existing subnet, there is no way to isolate clusters from each other on the VNet.

#### 5.9.5. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



## IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

### 5.9.6. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.



## IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



## NOTE

You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

### Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.



## NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

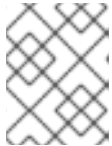
- View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

- Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.



#### NOTE

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- If the `ssh-agent` process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

#### Example output

```
Agent pid 31874
```



#### NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

- Add your SSH private key to the `ssh-agent`:

```
$ ssh-add <path>/<file_name> 1
```

- 1** Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

#### Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

#### Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

### 5.9.7. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

## Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space

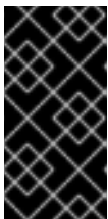
## Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



### IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



### IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#) . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

### 5.9.8. Manually creating the installation configuration file

When installing OpenShift Container Platform on Microsoft Azure into a government region, you must manually generate your installation configuration file.

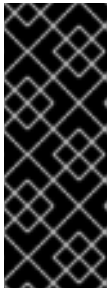
## Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

## Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```



### IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation\_directory>**.



### NOTE

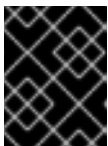
You must name this configuration file **install-config.yaml**.



### NOTE

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation\_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



### IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

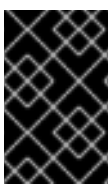
## 5.9.8.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.



### NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.



### IMPORTANT

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

### 5.9.8.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

**Table 5.30. Required parameters**

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;</b> . <b>&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}</b> . <b>{{.baseDomain}}</b> .	String of lowercase letters, hyphens (-), and periods (.), such as <b>dev</b> .
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws</b> , <b>baremetal</b> , <b>azure</b> , <b>gcp</b> , <b>openstack</b> , <b>ovirt</b> , <b>vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object


Parameter	Description	Values
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } }</pre>

### 5.9.8.1.2. Network configuration parameters


You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

**Table 5.31. Network parameters**

Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	Object <div style="display: flex; align-items: center; margin-top: 10px;">  <div> <p><b>NOTE</b></p> <p>You cannot modify parameters specified by the <b>networking</b> object after installation.</p> </div> </div>
<b>networking.network Type</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .




Parameter	Description	Values
<b>networking.clusterNetwork</b>	<p>The IP address blocks for pods.</p> <p>The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b>.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   clusterNetwork:     - cidr: 10.128.0.0/14       hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	<p>Required if you use <b>networking.clusterNetwork</b>. An IP address block.</p> <p>An IPv4 network.</p>	<p>An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b>.</p>
<b>networking.clusterNetwork.hostPrefix</b>	<p>The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b>. A <b>hostPrefix</b> value of <b>23</b> provides 510 (<math>2^{(32 - 23)} - 2</math>) pod IP addresses.</p>	<p>A subnet prefix.</p> <p>The default value is <b>23</b>.</p>
<b>networking.serviceNetwork</b>	<p>The IP address block for services. The default value is <b>172.30.0.0/16</b>.</p> <p>The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.</p>	<p>An array with an IP address block in CIDR format. For example:</p> <pre>networking:   serviceNetwork:     - 172.30.0.0/16</pre>
<b>networking.machineNetwork</b>	<p>The IP address blocks for machines.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   machineNetwork:     - cidr: 10.0.0.0/16</pre>
<b>networking.machineNetwork.cidr</b>	<p>Required if you use <b>networking.machineNetwork</b>. An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b>.</p>	<p>An IP network block in CIDR notation.</p> <p>For example, <b>10.0.0.0/16</b>.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p> </div> </div>



## 5.9.8.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:


Table 5.32. Optional parameters

Parameter	Description	Values
<b>additionalTrustBundle</b>	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
<b>compute</b>	The configuration for the machines that comprise the compute nodes.	Array of <b>MachinePool</b> objects.
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String
<b>compute.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>

Parameter	Description	Values
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String
<b>controlPlane.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div data-bbox="486 1093 593 1411" style="background-color: black; width: 67px; height: 142px; margin-bottom: 10px;"></div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platform</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>controlPlane.replicas</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.

Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.</p> <p> <b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators reference content</i>.</p> <p> <b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p>	<b>Mint, Passthrough, Manual</b> or an empty string ("").

Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start;"> <div style="width: 40px; height: 40px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 40px; height: 40px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<b>Internal</b> or <b>External</b> . To deploy a private cluster, which cannot be accessed from the internet, set <b>publish</b> to <b>Internal</b> . The default value is <b>External</b> .

Parameter	Description	Values
<b>sshKey</b>	<p>The SSH key or keys to authenticate access your cluster machines.</p>  <p><b>NOTE</b></p> <p>For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.</p>	<p>One or more keys. For example:</p> <pre>sshKey:   &lt;key1&gt;   &lt;key2&gt;   &lt;key3&gt;</pre>

#### 5.9.8.1.4. Additional Azure configuration parameters

Additional Azure configuration parameters are described in the following table:

Table 5.33. Additional Azure parameters

Parameter	Description	Values
<b>compute.platform.azure.osDisk.diskSizeGB</b>	The Azure disk size for the VM.	Integer that represents the size of the disk in GB. The default is <b>128</b> .
<b>compute.platform.azure.osDisk.diskType</b>	Defines the type of disk.	<b>standard_LRS</b> , <b>premium_LRS</b> , or <b>standardSSD_LRS</b> . The default is <b>premium_LRS</b> .
<b>controlPlane.platform.azure.osDisk.diskSizeGB</b>	The Azure disk size for the VM.	Integer that represents the size of the disk in GB. The default is <b>1024</b> .
<b>controlPlane.platform.azure.osDisk.diskType</b>	Defines the type of disk.	<b>premium_LRS</b> or <b>standardSSD_LRS</b> . The default is <b>premium_LRS</b> .
<b>platform.azure.baseDomainResourceGroupName</b>	The name of the resource group that contains the DNS zone for your base domain.	String, for example <b>production_cluster</b> .

Parameter	Description	Values
<b>platform.azure.resourceGroupName</b>	The name of an already existing resource group to install your cluster to. This resource group must be empty and only used for this specific cluster; the cluster components assume ownership of all resources in the resource group. If you limit the service principal scope of the installation program to this resource group, you must ensure all other resources used by the installation program in your environment have the necessary permissions, such as the public DNS zone and virtual network. Destroying the cluster using the installation program deletes this resource group.	String, for example <b>existing_resource_group</b> .
<b>platform.azure.outboundType</b>	The outbound routing strategy used to connect your cluster to the internet. If you are using user-defined routing, you must have pre-existing networking available where the outbound routing has already been configured prior to installing a cluster. The installation program is not responsible for configuring user-defined routing.	<b>LoadBalancer</b> or <b>UserDefinedRouting</b> . The default is <b>LoadBalancer</b> .
<b>platform.azure.region</b>	The name of the Azure region that hosts your cluster.	Any valid region name, such as <b>centralus</b> .
<b>platform.azure.zone</b>	List of availability zones to place machines in. For high availability, specify at least two zones.	List of zones, for example <b>["1", "2", "3"]</b> .
<b>platform.azure.networkResourceGroupName</b>	The name of the resource group that contains the existing VNet that you want to deploy your cluster to. This name cannot be the same as the <b>platform.azure.baseDomainResourceGroupName</b> .	String.
<b>platform.azure.virtualNetwork</b>	The name of the existing VNet that you want to deploy your cluster to.	String.
<b>platform.azure.controlPlaneSubnet</b>	The name of the existing subnet in your VNet that you want to deploy your control plane machines to.	Valid CIDR, for example <b>10.0.0.0/16</b> .

Parameter	Description	Values
<b>platform.azure.computeSubnet</b>	The name of the existing subnet in your VNet that you want to deploy your compute machines to.	Valid CIDR, for example <b>10.0.0.0/16</b> .
<b>platform.azure.cloudName</b>	The name of the Azure cloud environment that is used to configure the Azure SDK with the appropriate Azure API endpoints. If empty, the default value <b>AzurePublicCloud</b> is used.	Any valid cloud environment, such as <b>AzurePublicCloud</b> or <b>AzureUSGovernmentCloud</b> .

**NOTE**

You cannot customize [Azure Availability Zones](#) or [Use tags to organize your Azure resources](#) with an Azure cluster.

**5.9.8.2. Minimum resource requirements for cluster installation**

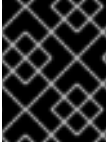
Each cluster machine must meet the following minimum requirements:

**Table 5.34. Minimum resource requirements**

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 7.9, or RHEL 8.4 [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.



**IMPORTANT**

You are required to use Azure virtual machines with **premiumIO** set to **true**. The machines must also have the **hyperVGeneration** property contain **V1**.

**5.9.8.3. Sample customized install-config.yaml file for Azure**

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

**IMPORTANT**

This sample YAML file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program and modify it.

```

apiVersion: v1
baseDomain: example.com 1
controlPlane: 2
  hyperthreading: Enabled 3 4
  name: master
  platform:
    azure:
      osDisk:
        diskSizeGB: 1024 5
        diskType: Premium_LRS
        type: Standard_D8s_v3
      replicas: 3
compute: 6
- hyperthreading: Enabled 7
  name: worker
  platform:
    azure:
      type: Standard_D2s_v3
      osDisk:
        diskSizeGB: 512 8
        diskType: Standard_LRS
      zones: 9
      - "1"
      - "2"
      - "3"
    replicas: 5
metadata:
  name: test-cluster 10
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
  azure:

```

```

baseDomainResourceGroupName: resource_group 11
region: usgovvirginia
resourceGroupName: existing_resource_group 12
networkResourceGroupName: vnet_resource_group 13
virtualNetwork: vnet 14
controlPlaneSubnet: control_plane_subnet 15
computeSubnet: compute_subnet 16
outboundType: UserDefinedRouting 17
cloudName: AzureUSGovernmentCloud 18
pullSecret: '{"auths": ...}' 19
fips: false 20
sshKey: ssh-ed25519 AAAA... 21
publish: Internal 22

```

1 10 19 Required.

2 6 If you do not provide these parameters and values, the installation program provides the default value.

3 7 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

4 Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.



### IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger virtual machine types, such as **Standard\_D8s\_v3**, for your machines if you disable simultaneous multithreading.

5 8 You can specify the size of the disk to use in GB. Minimum recommendation for control plane nodes is 1024 GB.

9 Specify a list of zones to deploy your machines to. For high availability, specify at least two zones.

11 Specify the name of the resource group that contains the DNS zone for your base domain.

12 Specify the name of an already existing resource group to install your cluster to. If undefined, a new resource group is created for the cluster.

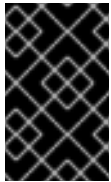
13 If you use an existing VNet, specify the name of the resource group that contains it.

14 If you use an existing VNet, specify its name.

15 If you use an existing VNet, specify the name of the subnet to host the control plane machines.

16 If you use an existing VNet, specify the name of the subnet to host the compute machines.

- 17 You can customize your own outbound routing. Configuring user-defined routing prevents exposing external endpoints in your cluster. User-defined routing for egress requires deploying
- 18 Specify the name of the Azure cloud environment to deploy your cluster to. Set **AzureUSGovernmentCloud** to deploy to a Microsoft Azure Government (MAG) region. The default value is **AzurePublicCloud**.
- 20 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.



### IMPORTANT

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

- 21 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.



### NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

- 22 How to publish the user-facing endpoints of your cluster. Set **publish** to **Internal** to deploy a private cluster, which cannot be accessed from the internet. The default value is **External**.

#### 5.9.8.4. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

#### Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



## NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

## Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
  additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
  ...
```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations.
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.



## NOTE

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

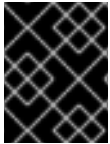


#### NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

### 5.9.9. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



#### IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

#### Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

#### Procedure

1. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
--log-level=info 2
```

- 1** For **<installation\_directory>**, specify the location of your customized **./install-config.yaml** file.

- 2** To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.



#### NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

When the cluster deployment completes, directions for accessing your cluster, including a link to its web console and credentials for the **kubeadmin** user, display in your terminal.

#### Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
```

```

KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Ee6gm-ymBZj-
Wt5AL"
INFO Time elapsed: 36m22s

```



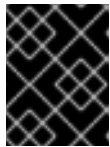
### NOTE

The cluster access and credential information also outputs to `<installation_directory>/openshift_install.log` when an installation succeeds.



### IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

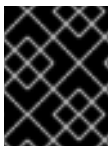


### IMPORTANT

You must not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

## 5.9.10. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



### IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

### Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.

3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

```
$ tar xvf <file>
```

5. Place the **oc** binary in a directory that is on your **PATH**.  
To check your **PATH**, execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

### Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your **PATH**.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### 5.9.11. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

#### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

#### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

#### Example output

```
system:admin
```

#### Additional resources

- See [Accessing the web console](#) for more details about accessing and understanding the OpenShift Container Platform web console.

### 5.9.12. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.



### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

### 5.9.13. Next steps

- [Customize your cluster.](#)
- If necessary, you can [opt out of remote health reporting](#) .

## 5.10. INSTALLING A CLUSTER ON AZURE USING ARM TEMPLATES

In OpenShift Container Platform version 4.9, you can install a cluster on Microsoft Azure by using infrastructure that you provide.

Several [Azure Resource Manager](#) (ARM) templates are provided to assist in completing these steps or to help model your own.



### IMPORTANT

The steps for performing a user-provisioned infrastructure installation are provided as an example only. Installing a cluster with infrastructure you provide requires knowledge of the cloud provider and the installation process of OpenShift Container Platform. Several ARM templates are provided to assist in completing these steps or to help model your own. You are also free to create the required resources through other methods; the templates are just an example.

### 5.10.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You [configured an Azure account](#) to host the cluster.
- You downloaded the Azure CLI and installed it on your computer. See [Install the Azure CLI](#) in the Azure documentation. The documentation below was last tested using version **2.38.0** of the Azure CLI. Azure CLI commands might perform differently based on the version you use.
- If you use a firewall and plan to use the Telemetry service, you [configured the firewall to allow the sites](#) that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can [manually create and maintain IAM credentials](#) .



### NOTE

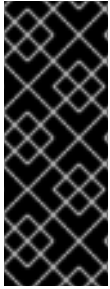
Be sure to also review this site list if you are configuring a proxy.

### 5.10.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



### IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

## 5.10.3. Configuring your Azure project

Before you can install OpenShift Container Platform, you must configure an Azure project to host it.



### IMPORTANT

All Azure resources that are available through public endpoints are subject to resource name restrictions, and you cannot create resources that use certain terms. For a list of terms that Azure restricts, see [Resolve reserved resource name errors](#) in the Azure documentation.

### 5.10.3.1. Azure account limits

The OpenShift Container Platform cluster uses a number of Microsoft Azure components, and the default [Azure subscription and service limits, quotas, and constraints](#) affect your ability to install OpenShift Container Platform clusters.



### IMPORTANT


Default limits vary by offer category types, such as Free Trial and Pay-As-You-Go, and by series, such as Dv2, F, and G. For example, the default for Enterprise Agreement subscriptions is 350 cores.

Check the limits for your subscription type and if necessary, increase quota limits for your account before you install a default cluster on Azure.

The following table summarizes the Azure components whose limits can impact your ability to install and run OpenShift Container Platform clusters.

Component	Number of components required by default	Default Azure limit	Description
vCPU	40	20 per region	<p>A default cluster requires 40 vCPUs, so you must increase the account limit.</p> <p>By default, each cluster creates the following instances:</p> <ul style="list-style-type: none"> <li>● One bootstrap machine, which is removed after installation</li> <li>● Three control plane machines</li> <li>● Three compute machines</li> </ul> <p>Because the bootstrap machine uses <b>Standard_D4s_v3</b> machines, which use 4 vCPUs, the control plane machines use <b>Standard_D8s_v3</b> virtual machines, which use 8 vCPUs, and the worker machines use <b>Standard_D4s_v3</b> virtual machines, which use 4 vCPUs, a default cluster requires 40 vCPUs. The bootstrap node VM, which uses 4 vCPUs, is used only during installation.</p> <p>To deploy more worker nodes, enable autoscaling, deploy large workloads, or use a different instance type, you must further increase the vCPU limit for your account to ensure that your cluster can deploy the machines that you require.</p> <p>By default, the installation program distributes control plane and compute machines across <a href="#">all availability zones</a> within a <a href="#">region</a>. To ensure high availability for your cluster, select a region with at least three availability zones. If your region contains fewer than three availability zones, the installation program places more than one control plane machine in the available zones.</p>

Component	Number of components required by default	Default Azure limit	Description				
OS Disk	7		<p>VM OS disk must be able to sustain a tested and recommended minimum throughput of 5000 IOPS / 200MBps for control plane machines. This throughput can be provided by having a minimum of 1 TiB Premium SSD (P30). In Azure, disk performance is directly dependent on SSD disk sizes, so to achieve the throughput supported by <b>Standard_D8s_v3</b>, or other similar machine types available, and the target of 5000 IOPS, at least a P30 disk is required.</p> <p>Host caching must be set to <b>ReadOnly</b> for low read latency and high read IOPS and throughput. The reads performed from the cache, which is present either in the VM memory or in the local SSD disk, are much faster than the reads from the data disk, which is in the blob storage.</p>				
VNet	1	1000 per region	Each default cluster requires one Virtual Network (VNet), which contains two subnets.				
Network interfaces	7	65,536 per region	Each default cluster requires seven network interfaces. If you create more machines or your deployed workloads create load balancers, your cluster uses more network interfaces.				
Network security groups	2	5000	<p>Each cluster creates network security groups for each subnet in the VNet. The default cluster creates network security groups for the control plane and for the compute node subnets:</p> <table border="1"> <tbody> <tr> <td><b>control plane</b></td> <td>Allows the control plane machines to be reached on port 6443 from anywhere</td> </tr> <tr> <td><b>node</b></td> <td>Allows worker nodes to be reached from the internet on ports 80 and 443</td> </tr> </tbody> </table>	<b>control plane</b>	Allows the control plane machines to be reached on port 6443 from anywhere	<b>node</b>	Allows worker nodes to be reached from the internet on ports 80 and 443
<b>control plane</b>	Allows the control plane machines to be reached on port 6443 from anywhere						
<b>node</b>	Allows worker nodes to be reached from the internet on ports 80 and 443						

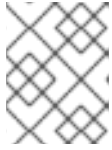
Component	Number of components required by default	Default Azure limit	Description						
Network load balancers	3	1000 per region	<p>Each cluster creates the following <a href="#">load balancers</a>:</p> <table border="1"> <tr> <td><b>default</b></td> <td>Public IP address that load balances requests to ports 80 and 443 across worker machines</td> </tr> <tr> <td><b>internal</b></td> <td>Private IP address that load balances requests to ports 6443 and 22623 across control plane machines</td> </tr> <tr> <td><b>external</b></td> <td>Public IP address that load balances requests to port 6443 across control plane machines</td> </tr> </table> <p>If your applications create more Kubernetes <b>LoadBalancer</b> service objects, your cluster uses more load balancers.</p>	<b>default</b>	Public IP address that load balances requests to ports 80 and 443 across worker machines	<b>internal</b>	Private IP address that load balances requests to ports 6443 and 22623 across control plane machines	<b>external</b>	Public IP address that load balances requests to port 6443 across control plane machines
<b>default</b>	Public IP address that load balances requests to ports 80 and 443 across worker machines								
<b>internal</b>	Private IP address that load balances requests to ports 6443 and 22623 across control plane machines								
<b>external</b>	Public IP address that load balances requests to port 6443 across control plane machines								
Public IP addresses	3		Each of the two public load balancers uses a public IP address. The bootstrap machine also uses a public IP address so that you can SSH into the machine to troubleshoot issues during installation. The IP address for the bootstrap node is used only during installation.						
Private IP addresses	7		The internal load balancer, each of the three control plane machines, and each of the three worker machines each use a private IP address.						
Spot VM vCPUs (optional)	0 If you configure spot VMs, your cluster must have two spot VM vCPUs for every compute node.	20 per region	<p>This is an optional component. To use spot VMs, you must increase the Azure default limit to at least twice the number of compute nodes in your cluster.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>Using spot VMs for control plane nodes is not recommended.</p> </div> </div>						

### 5.10.3.2. Configuring a public DNS zone in Azure

To install OpenShift Container Platform, the Microsoft Azure account you use must have a dedicated public hosted DNS zone in your account. This zone must be authoritative for the domain. This service provides cluster DNS resolution and name lookup for external connections to the cluster.

#### Procedure

1. Identify your domain, or subdomain, and registrar. You can transfer an existing domain and registrar or obtain a new one through Azure or another source.

**NOTE**

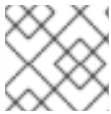
For more information about purchasing domains through Azure, see [Buy a custom domain name for Azure App Service](#) in the Azure documentation.

2. If you are using an existing domain and registrar, migrate its DNS to Azure. See [Migrate an active DNS name to Azure App Service](#) in the Azure documentation.
3. Configure DNS for your domain. Follow the steps in the [Tutorial: Host your domain in Azure DNS](#) in the Azure documentation to create a public hosted zone for your domain or subdomain, extract the new authoritative name servers, and update the registrar records for the name servers that your domain uses.  
Use an appropriate root domain, such as **openshiftcorp.com**, or subdomain, such as **clusters.openshiftcorp.com**.
4. If you use a subdomain, follow your company's procedures to add its delegation records to the parent domain.

You can view Azure's DNS solution by visiting this [example for creating DNS zones](#).

### 5.10.3.3. Increasing Azure account limits

To increase an account limit, file a support request on the Azure portal.

**NOTE**

You can increase only one type of quota per support request.

**Procedure**

1. From the Azure portal, click **Help + support** in the lower left corner.
2. Click **New support request** and then select the required values:
  - a. From the **Issue type** list, select **Service and subscription limits (quotas)**
  - b. From the **Subscription** list, select the subscription to modify.
  - c. From the **Quota type** list, select the quota to increase. For example, select **Compute-VM (cores-vCPUs) subscription limit increases** to increase the number of vCPUs, which is required to install a cluster.
  - d. Click **Next: Solutions**.
3. On the **Problem Details** page, provide the required information for your quota increase:
  - a. Click **Provide details** and provide the required details in the **Quota details** window.
  - b. In the **SUPPORT METHOD** and **CONTACT INFO** sections, provide the issue severity and your contact details.
4. Click **Next: Review + create** and then click **Create**.

### 5.10.3.4. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

### 5.10.3.5. Required Azure roles

OpenShift Container Platform needs a service principal so it can manage Microsoft Azure resources. Before you can create a service principal, your Azure account subscription must have the following roles:

- **User Access Administrator**
- **Contributor**

To set roles on the Azure portal, see the [Manage access to Azure resources using RBAC and the Azure portal](#) in the Azure documentation.

### 5.10.3.6. Creating a service principal

Because OpenShift Container Platform and its installation program create Microsoft Azure resources by using the Azure Resource Manager, you must create a service principal to represent it.

#### Prerequisites

- Install or update the [Azure CLI](#).
- Your Azure account has the required roles for the subscription that you use.

#### Procedure

1. Log in to the Azure CLI:

```
$ az login
```

2. If your Azure account uses subscriptions, ensure that you are using the right subscription:
  - a. View the list of available accounts and record the **tenantId** value for the subscription you want to use for your cluster:

```
$ az account list --refresh
```

#### Example output

```
[
  {
    "cloudName": "AzureCloud",
    "id": "9bab1460-96d5-40b3-a78e-17b15e978a80",
    "isDefault": true,
    "name": "Subscription Name",
    "state": "Enabled",
```

```

    "tenantId": "6057c7e9-b3ae-489d-a54e-de3f6bf6a8ee",
    "user": {
      "name": "you@example.com",
      "type": "user"
    }
  }
]

```

- b. View your active account details and confirm that the **tenantId** value matches the subscription you want to use:

```
$ az account show
```

### Example output

```

{
  "environmentName": "AzureCloud",
  "id": "9bab1460-96d5-40b3-a78e-17b15e978a80",
  "isDefault": true,
  "name": "Subscription Name",
  "state": "Enabled",
  "tenantId": "6057c7e9-b3ae-489d-a54e-de3f6bf6a8ee", 1
  "user": {
    "name": "you@example.com",
    "type": "user"
  }
}

```

- 1** Ensure that the value of the **tenantId** parameter is the correct subscription ID.

- c. If you are not using the right subscription, change the active subscription:

```
$ az account set -s <subscription_id> 1
```

- 1** Specify the subscription ID.

- d. Verify the subscription ID update:

```
$ az account show
```

### Example output

```

{
  "environmentName": "AzureCloud",
  "id": "33212d16-bdf6-45cb-b038-f6565b61edda",
  "isDefault": true,
  "name": "Subscription Name",
  "state": "Enabled",
  "tenantId": "8049c7e9-c3de-762d-a54e-dc3f6be6a7ee",
  "user": {
    "name": "you@example.com",

```



```

    "type": "user"
  }
}

```

- Record the **tenantId** and **id** parameter values from the output. You need these values during the OpenShift Container Platform installation.
- Create the service principal for your account:

```

$ az ad sp create-for-rbac --role Contributor --name <service_principal> \ 1
--scopes /subscriptions/<subscription_id> 2
--years <years> 3

```

- Specify the service principal name.
- Specify the subscription ID.
- Specify the number of years. By default, a service principal expires in one year. By using the **--years** option you can extend the validity of your service principal.

### Example output

```

Creating 'Contributor' role assignment under scope '/subscriptions/<subscription_id>'
The output includes credentials that you must protect. Be sure that you do not
include these credentials in your code or check the credentials into your source
control. For more information, see https://aka.ms/azadsp-cli
{
  "appId": "ac461d78-bf4b-4387-ad16-7e32e328aec6",
  "displayName": <service_principal>,
  "password": "00000000-0000-0000-0000-000000000000",
  "tenantId": "8049c7e9-c3de-762d-a54e-dc3f6be6a7ee"
}

```

- Record the values of the **appId** and **password** parameters from the previous output. You need these values during OpenShift Container Platform installation.
- Assign the **User Access Administrator** role by running the following command:

```

$ az role assignment create --role "User Access Administrator" \
--assignee-object-id $(az ad sp show --id <appId> --query id -o tsv) 1

```

- Specify the **appId** parameter value for your service principal.

### Additional resources

- For more information about CCO modes, see [About the Cloud Credential Operator](#).

#### 5.10.3.7. Supported Azure regions

The installation program dynamically generates the list of available Microsoft Azure regions based on your subscription.

## Supported Azure public regions

- **australiacentral** (Australia Central)
- **australiaeast** (Australia East)
- **australiasoutheast** (Australia South East)
- **brazilsouth** (Brazil South)
- **canadacentral** (Canada Central)
- **canadaeast** (Canada East)
- **centralindia** (Central India)
- **centralus** (Central US)
- **eastasia** (East Asia)
- **eastus** (East US)
- **eastus2** (East US 2)
- **francecentral** (France Central)
- **germanywestcentral** (Germany West Central)
- **japaneast** (Japan East)
- **japanwest** (Japan West)
- **koreacentral** (Korea Central)
- **koreasouth** (Korea South)
- **northcentralus** (North Central US)
- **northeurope** (North Europe)
- **norwayeast** (Norway East)
- **qatarcentral** (Qatar Central)
- **southafricanorth** (South Africa North)
- **southcentralus** (South Central US)
- **southeastasia** (Southeast Asia)
- **southindia** (South India)
- **switzerlandnorth** (Switzerland North)
- **uaenorth** (UAE North)
- **uksouth** (UK South)

- **ukwest** (UK West)
- **westcentralus** (West Central US)
- **westeurope** (West Europe)
- **westindia** (West India)
- **westus** (West US)
- **westus2** (West US 2)

#### Supported Azure Government regions

Support for the following Microsoft Azure Government (MAG) regions was added in OpenShift Container Platform version 4.6:

- **usgovtexas** (US Gov Texas)
- **usgovvirginia** (US Gov Virginia)

You can reference all available MAG regions in the [Azure documentation](#). Other provided MAG regions are expected to work with OpenShift Container Platform, but have not been tested.

### 5.10.4. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

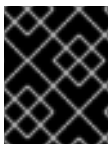
This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

#### 5.10.4.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

**Table 5.35. Minimum required hosts**

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.



#### IMPORTANT

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 7.9, or RHEL 8.4.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See [Red Hat Enterprise Linux technology capabilities and limits](#).

#### 5.10.4.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

**Table 5.36. Minimum resource requirements**

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 7.9, or RHEL 8.4 [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio:  $(\text{threads per core} \times \text{cores}) \times \text{sockets} = \text{vCPUs}$ .
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.



#### IMPORTANT

You are required to use Azure virtual machines with **premiumIO** set to **true**. The machines must also have the **hyperVGeneration** property contain **V1**.

#### 5.10.5. Selecting an Azure Marketplace image

If you are deploying an OpenShift Container Platform cluster using the Azure Marketplace offering, you must first obtain the Azure Marketplace image. The installation program uses this image to deploy worker nodes. When obtaining your image, consider the following:

- While the images are the same, the Azure Marketplace publisher is different depending on your region. If you are located in North America, specify **redhat** as the publisher. If you are located in EMEA, specify **redhat-limited** as the publisher.

- The offer includes a **rh-ocp-worker** SKU and a **rh-ocp-worker-gen1** SKU. The **rh-ocp-worker** SKU represents a Hyper-V generation version 2 VM image. The default instance types used in OpenShift Container Platform are version 2 compatible. If you are going to use an instance type that is only version 1 compatible, use the image associated with the **rh-ocp-worker-gen1** SKU. The **rh-ocp-worker-gen1** SKU represents a Hyper-V version 1 VM image.

## Prerequisites

- You have installed the Azure CLI client (**az**).
- Your Azure account is entitled for the offer and you have logged into this account with the Azure CLI client.

## Procedure

1. Display all of the available OpenShift Container Platform images by running one of the following commands:

- North America:

```
$ az vm image list --all --offer rh-ocp-worker --publisher redhat -o table
```

### Example output

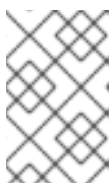
Offer	Publisher	Sku	Urn	Version
rh-ocp-worker-ocpworker:4.8.2021122100	RedHat	rh-ocp-worker	RedHat:rh-ocp-worker:rh-ocp-worker:4.8.2021122100	
rh-ocp-worker-gen1:4.8.2021122100	RedHat	rh-ocp-worker-gen1	RedHat:rh-ocp-worker:rh-ocp-worker-gen1:4.8.2021122100	

- EMEA:

```
$ az vm image list --all --offer rh-ocp-worker --publisher redhat-limited -o table
```

### Example output

Offer	Publisher	Sku	Urn	Version
rh-ocp-worker-worker:4.8.2021122100	redhat-limited	rh-ocp-worker	redhat-limited:rh-ocp-worker:rh-ocp-worker:4.8.2021122100	
rh-ocp-worker-gen1:4.8.2021122100	redhat-limited	rh-ocp-worker-gen1	redhat-limited:rh-ocp-worker:rh-ocp-worker-gen1:4.8.2021122100	



## NOTE

Regardless of the version of OpenShift Container Platform you are installing, the correct version of the Azure Marketplace image to use is 4.8.x. If required, as part of the installation process, your VMs are automatically upgraded.

2. Inspect the image for your offer by running one of the following commands:

- North America:  

```
$ az vm image show --urn redhat:rh-ocp-worker:rh-ocp-worker:<version>
```
  - EMEA:  

```
$ az vm image show --urn redhat-limited:rh-ocp-worker:rh-ocp-worker:<version>
```
3. Review the terms of the offer by running one of the following commands:
    - North America:  

```
$ az vm image terms show --urn redhat:rh-ocp-worker:rh-ocp-worker:<version>
```
    - EMEA:  

```
$ az vm image terms show --urn redhat-limited:rh-ocp-worker:rh-ocp-worker:<version>
```
  4. Accept the terms of the offering by running one of the following commands:
    - North America:  

```
$ az vm image terms accept --urn redhat:rh-ocp-worker:rh-ocp-worker:<version>
```
    - EMEA:  

```
$ az vm image terms accept --urn redhat-limited:rh-ocp-worker:rh-ocp-worker:<version>
```
  5. Record the image details of your offer and use them to update the **06\_workers.json** Azure Resource Manager (ARM) template.
  6. Update the **storageProfile.imageReference** field by deleting the **id** parameter and adding the **offer**, **publisher**, **sku**, and **version** parameters by using the values from your offer. You can find a sample template in the "Creating additional worker machines in Azure" section.

### 5.10.6. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

#### Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space

#### Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.

**IMPORTANT**

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.

**IMPORTANT**

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

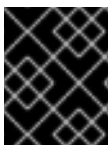
5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#) . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

### 5.10.7. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.

**IMPORTANT**

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

**NOTE**

You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

**Procedure**

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.



#### NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

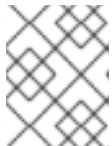
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.



#### NOTE

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

#### Example output

```
Agent pid 31874
```



#### NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```



- 1 Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

### Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

### Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program. If you install a cluster on infrastructure that you provision, you must provide the key to the installation program.

## 5.10.8. Creating the installation files for Azure

To install OpenShift Container Platform on Microsoft Azure using user-provisioned infrastructure, you must generate the files that the installation program needs to deploy your cluster and modify them so that the cluster creates only the machines that it will use. You generate and customize the **install-config.yaml** file, Kubernetes manifests, and Ignition config files. You also have the option to first set up a separate **var** partition during the preparation phases of installation.

### 5.10.8.1. Optional: Creating a separate **/var** partition

It is recommended that disk partitioning for OpenShift Container Platform be left to the installer. However, there are cases where you might want to create separate partitions in a part of the filesystem that you expect to grow.

OpenShift Container Platform supports the addition of a single partition to attach storage to either the **/var** partition or a subdirectory of **/var**. For example:

- **/var/lib/containers**: Holds container-related content that can grow as more images and containers are added to a system.
- **/var/lib/etcd**: Holds data that you might want to keep separate for purposes such as performance optimization of etcd storage.
- **/var**: Holds data that you might want to keep separate for purposes such as auditing.

Storing the contents of a **/var** directory separately makes it easier to grow storage for those areas as needed and reinstall OpenShift Container Platform at a later date and keep that data intact. With this method, you will not have to pull all your containers again, nor will you have to copy massive log files when you update systems.

Because **/var** must be in place before a fresh installation of Red Hat Enterprise Linux CoreOS (RHCOS), the following procedure sets up the separate **/var** partition by creating a machine config manifest that is inserted during the **openshift-install** preparation phases of an OpenShift Container Platform installation.



### IMPORTANT

If you follow the steps to create a separate **/var** partition in this procedure, it is not necessary to create the Kubernetes manifest and Ignition config files again as described later in this section.

## Procedure

1. Create a directory to hold the OpenShift Container Platform installation files:

```
$ mkdir $HOME/clusterconfig
```

2. Run **openshift-install** to create a set of files in the **manifest** and **openshift** subdirectories. Answer the system questions as you are prompted:

```
$ openshift-install create manifests --dir $HOME/clusterconfig
```

### Example output

```
? SSH Public Key ...
INFO Credentials loaded from the "myprofile" profile in file "/home/myuser/.aws/credentials"
INFO Consuming Install Config from target directory
INFO Manifests created in: $HOME/clusterconfig/manifests and
$HOME/clusterconfig/openshift
```

3. Optional: Confirm that the installation program created manifests in the **clusterconfig/openshift** directory:

```
$ ls $HOME/clusterconfig/openshift/
```

### Example output

```
99_kubeadmin-password-secret.yaml
99_openshift-cluster-api_master-machines-0.yaml
99_openshift-cluster-api_master-machines-1.yaml
99_openshift-cluster-api_master-machines-2.yaml
...
```

4. Create a Butane config that configures the additional partition. For example, name the file **\$HOME/clusterconfig/98-var-partition.bu**, change the disk device name to the name of the storage device on the **worker** systems, and set the storage size as appropriate. This example places the **/var** directory on a separate partition:

```
variant: openshift
version: 4.9.0
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 98-var-partition
storage:
  disks:
    - device: /dev/<device_name> 1
      partitions:
        - label: var
          start_mib: <partition_start_offset> 2
          size_mib: <partition_size> 3
  filesystems:
    - device: /dev/disk/by-partlabel/var
      path: /var
```

```
format: xfs
mount_options: [defaults, prjquota] 4
with_mount_unit: true
```

- 1 The storage device name of the disk that you want to partition.
- 2 When adding a data partition to the boot disk, a minimum value of 25000 MiB (Mebibytes) is recommended. The root file system is automatically resized to fill all available space up to the specified offset. If no value is specified, or if the specified value is smaller than the recommended minimum, the resulting root file system will be too small, and future reinstalls of RHCOS might overwrite the beginning of the data partition.
- 3 The size of the data partition in mebibytes.
- 4 The **prjquota** mount option must be enabled for filesystems used for container storage.



#### NOTE

When creating a separate **/var** partition, you cannot use different instance types for worker nodes, if the different instance types do not have the same device name.

5. Create a manifest from the Butane config and save it to the **clusterconfig/openshift** directory. For example, run the following command:

```
$ butane $HOME/clusterconfig/98-var-partition.bu -o $HOME/clusterconfig/openshift/98-var-partition.yaml
```

6. Run **openshift-install** again to create Ignition configs from a set of files in the **manifest** and **openshift** subdirectories:

```
$ openshift-install create ignition-configs --dir $HOME/clusterconfig
$ ls $HOME/clusterconfig/
auth bootstrap.ign master.ign metadata.json worker.ign
```

Now you can use the Ignition config files as input to the installation procedures to install Red Hat Enterprise Linux CoreOS (RHCOS) systems.

### 5.10.8.2. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Microsoft Azure.

#### Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

#### Procedure

1. Create the **install-config.yaml** file.
  - a. Change to the directory that contains the installation program and run the following

- a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

- 1** For **<installation\_directory>**, specify the directory name to store the files that the installation program creates.



### IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

- b. At the prompts, provide the configuration details for your cloud:
  - i. Optional: Select an SSH key to use to access your cluster machines.



### NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

- ii. Select **azure** as the platform to target.
  - iii. If you do not have a Microsoft Azure profile stored on your computer, specify the following Azure parameter values for your subscription and service principal:
    - **azure subscription id** The subscription ID to use for the cluster. Specify the **id** value in your account output.
    - **azure tenant id** The tenant ID. Specify the **tenantId** value in your account output.
    - **azure service principal client id** The value of the **appId** parameter for the service principal.
    - **azure service principal client secret** The value of the **password** parameter for the service principal.
  - iv. Select the region to deploy the cluster to.
  - v. Select the base domain to deploy the cluster to. The base domain corresponds to the Azure DNS Zone that you created for your cluster.
  - vi. Enter a descriptive name for your cluster.



### IMPORTANT

All Azure resources that are available through public endpoints are subject to resource name restrictions, and you cannot create resources that use certain terms. For a list of terms that Azure restricts, see [Resolve reserved resource name errors](#) in the Azure documentation.

- vii. Paste the [pull secret from the Red Hat OpenShift Cluster Manager](#) .
- c. Optional: If you do not want the cluster to provision compute machines, empty the compute pool by editing the resulting **install-config.yaml** file to set **replicas** to **0** for the **compute** pool:

```
compute:
- hyperthreading: Enabled
  name: worker
  platform: {}
  replicas: 0 1
```

**1** Set to **0**.

2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.
3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



### IMPORTANT

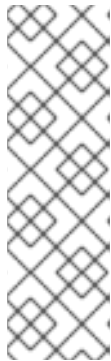
The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

#### 5.10.8.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

#### Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



## NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

## Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
  additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
  ...
```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations.
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.



## NOTE

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



#### NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

#### 5.10.8.4. Exporting common variables for ARM templates

You must export a common set of variables that are used with the provided Azure Resource Manager (ARM) templates used to assist in completing a user-provided infrastructure install on Microsoft Azure.



#### NOTE

Specific ARM templates can also require additional exported variables, which are detailed in their related procedures.

#### Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

#### Procedure

1. Export common variables found in the **install-config.yaml** to be used by the provided ARM templates:

```
$ export CLUSTER_NAME=<cluster_name> 1
$ export AZURE_REGION=<azure_region> 2
$ export SSH_KEY=<ssh_key> 3
$ export BASE_DOMAIN=<base_domain> 4
$ export BASE_DOMAIN_RESOURCE_GROUP=<base_domain_resource_group> 5
```

- 1 The value of the **.metadata.name** attribute from the **install-config.yaml** file.
- 2 The region to deploy the cluster into, for example **centralus**. This is the value of the **.platform.azure.region** attribute from the **install-config.yaml** file.
- 3 The SSH RSA public key file as a string. You must enclose the SSH key in quotes since it contains spaces. This is the value of the **.sshKey** attribute from the **install-config.yaml** file.
- 4 The base domain to deploy the cluster to. The base domain corresponds to the public DNS zone that you created for your cluster. This is the value of the **.baseDomain** attribute from the **install-config.yaml** file.
- 5 The resource group where the public DNS zone exists. This is the value of the **.platform.azure.baseDomainResourceGroupName** attribute from the **install-config.yaml** file.

For example:

-

```
$ export CLUSTER_NAME=test-cluster
$ export AZURE_REGION=centralus
$ export SSH_KEY="ssh-rsa xxx/xxx/xxx= user@email.com"
$ export BASE_DOMAIN=example.com
$ export BASE_DOMAIN_RESOURCE_GROUP=ocp-cluster
```

2. Export the kubeadmin credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

### 5.10.8.5. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.



#### IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

#### Prerequisites

- You obtained the OpenShift Container Platform installation program.
- You created the **install-config.yaml** installation configuration file.

#### Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

- 1** For **<installation\_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.



- Remove the Kubernetes manifest files that define the control plane machines:

```
$ rm -f <installation_directory>/openshift/99_openshift-cluster-api_master-machines-*.yaml
```

By removing these files, you prevent the cluster from automatically generating control plane machines.

- Remove the Kubernetes manifest files that define the worker machines:

```
$ rm -f <installation_directory>/openshift/99_openshift-cluster-api_worker-machineset-*.yaml
```

Because you create and manage the worker machines yourself, you do not need to initialize these machines.

- Check that the **mastersSchedulable** parameter in the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:
  - Open the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** file.
  - Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.
  - Save and exit the file.
- Optional: If you do not want [the Ingress Operator](#) to create DNS records on your behalf, remove the **privateZone** and **publicZone** sections from the **<installation\_directory>/manifests/cluster-dns-02-config.yml** DNS configuration file:

```
apiVersion: config.openshift.io/v1
kind: DNS
metadata:
  creationTimestamp: null
  name: cluster
spec:
  baseDomain: example.openshift.com
  privateZone: 1
    id: mycluster-100419-private-zone
  publicZone: 2
    id: example.openshift.com
status: {}
```

- Remove this section completely.

If you do so, you must add ingress DNS records manually in a later step.

- When configuring Azure on user-provisioned infrastructure, you must export some common variables defined in the manifest files to use later in the Azure Resource Manager (ARM) templates:
  - Export the infrastructure ID by using the following command:

```
$ export INFRA_ID=<infra_id> 1
```

- 1 The OpenShift Container Platform cluster has been assigned an identifier (**INFRA\_ID**) in the form of **<cluster\_name>-<random\_string>**. This will be used as the base name

b. Export the resource group by using the following command:

```
$ export RESOURCE_GROUP=<resource_group> 1
```

- 1 All resources created in this Azure deployment exists as part of a [resource group](#). The resource group name is also based on the **INFRA\_ID**, in the form of **<cluster\_name>-<random\_string>-rg**. This is the value of the **.status.platformStatus.azure.resourceGroupName** attribute from the **manifests/cluster-infrastructure-02-config.yml** file.

7. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$. /openshift-install create ignition-configs --dir <installation_directory> 1
```

- 1 For **<installation\_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation\_directory>/auth** directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

### 5.10.9. Creating the Azure resource group

You must create a Microsoft Azure [resource group](#) and an identity for that resource group. These are both used during the installation of your OpenShift Container Platform cluster on Azure.

#### Prerequisites

- Configure an Azure account.
- Generate the Ignition config files for your cluster.

#### Procedure

1. Create the resource group in a supported Azure region:

```
$ az group create --name ${RESOURCE_GROUP} --location ${AZURE_REGION}
```

2. Create an Azure identity for the resource group:

```
$ az identity create -g ${RESOURCE_GROUP} -n ${INFRA_ID}-identity
```

This is used to grant the required access to Operators in your cluster. For example, this allows the Ingress Operator to create a public IP and its load balancer. You must assign the Azure identity to a role.

3. Grant the Contributor role to the Azure identity:

- a. Export the following variables required by the Azure role assignment:

```
$ export PRINCIPAL_ID=`az identity show -g ${RESOURCE_GROUP} -n ${INFRA_ID}-identity --query principalId --out tsv`
```

```
$ export RESOURCE_GROUP_ID=`az group show -g ${RESOURCE_GROUP} --query id --out tsv`
```

- b. Assign the Contributor role to the identity:

```
$ az role assignment create --assignee "${PRINCIPAL_ID}" --role 'Contributor' --scope "${RESOURCE_GROUP_ID}"
```

### 5.10.10. Uploading the RHCOS cluster image and bootstrap Ignition config file

The Azure client does not support deployments based on files existing locally; therefore, you must copy and store the RHCOS virtual hard disk (VHD) cluster image and bootstrap Ignition config file in a storage container so they are accessible during deployment.

#### Prerequisites

- Configure an Azure account.
- Generate the Ignition config files for your cluster.

#### Procedure

1. Create an Azure storage account to store the VHD cluster image:

```
$ az storage account create -g ${RESOURCE_GROUP} --location ${AZURE_REGION} --name ${CLUSTER_NAME}sa --kind Storage --sku Standard_LRS
```



#### WARNING

The Azure storage account name must be between 3 and 24 characters in length and use numbers and lower-case letters only. If your **CLUSTER\_NAME** variable does not follow these restrictions, you must manually define the Azure storage account name. For more information on Azure storage account name restrictions, see [Resolve errors for storage account names](#) in the Azure documentation.

- Export the storage account key as an environment variable:

```
$ export ACCOUNT_KEY=`az storage account keys list -g ${RESOURCE_GROUP} --
account-name ${CLUSTER_NAME}sa --query "[0].value" -o tsv`
```

- Choose the RHCOS version to use and export the URL of its VHD to an environment variable:

```
$ export VHD_URL=`curl -s https://raw.githubusercontent.com/openshift/installer/release-
4.9/data/data/rhcos.json | jq -r .azure.url`
```



### IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must specify an image with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image version that matches your OpenShift Container Platform version if it is available.

- Create the storage container for the VHD:

```
$ az storage container create --name vhd --account-name ${CLUSTER_NAME}sa --account-
key ${ACCOUNT_KEY}
```

- Copy the chosen VHD to a blob:

```
$ az storage blob copy start --account-name ${CLUSTER_NAME}sa --account-key
${ACCOUNT_KEY} --destination-blob "rhcos.vhd" --destination-container vhd --source-uri
"${VHD_URL}"
```

- Create a blob storage container and upload the generated **bootstrap.ign** file:

```
$ az storage container create --name files --account-name ${CLUSTER_NAME}sa --
account-key ${ACCOUNT_KEY} --public-access blob
```

```
$ az storage blob upload --account-name ${CLUSTER_NAME}sa --account-key
${ACCOUNT_KEY} -c "files" -f "<installation_directory>/bootstrap.ign" -n "bootstrap.ign"
```

### 5.10.11. Example for creating DNS zones

DNS records are required for clusters that use user-provisioned infrastructure. You should choose the DNS strategy that fits your scenario.

For this example, [Azure's DNS solution](#) is used, so you will create a new public DNS zone for external (internet) visibility and a private DNS zone for internal cluster resolution.



### NOTE

The public DNS zone is not required to exist in the same resource group as the cluster deployment and might already exist in your organization for the desired base domain. If that is the case, you can skip creating the public DNS zone; be sure the installation config you generated earlier reflects that scenario.

## Prerequisites

- Configure an Azure account.
- Generate the Ignition config files for your cluster.

## Procedure

1. Create the new public DNS zone in the resource group exported in the **BASE\_DOMAIN\_RESOURCE\_GROUP** environment variable:

```
$ az network dns zone create -g ${BASE_DOMAIN_RESOURCE_GROUP} -n
${CLUSTER_NAME}.${BASE_DOMAIN}
```

You can skip this step if you are using a public DNS zone that already exists.

2. Create the private DNS zone in the same resource group as the rest of this deployment:

```
$ az network private-dns zone create -g ${RESOURCE_GROUP} -n
${CLUSTER_NAME}.${BASE_DOMAIN}
```

You can learn more about [configuring a public DNS zone in Azure](#) by visiting that section.

### 5.10.12. Creating a VNet in Azure

You must create a virtual network (VNet) in Microsoft Azure for your OpenShift Container Platform cluster to use. You can customize the VNet to meet your requirements. One way to create the VNet is to modify the provided Azure Resource Manager (ARM) template.



#### NOTE

If you do not use the provided ARM template to create your Azure infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

## Prerequisites

- Configure an Azure account.
- Generate the Ignition config files for your cluster.

## Procedure

1. Copy the template from the **ARM template for the VNet** section of this topic and save it as **01\_vnet.json** in your cluster's installation directory. This template describes the VNet that your cluster requires.
2. Create the deployment by using the **az** CLI:

```
$ az deployment group create -g ${RESOURCE_GROUP} \
--template-file "<installation_directory>/01_vnet.json" \
--parameters baseName="${INFRA_ID}" 1
```

- 1 The base name to be used in resource names; this is usually the cluster's infrastructure ID.

3. Link the VNet template to the private DNS zone:

```
$ az network private-dns link vnet create -g ${RESOURCE_GROUP} -z
${CLUSTER_NAME}.${BASE_DOMAIN} -n ${INFRA_ID}-network-link -v "${INFRA_ID}-vnet"
-e false
```

### 5.10.12.1. ARM template for the VNet

You can use the following Azure Resource Manager (ARM) template to deploy the VNet that you need for your OpenShift Container Platform cluster:

#### Example 5.1. 01\_vnet.json ARM template

```
{
  "$schema" : "https://schema.management.azure.com/schemas/2015-01-01/deploymentTemplate.json#",
  "contentVersion" : "1.0.0.0",
  "parameters" : {
    "baseName" : {
      "type" : "string",
      "minLength" : 1,
      "metadata" : {
        "description" : "Base name to be used in resource names (usually the cluster's Infra ID)"
      }
    }
  },
  "variables" : {
    "location" : "[resourceGroup().location]",
    "virtualNetworkName" : "[concat(parameters('baseName'), '-vnet')]",
    "addressPrefix" : "10.0.0.0/16",
    "masterSubnetName" : "[concat(parameters('baseName'), '-master-subnet')]",
    "masterSubnetPrefix" : "10.0.0.0/24",
    "nodeSubnetName" : "[concat(parameters('baseName'), '-worker-subnet')]",
    "nodeSubnetPrefix" : "10.0.1.0/24",
    "clusterNsgName" : "[concat(parameters('baseName'), '-nsg')]"
  },
  "resources" : [
    {
      "apiVersion" : "2018-12-01",
      "type" : "Microsoft.Network/virtualNetworks",
      "name" : "[variables('virtualNetworkName')]",
      "location" : "[variables('location')]",
      "dependsOn" : [
        "[concat('Microsoft.Network/networkSecurityGroups/', variables('clusterNsgName'))]"
      ],
      "properties" : {
        "addressSpace" : {
          "addressPrefixes" : [
            "[variables('addressPrefix')]"
          ]
        }
      },
      "subnets" : [
```

```

    {
      "name" : "[variables('masterSubnetName')]",
      "properties" : {
        "addressPrefix" : "[variables('masterSubnetPrefix')]",
        "serviceEndpoints" : [],
        "networkSecurityGroup" : {
          "id" : "[resourceId('Microsoft.Network/networkSecurityGroups',
variables('clusterNsgName'))]"
        }
      }
    },
    {
      "name" : "[variables('nodeSubnetName')]",
      "properties" : {
        "addressPrefix" : "[variables('nodeSubnetPrefix')]",
        "serviceEndpoints" : [],
        "networkSecurityGroup" : {
          "id" : "[resourceId('Microsoft.Network/networkSecurityGroups',
variables('clusterNsgName'))]"
        }
      }
    }
  ]
},
{
  "type" : "Microsoft.Network/networkSecurityGroups",
  "name" : "[variables('clusterNsgName')]",
  "apiVersion" : "2018-10-01",
  "location" : "[variables('location')]",
  "properties" : {
    "securityRules" : [
      {
        "name" : "apiserver_in",
        "properties" : {
          "protocol" : "Tcp",
          "sourcePortRange" : "*",
          "destinationPortRange" : "6443",
          "sourceAddressPrefix" : "*",
          "destinationAddressPrefix" : "*",
          "access" : "Allow",
          "priority" : 101,
          "direction" : "Inbound"
        }
      }
    ]
  }
}
]
}

```

### 5.10.13. Deploying the RHCOS cluster image for the Azure infrastructure

You must use a valid Red Hat Enterprise Linux CoreOS (RHCOS) image for Microsoft Azure for your OpenShift Container Platform nodes.

### Prerequisites

- Configure an Azure account.
- Generate the Ignition config files for your cluster.
- Store the RHCOS virtual hard disk (VHD) cluster image in an Azure storage container.
- Store the bootstrap Ignition config file in an Azure storage container.

### Procedure

1. Copy the template from the **ARM template for image storage** section of this topic and save it as **02\_storage.json** in your cluster's installation directory. This template describes the image storage that your cluster requires.
2. Export the RHCOS VHD blob URL as a variable:

```
$ export VHD_BLOB_URL=`az storage blob url --account-name ${CLUSTER_NAME}sa --account-key ${ACCOUNT_KEY} -c vhd -n "rhcos.vhd" -o tsv`
```

3. Deploy the cluster image:

```
$ az deployment group create -g ${RESOURCE_GROUP} \
  --template-file "<installation_directory>/02_storage.json" \
  --parameters vhdBlobURL="${VHD_BLOB_URL}" \ 1 \
  --parameters baseName="${INFRA_ID}" 2
```

- 1** The blob URL of the RHCOS VHD to be used to create master and worker machines.
- 2** The base name to be used in resource names; this is usually the cluster's infrastructure ID.

#### 5.10.13.1. ARM template for image storage

You can use the following Azure Resource Manager (ARM) template to deploy the stored Red Hat Enterprise Linux CoreOS (RHCOS) image that you need for your OpenShift Container Platform cluster:

##### Example 5.2. 02\_storage.json ARM template

```
{
  "$schema" : "https://schema.management.azure.com/schemas/2015-01-01/deploymentTemplate.json#",
  "contentVersion" : "1.0.0.0",
  "parameters" : {
    "baseName" : {
      "type" : "string",
      "minLength" : 1,
      "metadata" : {
        "description" : "Base name to be used in resource names (usually the cluster's Infra ID)"
      }
    }
  },
}
```



```

    "vhdBlobURL" : {
      "type" : "string",
      "metadata" : {
        "description" : "URL pointing to the blob where the VHD to be used to create master and
worker machines is located"
      }
    }
  },
  "variables" : {
    "location" : "[resourceGroup().location]",
    "imageName" : "[concat(parameters('baseName'), '-image')]"
  },
  "resources" : [
    {
      "apiVersion" : "2018-06-01",
      "type" : "Microsoft.Compute/images",
      "name" : "[variables('imageName')]",
      "location" : "[variables('location')]",
      "properties" : {
        "storageProfile" : {
          "osDisk" : {
            "osType" : "Linux",
            "osState" : "Generalized",
            "blobUri" : "[parameters('vhdBlobURL')]",
            "storageAccountType" : "Standard_LRS"
          }
        }
      }
    }
  ]
}

```

#### 5.10.14. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **inittamfs** during boot to fetch their Ignition config files.

##### 5.10.14.1. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.



#### IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

Table 5.37. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	<b>1936</b>	Metrics
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> and the Cluster Version Operator on port <b>9099</b> .
	<b>10250-10259</b>	The default ports that Kubernetes reserves
	<b>10256</b>	openshift-sdn
UDP	<b>4789</b>	VXLAN and Geneve
	<b>6081</b>	VXLAN and Geneve
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> .
	<b>500</b>	IPsec IKE packets
	<b>4500</b>	IPsec NAT-T packets
TCP/UDP	<b>30000-32767</b>	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 5.38. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	<b>6443</b>	Kubernetes API

Table 5.39. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	<b>2379-2380</b>	etcd server and peer ports

### 5.10.15. Creating networking and load balancing components in Azure

You must configure networking and load balancing in Microsoft Azure for your OpenShift Container Platform cluster to use. One way to create these components is to modify the provided Azure Resource Manager (ARM) template.



## NOTE

If you do not use the provided ARM template to create your Azure infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

## Prerequisites

- Configure an Azure account.
- Generate the Ignition config files for your cluster.
- Create and configure a VNet and associated subnets in Azure.

## Procedure

1. Copy the template from the **ARM template for the network and load balancers** section of this topic and save it as **03\_infra.json** in your cluster's installation directory. This template describes the networking and load balancing objects that your cluster requires.
2. Create the deployment by using the **az** CLI:

```
$ az deployment group create -g ${RESOURCE_GROUP} \
  --template-file "<installation_directory>/03_infra.json" \
  --parameters privateDNSZoneName="${CLUSTER_NAME}.${BASE_DOMAIN}" \ 1
  --parameters baseName="${INFRA_ID}" 2
```

- 1** The name of the private DNS zone.
- 2** The base name to be used in resource names; this is usually the cluster's infrastructure ID.

3. Create an **api** DNS record in the public zone for the API public load balancer. The **\${BASE\_DOMAIN\_RESOURCE\_GROUP}** variable must point to the resource group where the public DNS zone exists.

- a. Export the following variable:

```
$ export PUBLIC_IP=`az network public-ip list -g ${RESOURCE_GROUP} --query "[?
name=='${INFRA_ID}-master-pip'] | [0].ipAddress" -o tsv`
```

- b. Create the **api** DNS record in a new public zone:

```
$ az network dns record-set a add-record -g ${BASE_DOMAIN_RESOURCE_GROUP} -
z ${CLUSTER_NAME}.${BASE_DOMAIN} -n api -a ${PUBLIC_IP} --ttl 60
```

If you are adding the cluster to an existing public zone, you can create the **api** DNS record in it instead:

```
$ az network dns record-set a add-record -g ${BASE_DOMAIN_RESOURCE_GROUP} -
z ${BASE_DOMAIN} -n api.${CLUSTER_NAME} -a ${PUBLIC_IP} --ttl 60
```

### 5.10.15.1. ARM template for the network and load balancers

You can use the following Azure Resource Manager (ARM) template to deploy the networking objects and load balancers that you need for your OpenShift Container Platform cluster:

### Example 5.3. 03\_infra.json ARM template

```
{
  "$schema" : "https://schema.management.azure.com/schemas/2015-01-01/deploymentTemplate.json#",
  "contentVersion" : "1.0.0.0",
  "parameters" : {
    "baseName" : {
      "type" : "string",
      "minLength" : 1,
      "metadata" : {
        "description" : "Base name to be used in resource names (usually the cluster's Infra ID)"
      }
    },
    "privateDNSZoneName" : {
      "type" : "string",
      "metadata" : {
        "description" : "Name of the private DNS zone"
      }
    }
  },
  "variables" : {
    "location" : "[resourceGroup().location]",
    "virtualNetworkName" : "[concat(parameters('baseName'), '-vnet')]",
    "virtualNetworkID" : "[resourceId('Microsoft.Network/virtualNetworks', variables('virtualNetworkName'))]",
    "masterSubnetName" : "[concat(parameters('baseName'), '-master-subnet')]",
    "masterSubnetRef" : "[concat(variables('virtualNetworkID'), '/subnets/', variables('masterSubnetName'))]",
    "masterPublicIpAddressName" : "[concat(parameters('baseName'), '-master-pip')]",
    "masterPublicIpAddressID" : "[resourceId('Microsoft.Network/publicIPAddresses', variables('masterPublicIpAddressName'))]",
    "masterLoadBalancerName" : "[concat(parameters('baseName'), '-public-lb')]",
    "masterLoadBalancerID" : "[resourceId('Microsoft.Network/loadBalancers', variables('masterLoadBalancerName'))]",
    "internalLoadBalancerName" : "[concat(parameters('baseName'), '-internal-lb')]",
    "internalLoadBalancerID" : "[resourceId('Microsoft.Network/loadBalancers', variables('internalLoadBalancerName'))]",
    "skuName" : "Standard"
  },
  "resources" : [
    {
      "apiVersion" : "2018-12-01",
      "type" : "Microsoft.Network/publicIPAddresses",
      "name" : "[variables('masterPublicIpAddressName')]",
      "location" : "[variables('location')]",
      "sku" : {
        "name" : "[variables('skuName')]"
      },
      "properties" : {
        "publicIPAllocationMethod" : "Static",
        "dnsSettings" : {
          "domainNameLabel" : "[variables('masterPublicIpAddressName')]"
        }
      }
    }
  ]
}
```

```

    }
  }
},
{
  "apiVersion" : "2018-12-01",
  "type" : "Microsoft.Network/loadBalancers",
  "name" : "[variables('masterLoadBalancerName')]",
  "location" : "[variables('location')]",
  "sku": {
    "name": "[variables('skuName')]"
  },
  "dependsOn" : [
    "[concat('Microsoft.Network/publicIPAddresses/', variables('masterPublicIpAddressName'))]"
  ],
  "properties" : {
    "frontendIPConfigurations" : [
      {
        "name" : "public-lb-ip",
        "properties" : {
          "publicIPAddress" : {
            "id" : "[variables('masterPublicIpAddressID')]"
          }
        }
      }
    ],
    "backendAddressPools" : [
      {
        "name" : "public-lb-backend"
      }
    ],
    "loadBalancingRules" : [
      {
        "name" : "api-internal",
        "properties" : {
          "frontendIPConfiguration" : {
            "id" : "[concat(variables('masterLoadBalancerID'), '/frontendIPConfigurations/public-lb-
ip')]"
          },
          "backendAddressPool" : {
            "id" : "[concat(variables('masterLoadBalancerID'), '/backendAddressPools/public-lb-
backend')]"
          },
          "protocol" : "Tcp",
          "loadDistribution" : "Default",
          "idleTimeoutInMinutes" : 30,
          "frontendPort" : 6443,
          "backendPort" : 6443,
          "probe" : {
            "id" : "[concat(variables('masterLoadBalancerID'), '/probes/api-internal-probe')]"
          }
        }
      }
    ],
    "probes" : [
      {
        "name" : "api-internal-probe",

```

```

    "properties" : {
      "protocol" : "Https",
      "port" : 6443,
      "requestPath" : "/readyz",
      "intervalInSeconds" : 10,
      "numberOfProbes" : 3
    }
  }
]
},
{
  "apiVersion" : "2018-12-01",
  "type" : "Microsoft.Network/loadBalancers",
  "name" : "[variables('internalLoadBalancerName')]",
  "location" : "[variables('location')]",
  "sku" : {
    "name" : "[variables('skuName')]"
  },
  "properties" : {
    "frontendIPConfigurations" : [
      {
        "name" : "internal-lb-ip",
        "properties" : {
          "privateIPAllocationMethod" : "Dynamic",
          "subnet" : {
            "id" : "[variables('masterSubnetRef')]"
          },
          "privateIPAddressVersion" : "IPv4"
        }
      }
    ],
    "backendAddressPools" : [
      {
        "name" : "internal-lb-backend"
      }
    ],
    "loadBalancingRules" : [
      {
        "name" : "api-internal",
        "properties" : {
          "frontendIPConfiguration" : {
            "id" : "[concat(variables('internalLoadBalancerID'), '/frontendIPConfigurations/internal-lb-
ip')]"
          },
          "frontendPort" : 6443,
          "backendPort" : 6443,
          "enableFloatingIP" : false,
          "idleTimeoutInMinutes" : 30,
          "protocol" : "Tcp",
          "enableTcpReset" : false,
          "loadDistribution" : "Default",
          "backendAddressPool" : {
            "id" : "[concat(variables('internalLoadBalancerID'), '/backendAddressPools/internal-lb-
backend')]"
          },
        }
      }
    ]
  }
}
]
}
}

```

```

    "probe" : {
      "id" : "[concat(variables('internalLoadBalancerID'), '/probes/api-internal-probe')]"
    }
  },
  {
    "name" : "sint",
    "properties" : {
      "frontendIPConfiguration" : {
        "id" : "[concat(variables('internalLoadBalancerID'), '/frontendIPConfigurations/internal-lb-
ip')]"
      },
      "frontendPort" : 22623,
      "backendPort" : 22623,
      "enableFloatingIP" : false,
      "idleTimeoutInMinutes" : 30,
      "protocol" : "Tcp",
      "enableTcpReset" : false,
      "loadDistribution" : "Default",
      "backendAddressPool" : {
        "id" : "[concat(variables('internalLoadBalancerID'), '/backendAddressPools/internal-lb-
backend')]"
      },
      "probe" : {
        "id" : "[concat(variables('internalLoadBalancerID'), '/probes/sint-probe')]"
      }
    }
  },
],
"probes" : [
  {
    "name" : "api-internal-probe",
    "properties" : {
      "protocol" : "Https",
      "port" : 6443,
      "requestPath" : "/readyz",
      "intervalInSeconds" : 10,
      "numberOfProbes" : 3
    }
  },
  {
    "name" : "sint-probe",
    "properties" : {
      "protocol" : "Https",
      "port" : 22623,
      "requestPath" : "/healthz",
      "intervalInSeconds" : 10,
      "numberOfProbes" : 3
    }
  }
]
},
{
  "apiVersion" : "2018-09-01",
  "type" : "Microsoft.Network/privateDnsZones/A",

```

```

"name": "[concat(parameters('privateDNSZoneName'), '/api')]",
"location" : "[variables('location')]",
"dependsOn" : [
  "[concat('Microsoft.Network/loadBalancers/', variables('internalLoadBalancerName'))]"
],
"properties": {
  "ttl": 60,
  "aRecords": [
    {
      "ipv4Address": "[reference(variables('internalLoadBalancerName')).frontendIPConfigurations[0].properties.privateIPAddress]"
    }
  ]
}
},
{
  "apiVersion": "2018-09-01",
  "type": "Microsoft.Network/privateDnsZones/A",
  "name": "[concat(parameters('privateDNSZoneName'), '/api-int')]",
  "location" : "[variables('location')]",
  "dependsOn" : [
    "[concat('Microsoft.Network/loadBalancers/', variables('internalLoadBalancerName'))]"
  ],
  "properties": {
    "ttl": 60,
    "aRecords": [
      {
        "ipv4Address": "[reference(variables('internalLoadBalancerName')).frontendIPConfigurations[0].properties.privateIPAddress]"
      }
    ]
  }
}
]
}

```

### 5.10.16. Creating the bootstrap machine in Azure

You must create the bootstrap machine in Microsoft Azure to use during OpenShift Container Platform cluster initialization. One way to create this machine is to modify the provided Azure Resource Manager (ARM) template.



#### NOTE

If you do not use the provided ARM template to create your bootstrap machine, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

#### Prerequisites

- Configure an Azure account.



- Generate the Ignition config files for your cluster.
- Create and configure a VNet and associated subnets in Azure.
- Create and configure networking and load balancers in Azure.
- Create control plane and compute roles.

## Procedure

1. Copy the template from the **ARM template for the bootstrap machine** section of this topic and save it as **04\_bootstrap.json** in your cluster's installation directory. This template describes the bootstrap machine that your cluster requires.

2. Export the bootstrap URL variable:

```
$ export BOOTSTRAP_URL=`az storage blob url --account-name ${CLUSTER_NAME}sa --account-key ${ACCOUNT_KEY} -c "files" -n "bootstrap.ign" -o tsv`
```

3. Export the bootstrap ignition variable:

```
$ export BOOTSTRAP_IGNITION=`jq -rcnM --arg v "3.2.0" --arg url ${BOOTSTRAP_URL} '{ignition:{version:$v,config:{replace:{source:$url}}}}' | base64 | tr -d '\n`
```

4. Create the deployment by using the **az** CLI:

```
$ az deployment group create -g ${RESOURCE_GROUP} \
  --template-file "<installation_directory>/04_bootstrap.json" \
  --parameters bootstrapIgnition="${BOOTSTRAP_IGNITION}" \ 1
  --parameters sshKeyData="${SSH_KEY}" \ 2
  --parameters baseName="${INFRA_ID}" 3
```

- 1** The bootstrap Ignition content for the bootstrap cluster.
- 2** The SSH RSA public key file as a string.
- 3** The base name to be used in resource names; this is usually the cluster's infrastructure ID.

### 5.10.16.1. ARM template for the bootstrap machine

You can use the following Azure Resource Manager (ARM) template to deploy the bootstrap machine that you need for your OpenShift Container Platform cluster:

#### Example 5.4. 04\_bootstrap.json ARM template

```
{
  "$schema" : "https://schema.management.azure.com/schemas/2015-01-01/deploymentTemplate.json#",
  "contentVersion" : "1.0.0.0",
  "parameters" : {
    "baseName" : {
      "type" : "string",
      "minLength" : 1,
```

```
"metadata" : {
  "description" : "Base name to be used in resource names (usually the cluster's Infra ID)"
},
"bootstrapIgnition" : {
  "type" : "string",
  "minLength" : 1,
  "metadata" : {
    "description" : "Bootstrap ignition content for the bootstrap cluster"
  }
},
"sshKeyData" : {
  "type" : "securestring",
  "metadata" : {
    "description" : "SSH RSA public key file as a string."
  }
},
"bootstrapVMSize" : {
  "type" : "string",
  "defaultValue" : "Standard_D4s_v3",
  "allowedValues" : [
    "Standard_A2",
    "Standard_A3",
    "Standard_A4",
    "Standard_A5",
    "Standard_A6",
    "Standard_A7",
    "Standard_A8",
    "Standard_A9",
    "Standard_A10",
    "Standard_A11",
    "Standard_D2",
    "Standard_D3",
    "Standard_D4",
    "Standard_D11",
    "Standard_D12",
    "Standard_D13",
    "Standard_D14",
    "Standard_D2_v2",
    "Standard_D3_v2",
    "Standard_D4_v2",
    "Standard_D5_v2",
    "Standard_D8_v3",
    "Standard_D11_v2",
    "Standard_D12_v2",
    "Standard_D13_v2",
    "Standard_D14_v2",
    "Standard_E2_v3",
    "Standard_E4_v3",
    "Standard_E8_v3",
    "Standard_E16_v3",
    "Standard_E32_v3",
    "Standard_E64_v3",
    "Standard_E2s_v3",
    "Standard_E4s_v3",
    "Standard_E8s_v3",
```

```

"Standard_E16s_v3",
"Standard_E32s_v3",
"Standard_E64s_v3",
"Standard_G1",
"Standard_G2",
"Standard_G3",
"Standard_G4",
"Standard_G5",
"Standard_DS2",
"Standard_DS3",
"Standard_DS4",
"Standard_DS11",
"Standard_DS12",
"Standard_DS13",
"Standard_DS14",
"Standard_DS2_v2",
"Standard_DS3_v2",
"Standard_DS4_v2",
"Standard_DS5_v2",
"Standard_DS11_v2",
"Standard_DS12_v2",
"Standard_DS13_v2",
"Standard_DS14_v2",
"Standard_GS1",
"Standard_GS2",
"Standard_GS3",
"Standard_GS4",
"Standard_GS5",
"Standard_D2s_v3",
"Standard_D4s_v3",
"Standard_D8s_v3"
],
"metadata" : {
  "description" : "The size of the Bootstrap Virtual Machine"
}
},
"variables" : {
  "location" : "[resourceGroup().location]",
  "virtualNetworkName" : "[concat(parameters('baseName'), '-vnet')]",
  "virtualNetworkID" : "[resourceId('Microsoft.Network/virtualNetworks',
variables('virtualNetworkName'))]",
  "masterSubnetName" : "[concat(parameters('baseName'), '-master-subnet')]",
  "masterSubnetRef" : "[concat(variables('virtualNetworkID'), '/subnets/',
variables('masterSubnetName'))]",
  "masterLoadBalancerName" : "[concat(parameters('baseName'), '-public-lb')]",
  "internalLoadBalancerName" : "[concat(parameters('baseName'), '-internal-lb')]",
  "sshKeyPath" : "/home/core/.ssh/authorized_keys",
  "identityName" : "[concat(parameters('baseName'), '-identity')]",
  "vmName" : "[concat(parameters('baseName'), '-bootstrap')]",
  "nicName" : "[concat(variables('vmName'), '-nic')]",
  "imageName" : "[concat(parameters('baseName'), '-image')]",
  "clusterNsgName" : "[concat(parameters('baseName'), '-nsg')]",
  "sshPublicIpAddressName" : "[concat(variables('vmName'), '-ssh-pip')]"
},
"resources" : [

```

```

{
  "apiVersion" : "2018-12-01",
  "type" : "Microsoft.Network/publicIPAddresses",
  "name" : "[variables('sshPublicIpAddressName')]",
  "location" : "[variables('location')]",
  "sku": {
    "name": "Standard"
  },
  "properties" : {
    "publicIPAllocationMethod" : "Static",
    "dnsSettings" : {
      "domainNameLabel" : "[variables('sshPublicIpAddressName')]"
    }
  }
},
{
  "apiVersion" : "2018-06-01",
  "type" : "Microsoft.Network/networkInterfaces",
  "name" : "[variables('nicName')]",
  "location" : "[variables('location')]",
  "dependsOn" : [
    "[resourceId('Microsoft.Network/publicIPAddresses', variables('sshPublicIpAddressName'))]"
  ],
  "properties" : {
    "ipConfigurations" : [
      {
        "name" : "pipConfig",
        "properties" : {
          "privateIPAllocationMethod" : "Dynamic",
          "publicIPAddress": {
            "id": "[resourceId('Microsoft.Network/publicIPAddresses',
variables('sshPublicIpAddressName'))]"
          },
          "subnet" : {
            "id" : "[variables('masterSubnetRef')]"
          },
          "loadBalancerBackendAddressPools" : [
            {
              "id" : "[concat('/subscriptions/', subscription().subscriptionId, '/resourceGroups/',
resourceGroup().name, '/providers/Microsoft.Network/loadBalancers/',
variables('masterLoadBalancerName'), '/backendAddressPools/public-lb-backend')]"
            },
            {
              "id" : "[concat('/subscriptions/', subscription().subscriptionId, '/resourceGroups/',
resourceGroup().name, '/providers/Microsoft.Network/loadBalancers/',
variables('internalLoadBalancerName'), '/backendAddressPools/internal-lb-backend')]"
            }
          ]
        }
      }
    ]
  }
},
{
  "apiVersion" : "2018-06-01",
  "type" : "Microsoft.Compute/virtualMachines",

```

```

"name" : "[variables('vmName')]",
"location" : "[variables('location')]",
"identity" : {
  "type" : "userAssigned",
  "userAssignedIdentities" : {
    "[resourceID('Microsoft.ManagedIdentity/userAssignedIdentities/',
variables('identityName'))]" : {}
  }
},
"dependsOn" : [
  "[concat('Microsoft.Network/networkInterfaces/', variables('nicName'))]"
],
"properties" : {
  "hardwareProfile" : {
    "vmSize" : "[parameters('bootstrapVMSize')]"
  },
  "osProfile" : {
    "computerName" : "[variables('vmName')]",
    "adminUsername" : "core",
    "customData" : "[parameters('bootstrapIgnition')]",
    "linuxConfiguration" : {
      "disablePasswordAuthentication" : true,
      "ssh" : {
        "publicKeys" : [
          {
            "path" : "[variables('sshKeyPath')]",
            "keyData" : "[parameters('sshKeyData')]"
          }
        ]
      }
    }
  },
  "storageProfile" : {
    "imageReference": {
      "id": "[resourceId('Microsoft.Compute/images', variables('imageName'))]"
    },
    "osDisk" : {
      "name": "[concat(variables('vmName'),'_OSDisk')]",
      "osType" : "Linux",
      "createOption" : "FromImage",
      "managedDisk": {
        "storageAccountType": "Premium_LRS"
      },
      "diskSizeGB" : 100
    }
  },
  "networkProfile" : {
    "networkInterfaces" : [
      {
        "id" : "[resourceID('Microsoft.Network/networkInterfaces', variables('nicName'))]"
      }
    ]
  }
}
},
{

```

```

"apiVersion" : "2018-06-01",
"type": "Microsoft.Network/networkSecurityGroups/securityRules",
"name" : "[concat(variables('clusterNsgName'), '/bootstrap_ssh_in')]",
"location" : "[variables('location')]",
"dependsOn" : [
  "[resourceId('Microsoft.Compute/virtualMachines', variables('vmName'))]"
],
"properties": {
  "protocol" : "Tcp",
  "sourcePortRange" : "*",
  "destinationPortRange" : "22",
  "sourceAddressPrefix" : "*",
  "destinationAddressPrefix" : "*",
  "access" : "Allow",
  "priority" : 100,
  "direction" : "Inbound"
}
}
]
}

```

### 5.10.17. Creating the control plane machines in Azure

You must create the control plane machines in Microsoft Azure for your cluster to use. One way to create these machines is to modify the provided Azure Resource Manager (ARM) template.



#### NOTE

If you do not use the provided ARM template to create your control plane machines, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

#### Prerequisites

- Configure an Azure account.
- Generate the Ignition config files for your cluster.
- Create and configure a VNet and associated subnets in Azure.
- Create and configure networking and load balancers in Azure.
- Create control plane and compute roles.
- Create the bootstrap machine.

#### Procedure

1. Copy the template from the **ARM template for control plane machines** section of this topic and save it as **05\_masters.json** in your cluster's installation directory. This template describes the control plane machines that your cluster requires.
2. Export the following variable needed by the control plane machine deployment:

```
$ export MASTER_IGNITION=`cat <installation_directory>/master.ign | base64 | tr -d "\n"
```

3. Create the deployment by using the **az** CLI:

```
$ az deployment group create -g ${RESOURCE_GROUP} \
  --template-file "<installation_directory>/05_masters.json" \
  --parameters masterIgnition="${MASTER_IGNITION}" \ 1
  --parameters sshKeyData="${SSH_KEY}" \ 2
  --parameters privateDNSZoneName="${CLUSTER_NAME}.${BASE_DOMAIN}" \ 3
  --parameters baseName="${INFRA_ID}" \ 4
```

- 1** The Ignition content for the control plane nodes.
- 2** The SSH RSA public key file as a string.
- 3** The name of the private DNS zone to which the control plane nodes are attached.
- 4** The base name to be used in resource names; this is usually the cluster's infrastructure ID.

### 5.10.17.1. ARM template for control plane machines

You can use the following Azure Resource Manager (ARM) template to deploy the control plane machines that you need for your OpenShift Container Platform cluster:

#### Example 5.5. 05\_masters.json ARM template

```
{
  "$schema" : "https://schema.management.azure.com/schemas/2015-01-01/deploymentTemplate.json#",
  "contentVersion" : "1.0.0.0",
  "parameters" : {
    "baseName" : {
      "type" : "string",
      "minLength" : 1,
      "metadata" : {
        "description" : "Base name to be used in resource names (usually the cluster's Infra ID)"
      }
    },
    "masterIgnition" : {
      "type" : "string",
      "metadata" : {
        "description" : "Ignition content for the master nodes"
      }
    },
    "numberOfMasters" : {
      "type" : "int",
      "defaultValue" : 3,
      "minValue" : 2,
      "maxValue" : 30,
      "metadata" : {
        "description" : "Number of OpenShift masters to deploy"
      }
    }
  }
}
```

```
"sshKeyData" : {
  "type" : "securestring",
  "metadata" : {
    "description" : "SSH RSA public key file as a string"
  }
},
"privateDNSZoneName" : {
  "type" : "string",
  "metadata" : {
    "description" : "Name of the private DNS zone the master nodes are going to be attached to"
  }
},
"masterVMSize" : {
  "type" : "string",
  "defaultValue" : "Standard_D8s_v3",
  "allowedValues" : [
    "Standard_A2",
    "Standard_A3",
    "Standard_A4",
    "Standard_A5",
    "Standard_A6",
    "Standard_A7",
    "Standard_A8",
    "Standard_A9",
    "Standard_A10",
    "Standard_A11",
    "Standard_D2",
    "Standard_D3",
    "Standard_D4",
    "Standard_D11",
    "Standard_D12",
    "Standard_D13",
    "Standard_D14",
    "Standard_D2_v2",
    "Standard_D3_v2",
    "Standard_D4_v2",
    "Standard_D5_v2",
    "Standard_D8_v3",
    "Standard_D11_v2",
    "Standard_D12_v2",
    "Standard_D13_v2",
    "Standard_D14_v2",
    "Standard_E2_v3",
    "Standard_E4_v3",
    "Standard_E8_v3",
    "Standard_E16_v3",
    "Standard_E32_v3",
    "Standard_E64_v3",
    "Standard_E2s_v3",
    "Standard_E4s_v3",
    "Standard_E8s_v3",
    "Standard_E16s_v3",
    "Standard_E32s_v3",
    "Standard_E64s_v3",
    "Standard_G1",
    "Standard_G2",
```



```

"Standard_G3",
"Standard_G4",
"Standard_G5",
"Standard_DS2",
"Standard_DS3",
"Standard_DS4",
"Standard_DS11",
"Standard_DS12",
"Standard_DS13",
"Standard_DS14",
"Standard_DS2_v2",
"Standard_DS3_v2",
"Standard_DS4_v2",
"Standard_DS5_v2",
"Standard_DS11_v2",
"Standard_DS12_v2",
"Standard_DS13_v2",
"Standard_DS14_v2",
"Standard_GS1",
"Standard_GS2",
"Standard_GS3",
"Standard_GS4",
"Standard_GS5",
"Standard_D2s_v3",
"Standard_D4s_v3",
"Standard_D8s_v3"
],
"metadata" : {
  "description" : "The size of the Master Virtual Machines"
}
},
"diskSizeGB" : {
  "type" : "int",
  "defaultValue" : 1024,
  "metadata" : {
    "description" : "Size of the Master VM OS disk, in GB"
  }
}
},
"variables" : {
  "location" : "[resourceGroup().location]",
  "virtualNetworkName" : "[concat(parameters('baseName'), '-vnet')]",
  "virtualNetworkID" : "[resourceId('Microsoft.Network/virtualNetworks',
variables('virtualNetworkName'))]",
  "masterSubnetName" : "[concat(parameters('baseName'), '-master-subnet')]",
  "masterSubnetRef" : "[concat(variables('virtualNetworkID'), '/subnets/',
variables('masterSubnetName'))]",
  "masterLoadBalancerName" : "[concat(parameters('baseName'), '-public-lb')]",
  "internalLoadBalancerName" : "[concat(parameters('baseName'), '-internal-lb')]",
  "sshKeyPath" : "/home/core/.ssh/authorized_keys",
  "identityName" : "[concat(parameters('baseName'), '-identity')]",
  "imageName" : "[concat(parameters('baseName'), '-image')]",
  "copy" : [
    {
      "name" : "vmNames",
      "count" : "[parameters('numberOfMasters')]",

```

```

    "input" : "[concat(parameters('baseName'), '-master-', copyIndex('vmNames'))]"
  }
]
},
"resources" : [
{
  "apiVersion" : "2018-06-01",
  "type" : "Microsoft.Network/networkInterfaces",
  "copy" : {
    "name" : "nicCopy",
    "count" : "[length(variables('vmNames'))]"
  },
  "name" : "[concat(variables('vmNames')[copyIndex()], '-nic')]",
  "location" : "[variables('location')]",
  "properties" : {
    "ipConfigurations" : [
      {
        "name" : "pipConfig",
        "properties" : {
          "privateIPAllocationMethod" : "Dynamic",
          "subnet" : {
            "id" : "[variables('masterSubnetRef')]"
          },
          "loadBalancerBackendAddressPools" : [
            {
              "id" : "[concat('/subscriptions/', subscription().subscriptionId, '/resourceGroups/',
resourceGroup().name, '/providers/Microsoft.Network/loadBalancers/',
variables('masterLoadBalancerName'), '/backendAddressPools/public-lb-backend')]"
            },
            {
              "id" : "[concat('/subscriptions/', subscription().subscriptionId, '/resourceGroups/',
resourceGroup().name, '/providers/Microsoft.Network/loadBalancers/',
variables('internalLoadBalancerName'), '/backendAddressPools/internal-lb-backend')]"
            }
          ]
        }
      }
    ]
  }
},
{
  "apiVersion": "2018-09-01",
  "type": "Microsoft.Network/privateDnsZones/SRV",
  "name": "[concat(parameters('privateDNSZoneName'), '/_etcd-server-ssl._tcp')]",
  "location" : "[variables('location')]",
  "properties": {
    "ttl": 60,
    "copy": [{
      "name": "srvRecords",
      "count": "[length(variables('vmNames'))]",
      "input": {
        "priority": 0,
        "weight" : 10,
        "port" : 2380,
        "target" : "[concat('etcd-', copyIndex('srvRecords'), '.',
parameters('privateDNSZoneName'))]"

```

```

    }
  ]]
}
},
{
  "apiVersion": "2018-09-01",
  "type": "Microsoft.Network/privateDnsZones/A",
  "copy" : {
    "name" : "dnsCopy",
    "count" : "[length(variables('vmNames'))]"
  },
  "name": "[concat(parameters('privateDNSZoneName'), '/etcd-', copyIndex())]",
  "location" : "[variables('location')]",
  "dependsOn" : [
    "[concat('Microsoft.Network/networkInterfaces/', concat(variables('vmNames')[copyIndex()], '-nic'))]"
  ],
  "properties": {
    "ttl": 60,
    "aRecords": [
      {
        "ipv4Address": "[reference(concat(variables('vmNames')[copyIndex()], '-nic')).ipConfigurations[0].properties.privateIPAddress]"
      }
    ]
  }
},
{
  "apiVersion" : "2018-06-01",
  "type" : "Microsoft.Compute/virtualMachines",
  "copy" : {
    "name" : "vmCopy",
    "count" : "[length(variables('vmNames'))]"
  },
  "name" : "[variables('vmNames')[copyIndex()]]",
  "location" : "[variables('location')]",
  "identity" : {
    "type" : "userAssigned",
    "userAssignedIdentities" : {
      "[resourceID('Microsoft.ManagedIdentity/userAssignedIdentities/', variables('identityName'))]" : {}
    }
  },
  "dependsOn" : [
    "[concat('Microsoft.Network/networkInterfaces/', concat(variables('vmNames')[copyIndex()], '-nic'))]",
    "[concat('Microsoft.Network/privateDnsZones/', parameters('privateDNSZoneName'), '/A/etcd-', copyIndex())]",
    "[concat('Microsoft.Network/privateDnsZones/', parameters('privateDNSZoneName'), '/SRV/_etcd-server-ssl._tcp')]"
  ],
  "properties" : {
    "hardwareProfile" : {
      "vmSize" : "[parameters('masterVMSize')]"
    },
    "osProfile" : {

```

```

"computerName" : "[variables('vmNames')[copyIndex()]]",
"adminUsername" : "core",
"customData" : "[parameters('masterIgnition')]",
"linuxConfiguration" : {
  "disablePasswordAuthentication" : true,
  "ssh" : {
    "publicKeys" : [
      {
        "path" : "[variables('sshKeyPath')]",
        "keyData" : "[parameters('sshKeyData')]"
      }
    ]
  }
},
"storageProfile" : {
  "imageReference": {
    "id": "[resourceId('Microsoft.Compute/images', variables('imageName'))]"
  },
  "osDisk" : {
    "name": "[concat(variables('vmNames')[copyIndex()], '_OSDisk')]",
    "osType" : "Linux",
    "createOption" : "FromImage",
    "caching" : "ReadOnly",
    "writeAcceleratorEnabled": false,
    "managedDisk": {
      "storageAccountType": "Premium_LRS"
    },
    "diskSizeGB" : "[parameters('diskSizeGB')]"
  }
},
"networkProfile" : {
  "networkInterfaces" : [
    {
      "id" : "[resourceId('Microsoft.Network/networkInterfaces', concat(variables('vmNames')[copyIndex()], '-nic'))]",
      "properties": {
        "primary": false
      }
    }
  ]
}
]
}

```

### 5.10.18. Wait for bootstrap completion and remove bootstrap resources in Azure

After you create all of the required infrastructure in Microsoft Azure, wait for the bootstrap process to complete on the machines that you provisioned by using the Ignition config files that you generated with the installation program.

#### Prerequisites

- Configure an Azure account.
- Generate the Ignition config files for your cluster.
- Create and configure a VNet and associated subnets in Azure.
- Create and configure networking and load balancers in Azure.
- Create control plane and compute roles.
- Create the bootstrap machine.
- Create the control plane machines.

## Procedure

1. Change to the directory that contains the installation program and run the following command:

```

$ ./openshift-install wait-for bootstrap-complete --dir <installation_directory> \ 1
--log-level info 2

```

1 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

If the command exits without a **FATAL** warning, your production control plane has initialized.

2. Delete the bootstrap resources:

```

$ az network nsg rule delete -g ${RESOURCE_GROUP} --nsg-name ${INFRA_ID}-nsg --
name bootstrap_ssh_in
$ az vm stop -g ${RESOURCE_GROUP} --name ${INFRA_ID}-bootstrap
$ az vm deallocate -g ${RESOURCE_GROUP} --name ${INFRA_ID}-bootstrap
$ az vm delete -g ${RESOURCE_GROUP} --name ${INFRA_ID}-bootstrap --yes
$ az disk delete -g ${RESOURCE_GROUP} --name ${INFRA_ID}-bootstrap OSDisk --no-
wait --yes
$ az network nic delete -g ${RESOURCE_GROUP} --name ${INFRA_ID}-bootstrap-nic --no-
wait
$ az storage blob delete --account-key ${ACCOUNT_KEY} --account-name
${CLUSTER_NAME}sa --container-name files --name bootstrap.ign
$ az network public-ip delete -g ${RESOURCE_GROUP} --name ${INFRA_ID}-bootstrap-
ssh-pip

```



### NOTE

If you do not delete the bootstrap server, installation may not succeed due to API traffic being routed to the bootstrap server.

## 5.10.19. Creating additional worker machines in Azure

You can create worker machines in Microsoft Azure for your cluster to use by launching individual instances discretely or by automated processes outside the cluster, such as auto scaling groups. You can also take advantage of the built-in cluster scaling mechanisms and the machine API in OpenShift

Container Platform.

In this example, you manually launch one instance by using the Azure Resource Manager (ARM) template. Additional instances can be launched by including additional resources of type **06\_workers.json** in the file.



## NOTE

If you do not use the provided ARM template to create your worker machines, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

## Prerequisites

- Configure an Azure account.
- Generate the Ignition config files for your cluster.
- Create and configure a VNet and associated subnets in Azure.
- Create and configure networking and load balancers in Azure.
- Create control plane and compute roles.
- Create the bootstrap machine.
- Create the control plane machines.

## Procedure

1. Copy the template from the **ARM template for worker machines** section of this topic and save it as **06\_workers.json** in your cluster's installation directory. This template describes the worker machines that your cluster requires.
2. Export the following variable needed by the worker machine deployment:

```
$ export WORKER_IGNITION=`cat <installation_directory>/worker.ign | base64 | tr -d '\n'`
```

3. Create the deployment by using the **az** CLI:

```
$ az deployment group create -g ${RESOURCE_GROUP} \
  --template-file "<installation_directory>/06_workers.json" \
  --parameters workerIgnition="${WORKER_IGNITION}" \ 1
  --parameters sshKeyData="${SSH_KEY}" \ 2
  --parameters baseName="${INFRA_ID}" \ 3
```

- 1** The Ignition content for the worker nodes.
- 2** The SSH RSA public key file as a string.
- 3** The base name to be used in resource names; this is usually the cluster's infrastructure ID.

### 5.10.19.1. ARM template for worker machines

You can use the following Azure Resource Manager (ARM) template to deploy the worker machines that you need for your OpenShift Container Platform cluster:

#### Example 5.6. 06\_workers.json ARM template

```
{
  "$schema" : "https://schema.management.azure.com/schemas/2015-01-01/deploymentTemplate.json#",
  "contentVersion" : "1.0.0.0",
  "parameters" : {
    "baseName" : {
      "type" : "string",
      "minLength" : 1,
      "metadata" : {
        "description" : "Base name to be used in resource names (usually the cluster's Infra ID)"
      }
    },
    "workerIgnition" : {
      "type" : "string",
      "metadata" : {
        "description" : "Ignition content for the worker nodes"
      }
    },
    "numberOfNodes" : {
      "type" : "int",
      "defaultValue" : 3,
      "minValue" : 2,
      "maxValue" : 30,
      "metadata" : {
        "description" : "Number of OpenShift compute nodes to deploy"
      }
    },
    "sshKeyData" : {
      "type" : "securestring",
      "metadata" : {
        "description" : "SSH RSA public key file as a string"
      }
    },
    "nodeVMSize" : {
      "type" : "string",
      "defaultValue" : "Standard_D4s_v3",
      "allowedValues" : [
        "Standard_A2",
        "Standard_A3",
        "Standard_A4",
        "Standard_A5",
        "Standard_A6",
        "Standard_A7",
        "Standard_A8",
        "Standard_A9",
        "Standard_A10",
        "Standard_A11",
        "Standard_D2",
        "Standard_D3",
```

```
"Standard_D4",
"Standard_D11",
"Standard_D12",
"Standard_D13",
"Standard_D14",
"Standard_D2_v2",
"Standard_D3_v2",
"Standard_D4_v2",
"Standard_D5_v2",
"Standard_D8_v3",
"Standard_D11_v2",
"Standard_D12_v2",
"Standard_D13_v2",
"Standard_D14_v2",
"Standard_E2_v3",
"Standard_E4_v3",
"Standard_E8_v3",
"Standard_E16_v3",
"Standard_E32_v3",
"Standard_E64_v3",
"Standard_E2s_v3",
"Standard_E4s_v3",
"Standard_E8s_v3",
"Standard_E16s_v3",
"Standard_E32s_v3",
"Standard_E64s_v3",
"Standard_G1",
"Standard_G2",
"Standard_G3",
"Standard_G4",
"Standard_G5",
"Standard_DS2",
"Standard_DS3",
"Standard_DS4",
"Standard_DS11",
"Standard_DS12",
"Standard_DS13",
"Standard_DS14",
"Standard_DS2_v2",
"Standard_DS3_v2",
"Standard_DS4_v2",
"Standard_DS5_v2",
"Standard_DS11_v2",
"Standard_DS12_v2",
"Standard_DS13_v2",
"Standard_DS14_v2",
"Standard_GS1",
"Standard_GS2",
"Standard_GS3",
"Standard_GS4",
"Standard_GS5",
"Standard_D2s_v3",
"Standard_D4s_v3",
"Standard_D8s_v3"
],
"metadata" : {
```



```

    "description" : "The size of the each Node Virtual Machine"
  }
}
},
"variables" : {
  "location" : "[resourceGroup().location]",
  "virtualNetworkName" : "[concat(parameters('baseName'), '-vnet')]",
  "virtualNetworkID" : "[resourceId('Microsoft.Network/virtualNetworks',
variables('virtualNetworkName'))]",
  "nodeSubnetName" : "[concat(parameters('baseName'), '-worker-subnet')]",
  "nodeSubnetRef" : "[concat(variables('virtualNetworkID'), '/subnets/',
variables('nodeSubnetName'))]",
  "infraLoadBalancerName" : "[parameters('baseName')]",
  "sshKeyPath" : "/home/capi/.ssh/authorized_keys",
  "identityName" : "[concat(parameters('baseName'), '-identity')]",
  "imageName" : "[concat(parameters('baseName'), '-image')]",
  "copy" : [
    {
      "name" : "vmNames",
      "count" : "[parameters('numberOfNodes')]",
      "input" : "[concat(parameters('baseName'), '-worker-', variables('location'), '-',
copyIndex('vmNames', 1))]"
    }
  ]
},
"resources" : [
  {
    "apiVersion" : "2019-05-01",
    "name" : "[concat('node', copyIndex())]",
    "type" : "Microsoft.Resources/deployments",
    "copy" : {
      "name" : "nodeCopy",
      "count" : "[length(variables('vmNames'))]"
    },
    "properties" : {
      "mode" : "Incremental",
      "template" : {
        "$schema" : "http://schema.management.azure.com/schemas/2015-01-
01/deploymentTemplate.json#",
        "contentVersion" : "1.0.0.0",
        "resources" : [
          {
            "apiVersion" : "2018-06-01",
            "type" : "Microsoft.Network/networkInterfaces",
            "name" : "[concat(variables('vmNames')[copyIndex()], '-nic')]",
            "location" : "[variables('location')]",
            "properties" : {
              "ipConfigurations" : [
                {
                  "name" : "pipConfig",
                  "properties" : {
                    "privateIPAllocationMethod" : "Dynamic",
                    "subnet" : {
                      "id" : "[variables('nodeSubnetRef')]"
                    }
                  }
                }
              ]
            }
          }
        ]
      }
    }
  }
]
}
}

```

```

    }
  ]
}
},
{
  "apiVersion": "2018-06-01",
  "type": "Microsoft.Compute/virtualMachines",
  "name": "[variables('vmNames')[copyIndex()]]",
  "location": "[variables('location')]",
  "tags": {
    "kubernetes.io-cluster-ffranzupi": "owned"
  },
  "identity": {
    "type": "userAssigned",
    "userAssignedIdentities": {
      "[resourceID('Microsoft.ManagedIdentity/userAssignedIdentities/',
variables('identityName'))]": {}
    }
  },
  "dependsOn": [
    "[concat('Microsoft.Network/networkInterfaces/', concat(variables('vmNames')
[copyIndex()], '-nic'))]"
  ],
  "properties": {
    "hardwareProfile": {
      "vmSize": "[parameters('nodeVMSize')]"
    },
    "osProfile": {
      "computerName": "[variables('vmNames')[copyIndex()]]",
      "adminUsername": "capi",
      "customData": "[parameters('workerIgnition')]",
      "linuxConfiguration": {
        "disablePasswordAuthentication": true,
        "ssh": {
          "publicKeys": [
            {
              "path": "[variables('sshKeyPath')]",
              "keyData": "[parameters('sshKeyData')]"
            }
          ]
        }
      }
    }
  },
  "storageProfile": {
    "imageReference": {
      "id": "[resourceID('Microsoft.Compute/images', variables('imageName'))]"
    },
    "osDisk": {
      "name": "[concat(variables('vmNames')[copyIndex()], '_OSDisk')]",
      "osType": "Linux",
      "createOption": "FromImage",
      "managedDisk": {
        "storageAccountType": "Premium_LRS"
      },
      "diskSizeGB": 128
    }
  }
}
}

```



After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

### Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your **PATH**.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### 5.10.21. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The

**kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

#### Example output

```
system:admin
```

## 5.10.22. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

### Prerequisites

- You added machines to your cluster.

### Procedure

1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

#### Example output

```
NAME      STATUS  ROLES  AGE  VERSION
master-0  Ready   master 63m  v1.22.1
master-1  Ready   master 63m  v1.22.1
master-2  Ready   master 64m  v1.22.1
```

The output lists all of the machines that you created.

**NOTE**

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

- Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

**Example output**

```
NAME          AGE   REQUESTOR                                     CONDITION
csr-8b2br    15m   system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper Pending
csr-8vnps    15m   system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper Pending
...
```

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

- If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:

**NOTE**

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.

**NOTE**

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

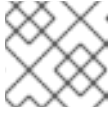
- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{\n"}\n' | xargs --no-run-if-empty oc adm certificate approve
```



#### NOTE

Some Operators might not become available until some CSRs are approved.

- Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

#### Example output

```
NAME      AGE   REQUESTOR                                     CONDITION
csr-bfd72 5m26s system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv 5m26s system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

- If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{\n"}\n' | xargs oc adm certificate approve
```

- After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

#### Example output

```
NAME      STATUS  ROLES  AGE  VERSION
master-0  Ready   master 73m  v1.22.1
master-1  Ready   master 73m  v1.22.1
```

```

master-2 Ready   master 74m v1.22.1
worker-0 Ready   worker 11m v1.22.1
worker-1 Ready   worker 11m v1.22.1

```



## NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

### Additional information

- For more information on CSRs, see [Certificate Signing Requests](#).

### 5.10.23. Adding the Ingress DNS records

If you removed the DNS Zone configuration when creating Kubernetes manifests and generating Ignition configs, you must manually create DNS records that point at the Ingress load balancer. You can create either a wildcard **\*.apps.{baseDomain}**, or specific records. You can use A, CNAME, and other records per your requirements.

### Prerequisites

- You deployed an OpenShift Container Platform cluster on Microsoft Azure by using infrastructure that you provisioned.
- Install the OpenShift CLI (**oc**).
- Install or update the [Azure CLI](#).

### Procedure

1. Confirm the Ingress router has created a load balancer and populated the **EXTERNAL-IP** field:

```
$ oc -n openshift-ingress get service router-default
```

### Example output

```

NAME          TYPE          CLUSTER-IP    EXTERNAL-IP    PORT(S)          AGE
router-default LoadBalancer  172.30.20.10  35.130.120.110 80:32288/TCP,443:31215/TCP 20

```

2. Export the Ingress router IP as a variable:

```
$ export PUBLIC_IP_ROUTER=`oc -n openshift-ingress get service router-default --no-headers | awk '{print $4}'`
```

3. Add a **\*.apps** record to the public DNS zone.

- a. If you are adding this cluster to a new public zone, run:

```
$ az network dns record-set a add-record -g ${BASE_DOMAIN_RESOURCE_GROUP} -z ${CLUSTER_NAME}.${BASE_DOMAIN} -n *.apps -a ${PUBLIC_IP_ROUTER} --ttl 300
```



- b. If you are adding this cluster to an already existing public zone, run:

```
$ az network dns record-set a add-record -g ${BASE_DOMAIN_RESOURCE_GROUP} -z ${BASE_DOMAIN} -n *.apps.${CLUSTER_NAME} -a ${PUBLIC_IP_ROUTER} --ttl 300
```

4. Add a **\*.apps** record to the private DNS zone:

- a. Create a **\*.apps** record by using the following command:

```
$ az network private-dns record-set a create -g ${RESOURCE_GROUP} -z ${CLUSTER_NAME}.${BASE_DOMAIN} -n *.apps --ttl 300
```

- b. Add the **\*.apps** record to the private DNS zone by using the following command:

```
$ az network private-dns record-set a add-record -g ${RESOURCE_GROUP} -z ${CLUSTER_NAME}.${BASE_DOMAIN} -n *.apps -a ${PUBLIC_IP_ROUTER}
```

If you prefer to add explicit domains instead of using a wildcard, you can create entries for each of the cluster's current routes:

```
$ oc get --all-namespaces -o jsonpath='{range .items[*]}{range .status.ingress[*]}{.host}{"\n"}{end}{end}' routes
```

### Example output

```
oauth-openshift.apps.cluster.basedomain.com
console-openshift-console.apps.cluster.basedomain.com
downloads-openshift-console.apps.cluster.basedomain.com
alertmanager-main-openshift-monitoring.apps.cluster.basedomain.com
grafana-openshift-monitoring.apps.cluster.basedomain.com
prometheus-k8s-openshift-monitoring.apps.cluster.basedomain.com
```

## 5.10.24. Completing an Azure installation on user-provisioned infrastructure

After you start the OpenShift Container Platform installation on Microsoft Azure user-provisioned infrastructure, you can monitor the cluster events until the cluster is ready.

### Prerequisites

- Deploy the bootstrap machine for an OpenShift Container Platform cluster on user-provisioned Azure infrastructure.
- Install the **oc** CLI and log in.

### Procedure

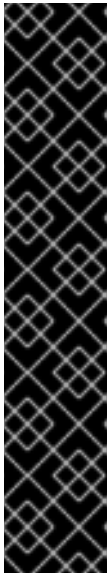
- Complete the cluster installation:

```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

### Example output

INFO Waiting up to 30m0s for the cluster to initialize...

- 1 For `<installation_directory>`, specify the path to the directory that you stored the installation files in.



### IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

## 5.10.25. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

## 5.11. UNINSTALLING A CLUSTER ON AZURE

You can remove a cluster that you deployed to Microsoft Azure.

### 5.11.1. Removing a cluster that uses installer-provisioned infrastructure

You can remove a cluster that uses installer-provisioned infrastructure from your cloud.



### NOTE

After uninstallation, check your cloud provider for any resources not removed properly, especially with User Provisioned Infrastructure (UPI) clusters. There might be resources that the installer did not create or that the installer is unable to access.

### Prerequisites

- Have a copy of the installation program that you used to deploy the cluster.
- Have the files that the installation program generated when you created your cluster.

While you can uninstall the cluster using the copy of the installation program that was used to deploy it, using OpenShift Container Platform version 4.13 or later is recommended.

The removal of service principals is dependent on the Microsoft Azure AD Graph API. Using version 4.13 or later of the installation program ensures that service principals are removed without the need for manual intervention, if and when Microsoft decides to [retire](#) the Azure AD Graph API.

## Procedure

1. From the directory that contains the installation program on the computer that you used to install the cluster, run the following command:

```
┌ $ ./openshift-install destroy cluster \  
└ --dir <installation_directory> --log-level info 1 2
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.
- 2** To view different details, specify **warn**, **debug**, or **error** instead of **info**.



### NOTE

You must specify the directory that contains the cluster definition files for your cluster. The installation program requires the **metadata.json** file in this directory to delete the cluster.

2. Optional: Delete the **<installation\_directory>** directory and the OpenShift Container Platform installation program.

## CHAPTER 6. INSTALLING ON AZURE STACK HUB

### 6.1. PREPARING TO INSTALL ON AZURE STACK HUB

#### 6.1.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You have installed Azure Stack Hub version 2008 or later.

#### 6.1.2. Requirements for installing OpenShift Container Platform on Azure Stack Hub

Before installing OpenShift Container Platform on Microsoft Azure Stack Hub, you must configure an Azure account. See [Configuring an Azure Stack Hub account](#) for details about account configuration, account limits, DNS zone configuration, required roles, and creating service principals.

You must manually manage your cloud credentials when installing a cluster to Azure Stack Hub. Do this by configuring the Cloud Credential Operator (CCO) for manual mode before you install the cluster. For more information, see [Manually creating IAM for Azure](#).

#### 6.1.3. Choosing a method to install OpenShift Container Platform on Azure Stack Hub

You can install OpenShift Container Platform on Azure Stack Hub using user-provisioned infrastructure. This means you must manage and maintain the cluster resources yourself. Installing OpenShift Container Platform on Azure Stack Hub using an installation program that automatically provisions the cluster infrastructure is not supported at this time.

See [Installation process](#) for more information about installer-provisioned and user-provisioned installation processes.

##### 6.1.3.1. Installing a cluster on user-provisioned infrastructure

You can install a cluster on Azure Stack Hub infrastructure that you provision, by using the following method:

- [Installing a cluster on Azure Stack Hub using ARM templates](#) You can install OpenShift Container Platform on Azure Stack Hub by using infrastructure that you provide. You can use the provided Azure Resource Manager (ARM) templates to assist with an installation.

#### 6.1.4. Next steps

- [Configuring an Azure Stack Hub account](#)

### 6.2. CONFIGURING AN AZURE STACK HUB ACCOUNT

Before you can install OpenShift Container Platform, you must configure a Microsoft Azure account.



## IMPORTANT

All Azure resources that are available through public endpoints are subject to resource name restrictions, and you cannot create resources that use certain terms. For a list of terms that Azure restricts, see [Resolve reserved resource name errors](#) in the Azure documentation.

### 6.2.1. Azure Stack Hub account limits

The OpenShift Container Platform cluster uses a number of Microsoft Azure Stack Hub components, and the default [Quota types in Azure Stack Hub](#) affect your ability to install OpenShift Container Platform clusters.

The following table summarizes the Azure Stack Hub components whose limits can impact your ability to install and run OpenShift Container Platform clusters.

Component	Number of components required by default	Description
vCPU	56	<p>A default cluster requires 56 vCPUs, so you must increase the account limit.</p> <p>By default, each cluster creates the following instances:</p> <ul style="list-style-type: none"> <li>● One bootstrap machine, which is removed after installation</li> <li>● Three control plane machines</li> <li>● Three compute machines</li> </ul> <p>Because the bootstrap, control plane, and worker machines use <b>Standard_DS4_v2</b> virtual machines, which use 8 vCPUs, a default cluster requires 56 vCPUs. The bootstrap node VM is used only during installation.</p> <p>To deploy more worker nodes, enable autoscaling, deploy large workloads, or use a different instance type, you must further increase the vCPU limit for your account to ensure that your cluster can deploy the machines that you require.</p>
OS Disk	7	<p>VM OS disk must be able to sustain a tested and recommended minimum throughput of 5000 IOPS / 200MBps for control plane machines. This throughput can be provided by having a minimum of 1 TiB Premium SSD (P30). In Azure Stack Hub, disk performance is directly dependent on SSD disk sizes, so to achieve the throughput supported by <b>Standard_D8s_v3</b>, or other similar machine types available, and the target of 5000 IOPS, at least a P30 disk is required.</p> <p>Host caching must be set to <b>ReadOnly</b> for low read latency and high read IOPS and throughput. The reads performed from the cache, which is present either in the VM memory or in the local SSD disk, are much faster than the reads from the data disk, which is in the blob storage.</p>

Component	Number of components required by default	Description						
VNet	1	Each default cluster requires one Virtual Network (VNet), which contains two subnets.						
Network interfaces	7	Each default cluster requires seven network interfaces. If you create more machines or your deployed workloads create load balancers, your cluster uses more network interfaces.						
Network security groups	2	Each cluster creates network security groups for each subnet in the VNet. The default cluster creates network security groups for the control plane and for the compute node subnets: <table border="1" data-bbox="663 698 1428 943"> <tr> <td><b>control plane</b></td> <td>Allows the control plane machines to be reached on port 6443 from anywhere</td> </tr> <tr> <td><b>node</b></td> <td>Allows worker nodes to be reached from the internet on ports 80 and 443</td> </tr> </table>	<b>control plane</b>	Allows the control plane machines to be reached on port 6443 from anywhere	<b>node</b>	Allows worker nodes to be reached from the internet on ports 80 and 443		
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Network load balancers	3	Each cluster creates the following <a href="#">load balancers</a> : <table border="1" data-bbox="663 1099 1428 1413"> <tr> <td><b>default</b></td> <td>Public IP address that load balances requests to ports 80 and 443 across worker machines</td> </tr> <tr> <td><b>internal</b></td> <td>Private IP address that load balances requests to ports 6443 and 22623 across control plane machines</td> </tr> <tr> <td><b>external</b></td> <td>Public IP address that load balances requests to port 6443 across control plane machines</td> </tr> </table> <p>If your applications create more Kubernetes <b>LoadBalancer</b> service objects, your cluster uses more load balancers.</p>	<b>default</b>	Public IP address that load balances requests to ports 80 and 443 across worker machines	<b>internal</b>	Private IP address that load balances requests to ports 6443 and 22623 across control plane machines	<b>external</b>	Public IP address that load balances requests to port 6443 across control plane machines
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Public IP addresses	2	The public load balancer uses a public IP address. The bootstrap machine also uses a public IP address so that you can SSH into the machine to troubleshoot issues during installation. The IP address for the bootstrap node is used only during installation.						
Private IP addresses	7	The internal load balancer, each of the three control plane machines, and each of the three worker machines each use a private IP address.						

### 6.2.2. Configuring a DNS zone in Azure Stack Hub

To successfully install OpenShift Container Platform on Azure Stack Hub, you must create DNS records in an Azure Stack Hub DNS zone. The DNS zone must be authoritative for the domain. To delegate a registrar's DNS zone to Azure Stack Hub, see Microsoft's documentation for [Azure Stack Hub](#)

[datacenter DNS integration](#).

### 6.2.3. Required Azure Stack Hub roles

Your Microsoft Azure Stack Hub account must have the following roles for the subscription that you use:

- **Owner**

To set roles on the Azure portal, see the [Manage access to resources in Azure Stack Hub with role-based access control](#) in the Microsoft documentation.

### 6.2.4. Creating a service principal

Because OpenShift Container Platform and its installation program create Microsoft Azure resources by using the Azure Resource Manager, you must create a service principal to represent it.

#### Prerequisites

- Install or update the [Azure CLI](#).
- Your Azure account has the required roles for the subscription that you use.

#### Procedure

1. Register your environment:

```
$ az cloud register -n AzureStackCloud --endpoint-resource-manager <endpoint> 1
```

- 1** Specify the Azure Resource Manager endpoint, `https://management.<region>.<fqdn>/`.`

See the [Microsoft documentation](#) for details.

2. Set the active environment:

```
$ az cloud set -n AzureStackCloud
```

3. Update your environment configuration to use the specific API version for Azure Stack Hub:

```
$ az cloud update --profile 2019-03-01-hybrid
```

4. Log in to the Azure CLI:

```
$ az login
```

If you are in a multitenant environment, you must also supply the tenant ID.

5. If your Azure account uses subscriptions, ensure that you are using the right subscription:

- a. View the list of available accounts and record the **tenantId** value for the subscription you want to use for your cluster:

```
$ az account list --refresh
```

### Example output

```
[
  {
    "cloudName": AzureStackCloud",
    "id": "9bab1460-96d5-40b3-a78e-17b15e978a80",
    "isDefault": true,
    "name": "Subscription Name",
    "state": "Enabled",
    "tenantId": "6057c7e9-b3ae-489d-a54e-de3f6bf6a8ee",
    "user": {
      "name": "you@example.com",
      "type": "user"
    }
  }
]
```

- b. View your active account details and confirm that the **tenantId** value matches the subscription you want to use:

```
$ az account show
```

### Example output

```
{
  "environmentName": AzureStackCloud",
  "id": "9bab1460-96d5-40b3-a78e-17b15e978a80",
  "isDefault": true,
  "name": "Subscription Name",
  "state": "Enabled",
  "tenantId": "6057c7e9-b3ae-489d-a54e-de3f6bf6a8ee", 1
  "user": {
    "name": "you@example.com",
    "type": "user"
  }
}
```

- 1** Ensure that the value of the **tenantId** parameter is the correct subscription ID.

- c. If you are not using the right subscription, change the active subscription:

```
$ az account set -s <subscription_id> 1
```

- 1** Specify the subscription ID.

- d. Verify the subscription ID update:

```
$ az account show
```

### Example output



```
{
  "environmentName": AzureStackCloud",
  "id": "33212d16-bdf6-45cb-b038-f6565b61edda",
  "isDefault": true,
  "name": "Subscription Name",
  "state": "Enabled",
  "tenantId": "8049c7e9-c3de-762d-a54e-dc3f6be6a7ee",
  "user": {
    "name": "you@example.com",
    "type": "user"
  }
}
```

- Record the **tenantId** and **id** parameter values from the output. You need these values during the OpenShift Container Platform installation.
- Create the service principal for your account:

```
$ az ad sp create-for-rbac --role Contributor --name <service_principal> \ 1
--scopes /subscriptions/<subscription_id> 2
--years <years> 3
```

- Specify the service principal name.
- Specify the subscription ID.
- Specify the number of years. By default, a service principal expires in one year. By using the **--years** option you can extend the validity of your service principal.

### Example output

```
Creating 'Contributor' role assignment under scope '/subscriptions/<subscription_id>'
The output includes credentials that you must protect. Be sure that you do not
include these credentials in your code or check the credentials into your source
control. For more information, see https://aka.ms/azadsp-cli
{
  "appId": "ac461d78-bf4b-4387-ad16-7e32e328aec6",
  "displayName": <service_principal>,
  "password": "00000000-0000-0000-0000-000000000000",
  "tenantId": "8049c7e9-c3de-762d-a54e-dc3f6be6a7ee"
}
```

- Record the values of the **appId** and **password** parameters from the previous output. You need these values during OpenShift Container Platform installation.

### Additional resources

- For more information about CCO modes, see [About the Cloud Credential Operator](#).

### 6.2.5. Next steps

- Configure your Azure Stack Hub credentials by following [Manually creating IAM for Azure Stack Hub](#).

- Install an OpenShift Container Platform cluster on Azure Stack Hub with user-provisioned infrastructure by following [Installing a cluster on Azure Stack Hub using ARM templates](#) .

## 6.3. MANUALLY CREATING IAM FOR AZURE STACK HUB

In environments where the cloud identity and access management (IAM) APIs are not reachable, you must put the Cloud Credential Operator (CCO) into manual mode before you install the cluster.

### 6.3.1. Alternatives to storing administrator-level secrets in the kube-system project

The Cloud Credential Operator (CCO) manages cloud provider credentials as Kubernetes custom resource definitions (CRDs). You can configure the CCO to suit the security requirements of your organization by setting different values for the **credentialsMode** parameter in the **install-config.yaml** file.

#### Additional resources

- For a detailed description of all available CCO credential modes and their supported platforms, see [About the Cloud Credential Operator](#).

### 6.3.2. Manually create IAM

The Cloud Credential Operator (CCO) only supports your cloud provider in manual mode. As a result, you must specify the identity and access management (IAM) secrets for your cloud provider.

#### Procedure

1. Change to the directory that contains the installation program and create the **install-config.yaml** file by running the following command:

```
$ openshift-install create install-config --dir <installation_directory>
```

where **<installation\_directory>** is the directory in which the installation program creates files.

2. Edit the **install-config.yaml** configuration file so that it contains the **credentialsMode** parameter set to **Manual**.

#### Example install-config.yaml configuration file

```
apiVersion: v1
baseDomain: cluster1.example.com
credentialsMode: Manual 1
compute:
- architecture: amd64
  hyperthreading: Enabled
...
```

- 1** This line is added to set the **credentialsMode** parameter to **Manual**.

3. To generate the manifests, run the following command from the directory that contains the installation program:

```
$ openshift-install create manifests --dir <installation_directory>
```

where **<installation\_directory>** is the directory in which the installation program creates files.

- From the directory that contains the installation program, obtain details of the OpenShift Container Platform release image that your **openshift-install** binary is built to use by running the following command:

```
$ openshift-install version
```

### Example output

```
release image quay.io/openshift-release-dev/ocp-release:4.y.z-x86_64
```

- Locate all **CredentialsRequest** objects in this release image that target the cloud you are deploying on by running the following command:

```
$ oc adm release extract quay.io/openshift-release-dev/ocp-release:4.y.z-x86_64 \
  --credentials-requests \
  --cloud=azure
```

This command creates a YAML file for each **CredentialsRequest** object.

### Sample CredentialsRequest object

```
apiVersion: cloudcredential.openshift.io/v1
kind: CredentialsRequest
metadata:
  name: <component-credentials-request>
  namespace: openshift-cloud-credential-operator
  ...
spec:
  providerSpec:
    apiVersion: cloudcredential.openshift.io/v1
    kind: AzureProviderSpec
    roleBindings:
      - role: Contributor
    ...
```

- Create YAML files for secrets in the **openshift-install** manifests directory that you generated previously. The secrets must be stored using the namespace and secret name defined in the **spec.secretRef** for each **CredentialsRequest** object.

### Sample CredentialsRequest object with secrets

```
apiVersion: cloudcredential.openshift.io/v1
kind: CredentialsRequest
metadata:
  name: <component-credentials-request>
  namespace: openshift-cloud-credential-operator
  ...
spec:
  providerSpec:
```

```

apiVersion: cloudcredential.openshift.io/v1
kind: AzureProviderSpec
roleBindings:
- role: Contributor
...
secretRef:
name: <component-secret>
namespace: <component-namespace>
...

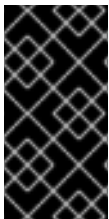
```

### Sample Secret object

```

apiVersion: v1
kind: Secret
metadata:
name: <component-secret>
namespace: <component-namespace>
data:
azure_subscription_id: <base64_encoded_azure_subscription_id>
azure_client_id: <base64_encoded_azure_client_id>
azure_client_secret: <base64_encoded_azure_client_secret>
azure_tenant_id: <base64_encoded_azure_tenant_id>
azure_resource_prefix: <base64_encoded_azure_resource_prefix>
azure_resourcegroup: <base64_encoded_azure_resourcegroup>
azure_region: <base64_encoded_azure_region>

```



### IMPORTANT

Before upgrading a cluster that uses manually maintained credentials, you must ensure that the CCO is in an upgradeable state. For details, see the "Upgrading clusters with manually maintained credentials" section of the installation content for your cloud provider.

### 6.3.3. Upgrading clusters with manually maintained credentials

The Cloud Credential Operator (CCO) **Upgradable** status for a cluster with manually maintained credentials is **False** by default.

- For minor releases, for example, from 4.8 to 4.9, this status prevents you from upgrading until you have addressed any updated permissions and annotated the **CloudCredential** resource to indicate that the permissions are updated as needed for the next version. This annotation changes the **Upgradable** status to **True**.
- For z-stream releases, for example, from 4.9.0 to 4.9.1, no permissions are added or changed, so the upgrade is not blocked.

Before upgrading a cluster with manually maintained credentials, you must create any new credentials for the release image that you are upgrading to. Additionally, you must review the required permissions for existing credentials and accommodate any new permissions requirements in the new release for those components.

#### Procedure

1. Extract and examine the **CredentialsRequest** custom resource for the new release.

The "Manually creating IAM" section of the installation content for your cloud provider explains how to obtain and use the credentials required for your cloud.

2. Update the manually maintained credentials on your cluster:
  - Create new secrets for any **CredentialsRequest** custom resources that are added by the new release image.
  - If the **CredentialsRequest** custom resources for any existing credentials that are stored in secrets have changed their permissions requirements, update the permissions as required.
3. When all of the secrets are correct for the new release, indicate that the cluster is ready to upgrade:
  - a. Log in to the OpenShift Container Platform CLI as a user with the **cluster-admin** role.
  - b. Edit the **CloudCredential** resource to add an **upgradeable-to** annotation within the **metadata** field:

```
$ oc edit cloudcredential cluster
```

#### Text to add

```
...
metadata:
  annotations:
    cloudcredential.openshift.io/upgradeable-to: <version_number>
...
```

Where **<version\_number>** is the version you are upgrading to, in the format **x.y.z**. For example, **4.8.2** for OpenShift Container Platform 4.8.2.

It may take several minutes after adding the annotation for the upgradeable status to change.

4. Verify that the CCO is upgradeable:
  - a. In the **Administrator** perspective of the web console, navigate to **Administration** → **Cluster Settings**.
  - b. To view the CCO status details, click **cloud-credential** in the **Cluster Operators** list.
  - c. If the **Upgradeable** status in the **Conditions** section is **False**, verify that the **upgradeable-to** annotation is free of typographical errors.

When the **Upgradeable** status in the **Conditions** section is **True**, you can begin the OpenShift Container Platform upgrade.

### 6.3.4. Next steps

- Install an OpenShift Container Platform cluster on Azure Stack Hub with user-provisioned infrastructure by following [Installing a cluster on Azure Stack Hub using ARM templates](#) .

## 6.4. INSTALLING A CLUSTER ON AZURE STACK HUB USING ARM TEMPLATES

In OpenShift Container Platform version 4.9, you can install a cluster on Microsoft Azure Stack Hub by using infrastructure that you provide.

Several [Azure Resource Manager \(ARM\)](#) templates are provided to assist in completing these steps or to help model your own.



### IMPORTANT

The steps for performing a user-provisioned infrastructure installation are provided as an example only. Installing a cluster with infrastructure you provide requires knowledge of the cloud provider and the installation process of OpenShift Container Platform. Several ARM templates are provided to assist in completing these steps or to help model your own. You are also free to create the required resources through other methods; the templates are just an example.

## 6.4.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You [configured an Azure Stack Hub account](#) to host the cluster.
- You downloaded the Azure CLI and installed it on your computer. See [Install the Azure CLI](#) in the Azure documentation. The documentation below was tested using version **2.28.0** of the Azure CLI. Azure CLI commands might perform differently based on the version you use.
- If you use a firewall and plan to use the Telemetry service, you [configured the firewall to allow the sites](#) that your cluster requires access to.



### NOTE

Be sure to also review this site list if you are configuring a proxy.

## 6.4.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

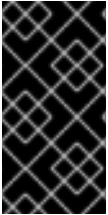


## IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

### 6.4.3. Configuring your Azure Stack Hub project

Before you can install OpenShift Container Platform, you must configure an Azure project to host it.



## IMPORTANT

All Azure Stack Hub resources that are available through public endpoints are subject to resource name restrictions, and you cannot create resources that use certain terms. For a list of terms that Azure Stack Hub restricts, see [Resolve reserved resource name errors](#) in the Azure documentation.

#### 6.4.3.1. Azure Stack Hub account limits

The OpenShift Container Platform cluster uses a number of Microsoft Azure Stack Hub components, and the default [Quota types in Azure Stack Hub](#) affect your ability to install OpenShift Container Platform clusters.

The following table summarizes the Azure Stack Hub components whose limits can impact your ability to install and run OpenShift Container Platform clusters.

Component	Number of components required by default	Description
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Component	Number of components required by default	Description						
OS Disk	7	<p>VM OS disk must be able to sustain a tested and recommended minimum throughput of 5000 IOPS / 200MBps for control plane machines. This throughput can be provided by having a minimum of 1 TiB Premium SSD (P30). In Azure Stack Hub, disk performance is directly dependent on SSD disk sizes, so to achieve the throughput supported by <b>Standard_D8s_v3</b>, or other similar machine types available, and the target of 5000 IOPS, at least a P30 disk is required.</p> <p>Host caching must be set to <b>ReadOnly</b> for low read latency and high read IOPS and throughput. The reads performed from the cache, which is present either in the VM memory or in the local SSD disk, are much faster than the reads from the data disk, which is in the blob storage.</p>						
VNet	1	Each default cluster requires one Virtual Network (VNet), which contains two subnets.						
Network interfaces	7	Each default cluster requires seven network interfaces. If you create more machines or your deployed workloads create load balancers, your cluster uses more network interfaces.						
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<b>default</b>	Public IP address that load balances requests to ports 80 and 443 across worker machines							
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Component	Number of components required by default	Description
Public IP addresses	2	The public load balancer uses a public IP address. The bootstrap machine also uses a public IP address so that you can SSH into the machine to troubleshoot issues during installation. The IP address for the bootstrap node is used only during installation.
Private IP addresses	7	The internal load balancer, each of the three control plane machines, and each of the three worker machines each use a private IP address.

### 6.4.3.2. Configuring a DNS zone in Azure Stack Hub

To successfully install OpenShift Container Platform on Azure Stack Hub, you must create DNS records in an Azure Stack Hub DNS zone. The DNS zone must be authoritative for the domain. To delegate a registrar's DNS zone to Azure Stack Hub, see Microsoft's documentation for [Azure Stack Hub datacenter DNS integration](#).

You can view Azure's DNS solution by visiting this [example for creating DNS zones](#).

### 6.4.3.3. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

### 6.4.3.4. Required Azure Stack Hub roles

Your Microsoft Azure Stack Hub account must have the following roles for the subscription that you use:

- **Owner**

To set roles on the Azure portal, see the [Manage access to resources in Azure Stack Hub with role-based access control](#) in the Microsoft documentation.

### 6.4.3.5. Creating a service principal

Because OpenShift Container Platform and its installation program create Microsoft Azure resources by using the Azure Resource Manager, you must create a service principal to represent it.

#### Prerequisites

- Install or update the [Azure CLI](#).
- Your Azure account has the required roles for the subscription that you use.

#### Procedure

1. Register your environment:

```
$ az cloud register -n AzureStackCloud --endpoint-resource-manager <endpoint> 1
```

- 1 Specify the Azure Resource Manager endpoint, ``https://management.<region>.<fqdn>/``.

See the [Microsoft documentation](#) for details.

2. Set the active environment:

```
$ az cloud set -n AzureStackCloud
```

3. Update your environment configuration to use the specific API version for Azure Stack Hub:

```
$ az cloud update --profile 2019-03-01-hybrid
```

4. Log in to the Azure CLI:

```
$ az login
```

If you are in a multitenant environment, you must also supply the tenant ID.

5. If your Azure account uses subscriptions, ensure that you are using the right subscription:

- a. View the list of available accounts and record the **tenantId** value for the subscription you want to use for your cluster:

```
$ az account list --refresh
```

#### Example output

```
[
  {
    "cloudName": "AzureStackCloud",
    "id": "9bab1460-96d5-40b3-a78e-17b15e978a80",
    "isDefault": true,
    "name": "Subscription Name",
    "state": "Enabled",
    "tenantId": "6057c7e9-b3ae-489d-a54e-de3f6bf6a8ee",
    "user": {
      "name": "you@example.com",
      "type": "user"
    }
  }
]
```

- b. View your active account details and confirm that the **tenantId** value matches the subscription you want to use:

```
$ az account show
```

#### Example output

```
-
```

```
{
  "environmentName": "AzureStackCloud",
  "id": "9bab1460-96d5-40b3-a78e-17b15e978a80",
  "isDefault": true,
  "name": "Subscription Name",
  "state": "Enabled",
  "tenantId": "6057c7e9-b3ae-489d-a54e-de3f6bf6a8ee", ❶
  "user": {
    "name": "you@example.com",
    "type": "user"
  }
}
```

❶ Ensure that the value of the **tenantId** parameter is the correct subscription ID.

c. If you are not using the right subscription, change the active subscription:

```
$ az account set -s <subscription_id> ❶
```

❶ Specify the subscription ID.

d. Verify the subscription ID update:

```
$ az account show
```

### Example output

```
{
  "environmentName": "AzureStackCloud",
  "id": "33212d16-bdf6-45cb-b038-f6565b61edda",
  "isDefault": true,
  "name": "Subscription Name",
  "state": "Enabled",
  "tenantId": "8049c7e9-c3de-762d-a54e-dc3f6be6a7ee",
  "user": {
    "name": "you@example.com",
    "type": "user"
  }
}
```

6. Record the **tenantId** and **id** parameter values from the output. You need these values during the OpenShift Container Platform installation.

7. Create the service principal for your account:

```
$ az ad sp create-for-rbac --role Contributor --name <service_principal> \ ❶
--scopes /subscriptions/<subscription_id> ❷
--years <years> ❸
```

❶ Specify the service principal name.

❷ Specify the subscription ID.

- 3** Specify the number of years. By default, a service principal expires in one year. By using the **--years** option you can extend the validity of your service principal.

### Example output

Creating 'Contributor' role assignment under scope '/subscriptions/<subscription\_id>  
The output includes credentials that you must protect. Be sure that you do not include these credentials in your code or check the credentials into your source control. For more information, see <https://aka.ms/azadsp-cli>

```
{
  "appId": "ac461d78-bf4b-4387-ad16-7e32e328aec6",
  "displayName": <service_principal>,
  "password": "00000000-0000-0000-0000-000000000000",
  "tenantId": "8049c7e9-c3de-762d-a54e-dc3f6be6a7ee"
}
```

8. Record the values of the **appId** and **password** parameters from the previous output. You need these values during OpenShift Container Platform installation.

### Additional resources

- For more information about CCO modes, see [About the Cloud Credential Operator](#).

## 6.4.4. Obtaining the installation program

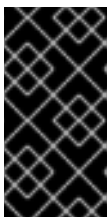
Before you install OpenShift Container Platform, download the installation file on a local computer.

### Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space

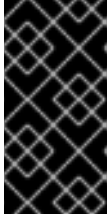
### Procedure

- Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
- Select **Azure** as the cloud provider if you are installing your cluster on Azure Stack Hub.
- Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



### IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



### IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#). This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

#### 6.4.5. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.



### IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



### NOTE

You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

#### Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> ❶
```

- ❶ Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.

**NOTE**

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.

**NOTE**

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

**Example output**

```
Agent pid 31874
```

**NOTE**

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1** Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

**Example output**

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

**Next steps**

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

## 6.4.6. Creating the installation files for Azure Stack Hub

To install OpenShift Container Platform on Microsoft Azure Stack Hub using user-provisioned infrastructure, you must generate the files that the installation program needs to deploy your cluster and modify them so that the cluster creates only the machines that it will use. You manually create the **install-config.yaml** file, and then generate and customize the Kubernetes manifests and Ignition config files. You also have the option to first set up a separate **var** partition during the preparation phases of installation.

### 6.4.6.1. Manually creating the installation configuration file

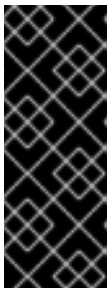
#### Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

#### Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```



#### IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation\_directory>**.



#### NOTE

You must name this configuration file **install-config.yaml**.

Make the following modifications for Azure Stack Hub:

- a. Set the **replicas** parameter to **0** for the **compute** pool:

```
compute:
- hyperthreading: Enabled
  name: worker
```

```
platform: {}
replicas: 0 1
```

- 1** Set to **0**.

The compute machines will be provisioned manually later.

- b. Update the **platform.azure** section of the **install-config.yaml** file to configure your Azure Stack Hub configuration:

```
platform:
  azure:
    armEndpoint: <azurestack_arm_endpoint> 1
    baseDomainResourceGroupName: <resource_group> 2
    cloudName: AzureStackCloud 3
    region: <azurestack_region> 4
```

- 1** Specify the Azure Resource Manager endpoint of your Azure Stack Hub environment, like **https://management.local.azurestack.external**.
- 2** Specify the name of the resource group that contains the DNS zone for your base domain.
- 3** Specify the Azure Stack Hub environment, which is used to configure the Azure SDK with the appropriate Azure API endpoints.
- 4** Specify the name of your Azure Stack Hub region.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

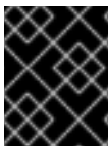


### IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

#### 6.4.6.2. Sample customized install-config.yaml file for Azure Stack Hub

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.



### IMPORTANT

This sample YAML file is provided for reference only. Use it as a resource to enter parameter values into the installation configuration file that you created manually.

```
apiVersion: v1
baseDomain: example.com
controlPlane: 1
  name: master
  replicas: 3
compute: 2
  - name: worker
```



```

platform: {}
replicas: 0
metadata:
  name: test-cluster 3
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
  azure:
    armEndpoint: azurestack_arm_endpoint 4
    baseDomainResourceGroupName: resource_group 5
    region: azure_stack_local_region 6
    resourceGroupName: existing_resource_group 7
    outboundType: Loadbalancer
    cloudName: AzureStackCloud 8
pullSecret: '{"auths": ...}' 9
fips: false 10
additionalTrustBundle: | 11
  -----BEGIN CERTIFICATE-----
  <MY_TRUSTED_CA_CERT>
  -----END CERTIFICATE-----
sshKey: ssh-ed25519 AAAA... 12

```

- 1 2 The **controlPlane** section is a single mapping, but the compute section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. Only one control plane pool is used.
- 3 Specify the name of the cluster.
- 4 Specify the Azure Resource Manager endpoint that your Azure Stack Hub operator provides.
- 5 Specify the name of the resource group that contains the DNS zone for your base domain.
- 6 Specify the name of your Azure Stack Hub local region.
- 7 Specify the name of an already existing resource group to install your cluster to. If undefined, a new resource group is created for the cluster.
- 8 Specify the Azure Stack Hub environment as your target platform.
- 9 Specify the pull secret required to authenticate your cluster.
- 10 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

**IMPORTANT**

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

- 11 If your Azure Stack Hub environment uses an internal certificate authority (CA), add the necessary certificate bundle in **.pem** format.
- 12 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.

**NOTE**

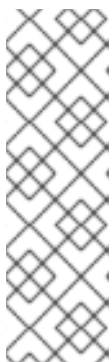
For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

**6.4.6.3. Configuring the cluster-wide proxy during installation**

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

**Prerequisites**

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

**NOTE**

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

**Procedure**

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
```

```
additionalTrustBundle: | 4
-----BEGIN CERTIFICATE-----
<MY_TRUSTED_CA_CERT>
-----END CERTIFICATE-----
...

```

- 1** A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2** A proxy URL to use for creating HTTPS connections outside the cluster.
- 3** A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations.
- 4** If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.



#### NOTE

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



#### NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

#### 6.4.6.4. Exporting common variables for ARM templates

You must export a common set of variables that are used with the provided Azure Resource Manager (ARM) templates used to assist in completing a user-provided infrastructure install on Microsoft Azure Stack Hub.



#### NOTE

Specific ARM templates can also require additional exported variables, which are detailed in their related procedures.

#### Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

## Procedure

1. Export common variables found in the **install-config.yaml** to be used by the provided ARM templates:

```
$ export CLUSTER_NAME=<cluster_name> 1
$ export AZURE_REGION=<azure_region> 2
$ export SSH_KEY=<ssh_key> 3
$ export BASE_DOMAIN=<base_domain> 4
$ export BASE_DOMAIN_RESOURCE_GROUP=<base_domain_resource_group> 5
```

- 1 The value of the **.metadata.name** attribute from the **install-config.yaml** file.
- 2 The region to deploy the cluster into. This is the value of the **.platform.azure.region** attribute from the **install-config.yaml** file.
- 3 The SSH RSA public key file as a string. You must enclose the SSH key in quotes since it contains spaces. This is the value of the **.sshKey** attribute from the **install-config.yaml** file.
- 4 The base domain to deploy the cluster to. The base domain corresponds to the DNS zone that you created for your cluster. This is the value of the **.baseDomain** attribute from the **install-config.yaml** file.
- 5 The resource group where the DNS zone exists. This is the value of the **.platform.azure.baseDomainResourceGroupName** attribute from the **install-config.yaml** file.

For example:

```
$ export CLUSTER_NAME=test-cluster
$ export AZURE_REGION=centralus
$ export SSH_KEY="ssh-rsa xxx/xxx/xxx= user@email.com"
$ export BASE_DOMAIN=example.com
$ export BASE_DOMAIN_RESOURCE_GROUP=ocp-cluster
```

2. Export the kubeadmin credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

### 6.4.6.5. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.



## IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

## Prerequisites

- You obtained the OpenShift Container Platform installation program.
- You created the **install-config.yaml** installation configuration file.

## Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

- 1** For **<installation\_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

2. Remove the Kubernetes manifest files that define the control plane machines:

```
$ rm -f <installation_directory>/openshift/99_openshift-cluster-api_master-machines-*.yaml
```

By removing these files, you prevent the cluster from automatically generating control plane machines.

3. Remove the Kubernetes manifest files that define the worker machines:

```
$ rm -f <installation_directory>/openshift/99_openshift-cluster-api_worker-machineset-*.yaml
```

Because you create and manage the worker machines yourself, you do not need to initialize these machines.

4. Check that the **mastersSchedulable** parameter in the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:

- a. Open the `<installation_directory>/manifests/cluster-scheduler-02-config.yml` file.
  - b. Locate the `mastersSchedulable` parameter and ensure that it is set to `false`.
  - c. Save and exit the file.
5. Optional: If you do not want [the Ingress Operator](#) to create DNS records on your behalf, remove the `privateZone` and `publicZone` sections from the `<installation_directory>/manifests/cluster-dns-02-config.yml` DNS configuration file:

```
apiVersion: config.openshift.io/v1
kind: DNS
metadata:
  creationTimestamp: null
  name: cluster
spec:
  baseDomain: example.openshift.com
  privateZone: ❶
    id: mycluster-100419-private-zone
  publicZone: ❷
    id: example.openshift.com
status: {}
```

- ❶ ❷ Remove this section completely.

If you do so, you must add ingress DNS records manually in a later step.

6. Optional: If your Azure Stack Hub environment uses an internal certificate authority (CA), you must update the `.spec.trustedCA.name` field in the `<installation_directory>/manifests/cluster-proxy-01-config.yaml` file to use `user-ca-bundle`:

```
...
spec:
  trustedCA:
    name: user-ca-bundle
...
```

Later, you must update your bootstrap ignition to include the CA.

7. When configuring Azure on user-provisioned infrastructure, you must export some common variables defined in the manifest files to use later in the Azure Resource Manager (ARM) templates:

- a. Export the infrastructure ID by using the following command:

```
$ export INFRA_ID=<infra_id> ❶
```

- ❶ The OpenShift Container Platform cluster has been assigned an identifier (`INFRA_ID`) in the form of `<cluster_name>-<random_string>`. This will be used as the base name for most resources created using the provided ARM templates. This is the value of the `.status.infrastructureName` attribute from the `manifests/cluster-infrastructure-02-config.yml` file.

- b. Export the resource group by using the following command:

```
$ export RESOURCE_GROUP=<resource_group> 1
```

- 1 All resources created in this Azure deployment exists as part of a [resource group](#). The resource group name is also based on the **INFRA\_ID**, in the form of **<cluster\_name>-<random\_string>-rg**. This is the value of the **.status.platformStatus.azure.resourceGroupName** attribute from the **manifests/cluster-infrastructure-02-config.yml** file.

## 8. Manually create your cloud credentials.

- a. From the directory that contains the installation program, obtain details of the OpenShift Container Platform release image that your **openshift-install** binary is built to use:

```
$ openshift-install version
```

### Example output

```
release image quay.io/openshift-release-dev/ocp-release:4.y.z-x86_64
```

- b. Locate all **CredentialsRequest** objects in this release image that target the cloud you are deploying on:

```
$ oc adm release extract quay.io/openshift-release-dev/ocp-release:4.y.z-x86_64 --
credentials-requests --cloud=azure
```

This command creates a YAML file for each **CredentialsRequest** object.

### Sample **CredentialsRequest** object

```
apiVersion: cloudcredential.openshift.io/v1
kind: CredentialsRequest
metadata:
  labels:
    controller-tools.k8s.io: "1.0"
  name: openshift-image-registry-azure
  namespace: openshift-cloud-credential-operator
spec:
  secretRef:
    name: installer-cloud-credentials
    namespace: openshift-image-registry
  providerSpec:
    apiVersion: cloudcredential.openshift.io/v1
    kind: AzureProviderSpec
    roleBindings:
      - role: Contributor
```

- c. Create YAML files for secrets in the **openshift-install** manifests directory that you generated previously. The secrets must be stored using the namespace and secret name defined in the **spec.secretRef** for each **CredentialsRequest** object. The format for the secret data varies for each cloud provider.
- d. Create a **cco-configmap.yaml** file in the manifests directory with the Cloud Config Operator (CCO) disabled:

### Sample ConfigMap object

```

apiVersion: v1
kind: ConfigMap
metadata:
  name: cloud-credential-operator-config
  namespace: openshift-cloud-credential-operator
  annotations:
    release.openshift.io/create-only: "true"
data:
  disabled: "true"

```

- To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

- For **<installation\_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation\_directory>/auth** directory:

```

.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign

```

#### 6.4.6.6. Optional: Creating a separate **/var** partition

It is recommended that disk partitioning for OpenShift Container Platform be left to the installer. However, there are cases where you might want to create separate partitions in a part of the filesystem that you expect to grow.

OpenShift Container Platform supports the addition of a single partition to attach storage to either the **/var** partition or a subdirectory of **/var**. For example:

- **/var/lib/containers**: Holds container-related content that can grow as more images and containers are added to a system.
- **/var/lib/etcd**: Holds data that you might want to keep separate for purposes such as performance optimization of etcd storage.
- **/var**: Holds data that you might want to keep separate for purposes such as auditing.

Storing the contents of a **/var** directory separately makes it easier to grow storage for those areas as needed and reinstall OpenShift Container Platform at a later date and keep that data intact. With this method, you will not have to pull all your containers again, nor will you have to copy massive log files when you update systems.



Because **/var** must be in place before a fresh installation of Red Hat Enterprise Linux CoreOS (RHCOS), the following procedure sets up the separate **/var** partition by creating a machine config manifest that is inserted during the **openshift-install** preparation phases of an OpenShift Container Platform installation.



## IMPORTANT

If you follow the steps to create a separate **/var** partition in this procedure, it is not necessary to create the Kubernetes manifest and Ignition config files again as described later in this section.

## Procedure

1. Create a directory to hold the OpenShift Container Platform installation files:

```
$ mkdir $HOME/clusterconfig
```

2. Run **openshift-install** to create a set of files in the **manifest** and **openshift** subdirectories. Answer the system questions as you are prompted:

```
$ openshift-install create manifests --dir $HOME/clusterconfig
```

### Example output

```
? SSH Public Key ...
INFO Credentials loaded from the "myprofile" profile in file "/home/myuser/.aws/credentials"
INFO Consuming Install Config from target directory
INFO Manifests created in: $HOME/clusterconfig/manifests and
$HOME/clusterconfig/openshift
```

3. Optional: Confirm that the installation program created manifests in the **clusterconfig/openshift** directory:

```
$ ls $HOME/clusterconfig/openshift/
```

### Example output

```
99_kubeadmin-password-secret.yaml
99_openshift-cluster-api_master-machines-0.yaml
99_openshift-cluster-api_master-machines-1.yaml
99_openshift-cluster-api_master-machines-2.yaml
...
```

4. Create a Butane config that configures the additional partition. For example, name the file **\$HOME/clusterconfig/98-var-partition.bu**, change the disk device name to the name of the storage device on the **worker** systems, and set the storage size as appropriate. This example places the **/var** directory on a separate partition:

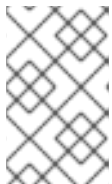
```
variant: openshift
version: 4.9.0
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
```

```

name: 98-var-partition
storage:
  disks:
    - device: /dev/<device_name> ❶
      partitions:
        - label: var
          start_mib: <partition_start_offset> ❷
          size_mib: <partition_size> ❸
      filesystems:
        - device: /dev/disk/by-partlabel/var
          path: /var
          format: xfs
          mount_options: [defaults, prjquota] ❹
          with_mount_unit: true

```

- ❶ The storage device name of the disk that you want to partition.
- ❷ When adding a data partition to the boot disk, a minimum value of 25000 MiB (Mebibytes) is recommended. The root file system is automatically resized to fill all available space up to the specified offset. If no value is specified, or if the specified value is smaller than the recommended minimum, the resulting root file system will be too small, and future reinstalls of RHCOS might overwrite the beginning of the data partition.
- ❸ The size of the data partition in mebibytes.
- ❹ The **prjquota** mount option must be enabled for filesystems used for container storage.



#### NOTE

When creating a separate **/var** partition, you cannot use different instance types for worker nodes, if the different instance types do not have the same device name.

5. Create a manifest from the Butane config and save it to the **clusterconfig/openshift** directory. For example, run the following command:

```
$ butane $HOME/clusterconfig/98-var-partition.bu -o $HOME/clusterconfig/openshift/98-var-partition.yaml
```

6. Run **openshift-install** again to create Ignition configs from a set of files in the **manifest** and **openshift** subdirectories:

```
$ openshift-install create ignition-configs --dir $HOME/clusterconfig
$ ls $HOME/clusterconfig/
auth bootstrap.ign master.ign metadata.json worker.ign
```

Now you can use the Ignition config files as input to the installation procedures to install Red Hat Enterprise Linux CoreOS (RHCOS) systems.

### 6.4.7. Creating the Azure resource group

You must create a Microsoft Azure [resource group](#). This is used during the installation of your OpenShift Container Platform cluster on Azure Stack Hub.

## Prerequisites

- Configure an Azure account.
- Generate the Ignition config files for your cluster.

## Procedure

- Create the resource group in a supported Azure region:

```
$ az group create --name ${RESOURCE_GROUP} --location ${AZURE_REGION}
```

### 6.4.8. Uploading the RHCOS cluster image and bootstrap Ignition config file

The Azure client does not support deployments based on files existing locally; therefore, you must copy and store the RHCOS virtual hard disk (VHD) cluster image and bootstrap Ignition config file in a storage container so they are accessible during deployment.

## Prerequisites

- Configure an Azure account.
- Generate the Ignition config files for your cluster.

## Procedure

1. Create an Azure storage account to store the VHD cluster image:

```
$ az storage account create -g ${RESOURCE_GROUP} --location ${AZURE_REGION} --name ${CLUSTER_NAME}sa --kind Storage --sku Standard_LRS
```



#### WARNING

The Azure storage account name must be between 3 and 24 characters in length and use numbers and lower-case letters only. If your **CLUSTER\_NAME** variable does not follow these restrictions, you must manually define the Azure storage account name. For more information on Azure storage account name restrictions, see [Resolve errors for storage account names](#) in the Azure documentation.

2. Export the storage account key as an environment variable:

```
$ export ACCOUNT_KEY=`az storage account keys list -g ${RESOURCE_GROUP} --account-name ${CLUSTER_NAME}sa --query "[0].value" -o tsv`
```

3. Choose the RHCOS version to use and export the URL of its VHD to an environment variable:

```
$ export COMPRESSED_VHD_URL=`curl -s
https://raw.githubusercontent.com/openshift/installer/release-4.9/data/data/rhcos-amd64.json
| jq -r '(.baseURI + .images.azurestack.path)`
```



### IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must specify an image with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image version that matches your OpenShift Container Platform version if it is available.

4. Create the storage container for the VHD:

```
$ az storage container create --name vhd --account-name ${CLUSTER_NAME}sa --account-
key ${ACCOUNT_KEY}
```

5. Download the compressed RHCOS VHD file locally:

```
$ curl -O -L ${COMPRESSED_VHD_URL}
```

6. Decompress the VHD file.



### NOTE

The decompressed VHD file is approximately 16 GB, so be sure that your host system has 16 GB of free space available. The VHD file can be deleted once you have uploaded it.

7. Copy the chosen VHD to a blob:

```
$ az storage blob upload --account-name ${CLUSTER_NAME}sa --account-key
${ACCOUNT_KEY} -c vhd -n "rhcos.vhd" -f rhcos-<rhcos_version>-azurestack.x86_64.vhd
```

8. Create a blob storage container and upload the generated **bootstrap.ign** file:

```
$ az storage container create --name files --account-name ${CLUSTER_NAME}sa --
account-key ${ACCOUNT_KEY} --public-access blob
```

```
$ az storage blob upload --account-name ${CLUSTER_NAME}sa --account-key
${ACCOUNT_KEY} -c "files" -f "<installation_directory>/bootstrap.ign" -n "bootstrap.ign"
```

## 6.4.9. Example for creating DNS zones

DNS records are required for clusters that use user-provisioned infrastructure. You should choose the DNS strategy that fits your scenario.

For this example, [Azure Stack Hub's datacenter DNS integration](#) is used, so you will create a DNS zone.

**NOTE**

The DNS zone is not required to exist in the same resource group as the cluster deployment and might already exist in your organization for the desired base domain. If that is the case, you can skip creating the DNS zone; be sure the installation config you generated earlier reflects that scenario.

**Prerequisites**

- Configure an Azure account.
- Generate the Ignition config files for your cluster.

**Procedure**

- Create the new DNS zone in the resource group exported in the **BASE\_DOMAIN\_RESOURCE\_GROUP** environment variable:

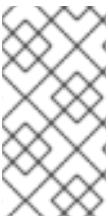
```
$ az network dns zone create -g ${BASE_DOMAIN_RESOURCE_GROUP} -n
${CLUSTER_NAME}.${BASE_DOMAIN}
```

You can skip this step if you are using a DNS zone that already exists.

You can learn more about [configuring a DNS zone in Azure Stack Hub](#) by visiting that section.

**6.4.10. Creating a VNet in Azure Stack Hub**

You must create a virtual network (VNet) in Microsoft Azure Stack Hub for your OpenShift Container Platform cluster to use. You can customize the VNet to meet your requirements. One way to create the VNet is to modify the provided Azure Resource Manager (ARM) template.

**NOTE**

If you do not use the provided ARM template to create your Azure Stack Hub infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

**Prerequisites**

- Configure an Azure account.
- Generate the Ignition config files for your cluster.

**Procedure**

1. Copy the template from the **ARM template for the VNet** section of this topic and save it as **01\_vnet.json** in your cluster's installation directory. This template describes the VNet that your cluster requires.
2. Create the deployment by using the **az** CLI:

```
$ az deployment group create -g ${RESOURCE_GROUP} \
  --template-file "<installation_directory>/01_vnet.json" \
  --parameters baseName="${INFRA_ID}" 1
```

- 1** The base name to be used in resource names; this is usually the cluster's infrastructure ID.

#### 6.4.10.1. ARM template for the VNet

You can use the following Azure Resource Manager (ARM) template to deploy the VNet that you need for your OpenShift Container Platform cluster:

##### Example 6.1. 01\_vnet.json ARM template

link:[https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/azurestack/01\\_vnet.json](https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/azurestack/01_vnet.json)

#### 6.4.11. Deploying the RHCOS cluster image for the Azure Stack Hub infrastructure

You must use a valid Red Hat Enterprise Linux CoreOS (RHCOS) image for Microsoft Azure Stack Hub for your OpenShift Container Platform nodes.

##### Prerequisites

- Configure an Azure account.
- Generate the Ignition config files for your cluster.
- Store the RHCOS virtual hard disk (VHD) cluster image in an Azure storage container.
- Store the bootstrap Ignition config file in an Azure storage container.

##### Procedure

1. Copy the template from the **ARM template for image storage** section of this topic and save it as **02\_storage.json** in your cluster's installation directory. This template describes the image storage that your cluster requires.
2. Export the RHCOS VHD blob URL as a variable:

```
$ export VHD_BLOB_URL=`az storage blob url --account-name ${CLUSTER_NAME}sa --
  account-key ${ACCOUNT_KEY} -c vhd -n "rhcos.vhd" -o tsv`
```

3. Deploy the cluster image:

```
$ az deployment group create -g ${RESOURCE_GROUP} \
  --template-file "<installation_directory>/02_storage.json" \
  --parameters vhdBlobURL="${VHD_BLOB_URL}" 1 \
  --parameters baseName="${INFRA_ID}" 2
```

- 1** The blob URL of the RHCOS VHD to be used to create master and worker machines.

- 2** The base name to be used in resource names; this is usually the cluster's infrastructure ID.

### 6.4.11.1. ARM template for image storage

You can use the following Azure Resource Manager (ARM) template to deploy the stored Red Hat Enterprise Linux CoreOS (RHCOS) image that you need for your OpenShift Container Platform cluster:

#### Example 6.2. 02\_storage.json ARM template

link:[https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/azurestack/02\\_storage.json](https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/azurestack/02_storage.json)

### 6.4.12. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

#### 6.4.12.1. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.



#### IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

Table 6.1. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	<b>1936</b>	Metrics
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> and the Cluster Version Operator on port <b>9099</b> .
	<b>10250-10259</b>	The default ports that Kubernetes reserves
	<b>10256</b>	openshift-sdn
UDP	<b>4789</b>	VXLAN and Geneve
	<b>6081</b>	VXLAN and Geneve

Protocol	Port	Description
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> .
	<b>500</b>	IPsec IKE packets
	<b>4500</b>	IPsec NAT-T packets
TCP/UDP	<b>30000-32767</b>	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 6.2. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	<b>6443</b>	Kubernetes API

Table 6.3. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	<b>2379-2380</b>	etcd server and peer ports

### 6.4.13. Creating networking and load balancing components in Azure Stack Hub

You must configure networking and load balancing in Microsoft Azure Stack Hub for your OpenShift Container Platform cluster to use. One way to create these components is to modify the provided Azure Resource Manager (ARM) template.

Load balancing requires the following DNS records:

- An **api** DNS record for the API public load balancer in the DNS zone.
- An **api-int** DNS record for the API internal load balancer in the DNS zone.



#### NOTE

If you do not use the provided ARM template to create your Azure Stack Hub infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

#### Prerequisites

- Configure an Azure account.
- Generate the Ignition config files for your cluster.



- Create and configure a VNet and associated subnets in Azure Stack Hub.

## Procedure

1. Copy the template from the **ARM template for the network and load balancers** section of this topic and save it as **03\_infra.json** in your cluster's installation directory. This template describes the networking and load balancing objects that your cluster requires.
2. Create the deployment by using the **az** CLI:

```
$ az deployment group create -g ${RESOURCE_GROUP} \
  --template-file "<installation_directory>/03_infra.json" \
  --parameters baseName="${INFRA_ID}" 1
```

- 1** The base name to be used in resource names; this is usually the cluster's infrastructure ID.

3. Create an **api** DNS record and an **api-int** DNS record. When creating the API DNS records, the **\${BASE\_DOMAIN\_RESOURCE\_GROUP}** variable must point to the resource group where the DNS zone exists.

- a. Export the following variable:

```
$ export PUBLIC_IP=`az network public-ip list -g ${RESOURCE_GROUP} --query "[?
name=='${INFRA_ID}-master-pip'] | [0].ipAddress" -o tsv`
```

- b. Export the following variable:

```
$ export PRIVATE_IP=`az network lb frontend-ip show -g "$RESOURCE_GROUP" --lb-
name "${INFRA_ID}-internal" -n internal-lb-ip --query "privatelbAddress" -o tsv`
```

- c. Create the **api** DNS record in a new DNS zone:

```
$ az network dns record-set a add-record -g ${BASE_DOMAIN_RESOURCE_GROUP} -
z ${CLUSTER_NAME}.${BASE_DOMAIN} -n api -a ${PUBLIC_IP} --ttl 60
```

If you are adding the cluster to an existing DNS zone, you can create the **api** DNS record in it instead:

```
$ az network dns record-set a add-record -g ${BASE_DOMAIN_RESOURCE_GROUP} -
z ${BASE_DOMAIN} -n api.${CLUSTER_NAME} -a ${PUBLIC_IP} --ttl 60
```

- d. Create the **api-int** DNS record in a new DNS zone:

```
$ az network dns record-set a add-record -g ${BASE_DOMAIN_RESOURCE_GROUP} -
z "${CLUSTER_NAME}.${BASE_DOMAIN}" -n api-int -a ${PRIVATE_IP} --ttl 60
```

If you are adding the cluster to an existing DNS zone, you can create the **api-int** DNS record in it instead:

```
$ az network dns record-set a add-record -g ${BASE_DOMAIN_RESOURCE_GROUP} -
z ${BASE_DOMAIN} -n api-int.${CLUSTER_NAME} -a ${PRIVATE_IP} --ttl 60
```

### 6.4.13.1. ARM template for the network and load balancers

You can use the following Azure Resource Manager (ARM) template to deploy the networking objects and load balancers that you need for your OpenShift Container Platform cluster:

#### Example 6.3. 03\_infra.json ARM template

link:[https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/azurestack/03\\_infra.json](https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/azurestack/03_infra.json)

### 6.4.14. Creating the bootstrap machine in Azure Stack Hub

You must create the bootstrap machine in Microsoft Azure Stack Hub to use during OpenShift Container Platform cluster initialization. One way to create this machine is to modify the provided Azure Resource Manager (ARM) template.



#### NOTE

If you do not use the provided ARM template to create your bootstrap machine, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

#### Prerequisites

- Configure an Azure account.
- Generate the Ignition config files for your cluster.
- Create and configure a VNet and associated subnets in Azure Stack Hub.
- Create and configure networking and load balancers in Azure Stack Hub.
- Create control plane and compute roles.

#### Procedure

1. Copy the template from the **ARM template for the bootstrap machines** section of this topic and save it as **04\_bootstrap.json** in your cluster's installation directory. This template describes the bootstrap machine that your cluster requires.

2. Export the bootstrap URL variable:

```
$ export BOOTSTRAP_URL=`az storage blob url --account-name ${CLUSTER_NAME}sa --account-key ${ACCOUNT_KEY} -c "files" -n "bootstrap.ign" -o tsv`
```

3. Export the bootstrap ignition variable:

- a. If your environment uses a public certificate authority (CA), run this command:

```
$ export BOOTSTRAP_IGNITION=`jq -rcnM --arg v "3.2.0" --arg url ${BOOTSTRAP_URL} '{ignition:{version:$v,config:{replace:{source:$url}}}}' | base64 | tr -d '\n'`
```

- b. If your environment uses an internal CA, you must add your PEM encoded bundle to the bootstrap ignition stub so that your bootstrap virtual machine can pull the bootstrap ignition from the storage account. Run the following commands, which assume your CA is in a file called **CA.pem**:

```
$ export CA="data:text/plain;charset=utf-8;base64,$(cat CA.pem |base64 |tr -d '\n')"
```

```
$ export BOOTSTRAP_IGNITION=`jq -rcnM --arg v "3.2.0" --arg url
"$BOOTSTRAP_URL" --arg cert "$CA" '{ignition:{version:$v,security:{tls:
{certificateAuthorities:[{source:$cert}]}}},config:{replace:{source:$url}}}' | base64 | tr -d
'\n'`
```

4. Create the deployment by using the **az** CLI:

```
$ az deployment group create --verbose -g ${RESOURCE_GROUP} \
--template-file "<installation_directory>/04_bootstrap.json" \
--parameters bootstrapIgnition="${BOOTSTRAP_IGNITION}" \ 1
--parameters sshKeyData="${SSH_KEY}" \ 2
--parameters baseName="${INFRA_ID}" \ 3
--parameters diagnosticsStorageAccountName="${CLUSTER_NAME}sa" 4
```

- 1** The bootstrap Ignition content for the bootstrap cluster.
- 2** The SSH RSA public key file as a string.
- 3** The base name to be used in resource names; this is usually the cluster's infrastructure ID.
- 4** The name of the storage account for your cluster.

#### 6.4.14.1. ARM template for the bootstrap machine

You can use the following Azure Resource Manager (ARM) template to deploy the bootstrap machine that you need for your OpenShift Container Platform cluster:

##### Example 6.4. 04\_bootstrap.json ARM template

link:[https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/azurestack/04\\_bootstrap.json](https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/azurestack/04_bootstrap.json)

#### 6.4.15. Creating the control plane machines in Azure Stack Hub

You must create the control plane machines in Microsoft Azure Stack Hub for your cluster to use. One way to create these machines is to modify the provided Azure Resource Manager (ARM) template.



#### NOTE

If you do not use the provided ARM template to create your control plane machines, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

## Prerequisites

- Configure an Azure account.
- Generate the Ignition config files for your cluster.
- Create and configure a VNet and associated subnets in Azure Stack Hub.
- Create and configure networking and load balancers in Azure Stack Hub.
- Create control plane and compute roles.
- Create the bootstrap machine.

## Procedure

1. Copy the template from the **ARM template for control plane machines** section of this topic and save it as **05\_masters.json** in your cluster's installation directory. This template describes the control plane machines that your cluster requires.
2. Export the following variable needed by the control plane machine deployment:

```
$ export MASTER_IGNITION=`cat <installation_directory>/master.ign | base64 | tr -d '\n`
```

3. Create the deployment by using the **az** CLI:

```
$ az deployment group create -g ${RESOURCE_GROUP} \
  --template-file "<installation_directory>/05_masters.json" \
  --parameters masterIgnition="${MASTER_IGNITION}" ① \
  --parameters sshKeyData="${SSH_KEY}" ② \
  --parameters baseName="${INFRA_ID}" ③ \
  --parameters diagnosticsStorageAccountName="${CLUSTER_NAME}sa" ④
```

- ① The Ignition content for the control plane nodes (also known as the master nodes).
- ② The SSH RSA public key file as a string.
- ③ The base name to be used in resource names; this is usually the cluster's infrastructure ID.
- ④ The name of the storage account for your cluster.

### 6.4.15.1. ARM template for control plane machines

You can use the following Azure Resource Manager (ARM) template to deploy the control plane machines that you need for your OpenShift Container Platform cluster:

#### Example 6.5. 05\_masters.json ARM template

```
link:https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/azurestack/05_masters.json[]
```

## 6.4.16. Wait for bootstrap completion and remove bootstrap resources in Azure Stack Hub

After you create all of the required infrastructure in Microsoft Azure Stack Hub, wait for the bootstrap process to complete on the machines that you provisioned by using the Ignition config files that you generated with the installation program.

### Prerequisites

- Configure an Azure account.
- Generate the Ignition config files for your cluster.
- Create and configure a VNet and associated subnets in Azure Stack Hub.
- Create and configure networking and load balancers in Azure Stack Hub.
- Create control plane and compute roles.
- Create the bootstrap machine.
- Create the control plane machines.

### Procedure

1. Change to the directory that contains the installation program and run the following command:

```

$ ./openshift-install wait-for bootstrap-complete --dir <installation_directory> \ 1
--log-level info 2

```

1 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

If the command exits without a **FATAL** warning, your production control plane has initialized.

2. Delete the bootstrap resources:

```

$ az network nsg rule delete -g ${RESOURCE_GROUP} --nsg-name ${INFRA_ID}-nsg --
name bootstrap_ssh_in
$ az vm stop -g ${RESOURCE_GROUP} --name ${INFRA_ID}-bootstrap
$ az vm deallocate -g ${RESOURCE_GROUP} --name ${INFRA_ID}-bootstrap
$ az vm delete -g ${RESOURCE_GROUP} --name ${INFRA_ID}-bootstrap --yes
$ az disk delete -g ${RESOURCE_GROUP} --name ${INFRA_ID}-bootstrap OSDisk --no-
wait --yes
$ az network nic delete -g ${RESOURCE_GROUP} --name ${INFRA_ID}-bootstrap-nic --no-
wait
$ az storage blob delete --account-key ${ACCOUNT_KEY} --account-name
${CLUSTER_NAME}sa --container-name files --name bootstrap.ign
$ az network public-ip delete -g ${RESOURCE_GROUP} --name ${INFRA_ID}-bootstrap-
ssh-pip

```

**NOTE**

If you do not delete the bootstrap server, installation may not succeed due to API traffic being routed to the bootstrap server.

**6.4.17. Creating additional worker machines in Azure Stack Hub**

You can create worker machines in Microsoft Azure Stack Hub for your cluster to use by launching individual instances discretely or by automated processes outside the cluster, such as auto scaling groups. You can also take advantage of the built-in cluster scaling mechanisms and the machine API in OpenShift Container Platform.

In this example, you manually launch one instance by using the Azure Resource Manager (ARM) template. Additional instances can be launched by including additional resources of type **06\_workers.json** in the file.

**NOTE**

If you do not use the provided ARM template to create your worker machines, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

**Prerequisites**

- Configure an Azure account.
- Generate the Ignition config files for your cluster.
- Create and configure a VNet and associated subnets in Azure Stack Hub.
- Create and configure networking and load balancers in Azure Stack Hub.
- Create control plane and compute roles.
- Create the bootstrap machine.
- Create the control plane machines.

**Procedure**

1. Copy the template from the **ARM template for worker machines** section of this topic and save it as **06\_workers.json** in your cluster's installation directory. This template describes the worker machines that your cluster requires.
2. Export the following variable needed by the worker machine deployment:

```
$ export WORKER_IGNITION=`cat <installation_directory>/worker.ign | base64 | tr -d '\n'`
```

3. Create the deployment by using the **az** CLI:

```
$ az deployment group create -g ${RESOURCE_GROUP} \
  --template-file "<installation_directory>/06_workers.json" \
  --parameters workerIgnition="${WORKER_IGNITION}" \ 1
```

```
--parameters sshKeyData="{SSH_KEY}" \ 2
--parameters baseName="{INFRA_ID}" 3
--parameters diagnosticsStorageAccountName="{CLUSTER_NAME}sa" 4
```

- 1 The Ignition content for the worker nodes.
- 2 The SSH RSA public key file as a string.
- 3 The base name to be used in resource names; this is usually the cluster's infrastructure ID.
- 4 The name of the storage account for your cluster.

### 6.4.17.1. ARM template for worker machines

You can use the following Azure Resource Manager (ARM) template to deploy the worker machines that you need for your OpenShift Container Platform cluster:

#### Example 6.6. 06\_workers.json ARM template

```
link:https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/azurestack/06_workers.json[]
```

### 6.4.18. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



#### IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

#### Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

```
$ tar xvf <file>
```

5. Place the **oc** binary in a directory that is on your **PATH**. To check your **PATH**, execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

### Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```



### 6.4.19. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

#### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

#### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

#### Example output

```
system:admin
```

### 6.4.20. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

#### Prerequisites

- You added machines to your cluster.

#### Procedure

1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

#### Example output

```
NAME      STATUS  ROLES  AGE  VERSION
master-0  Ready   master 63m  v1.22.1
master-1  Ready   master 63m  v1.22.1
master-2  Ready   master 64m  v1.22.1
```

The output lists all of the machines that you created.



#### NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

- Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

#### Example output

```
NAME      AGE   REQUESTOR                                     CONDITION
csr-8b2br 15m   system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper Pending
csr-8vnps 15m   system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper Pending
...
```

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

- If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:



#### NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.



#### NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

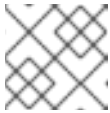
- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

**1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{\n"}\n{{end}}\n{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```



#### NOTE

Some Operators might not become available until some CSRs are approved.

- Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

#### Example output

```
NAME      AGE   REQUESTOR                                     CONDITION
csr-bfd72 5m26s system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv 5m26s system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

- If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

**1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{\n"}\n{{end}}\n{{end}}' | xargs oc adm certificate approve
```

- After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

#### Example output

```
NAME      STATUS   ROLES    AGE   VERSION
master-0 Ready    master   73m   v1.22.1
```

```

master-1 Ready   master 73m v1.22.1
master-2 Ready   master 74m v1.22.1
worker-0 Ready   worker 11m v1.22.1
worker-1 Ready   worker 11m v1.22.1

```



## NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

### Additional information

- For more information on CSRs, see [Certificate Signing Requests](#).

### 6.4.21. Adding the Ingress DNS records

If you removed the DNS Zone configuration when creating Kubernetes manifests and generating Ignition configs, you must manually create DNS records that point at the Ingress load balancer. You can create either a wildcard **\*.apps.{baseDomain}**, or specific records. You can use A, CNAME, and other records per your requirements.

### Prerequisites

- You deployed an OpenShift Container Platform cluster on Microsoft Azure Stack Hub by using infrastructure that you provisioned.
- Install the OpenShift CLI (**oc**).
- Install or update the [Azure CLI](#).

### Procedure

1. Confirm the Ingress router has created a load balancer and populated the **EXTERNAL-IP** field:

```
$ oc -n openshift-ingress get service router-default
```

### Example output

```

NAME          TYPE          CLUSTER-IP    EXTERNAL-IP    PORT(S)          AGE
router-default LoadBalancer  172.30.20.10  35.130.120.110 80:32288/TCP,443:31215/TCP 20

```

2. Export the Ingress router IP as a variable:

```
$ export PUBLIC_IP_ROUTER=`oc -n openshift-ingress get service router-default --no-headers | awk '{print $4}'`
```

3. Add a **\*.apps** record to the DNS zone.

- a. If you are adding this cluster to a new DNS zone, run:

```
$ az network dns record-set a add-record -g ${BASE_DOMAIN_RESOURCE_GROUP} -z ${CLUSTER_NAME}.${BASE_DOMAIN} -n *.apps -a ${PUBLIC_IP_ROUTER} --ttl 300
```

b. If you are adding this cluster to an already existing DNS zone, run:

```
$ az network dns record-set a add-record -g ${BASE_DOMAIN_RESOURCE_GROUP} -
z ${BASE_DOMAIN} -n *.apps.${CLUSTER_NAME} -a ${PUBLIC_IP_ROUTER} --ttl 300
```

If you prefer to add explicit domains instead of using a wildcard, you can create entries for each of the cluster's current routes:

```
$ oc get --all-namespaces -o jsonpath='{range .items[*]}{range .status.ingress[*]}{.host}{"\n"}{end}
{end}' routes
```

### Example output

```
oauth-openshift.apps.cluster.basedomain.com
console-openshift-console.apps.cluster.basedomain.com
downloads-openshift-console.apps.cluster.basedomain.com
alertmanager-main-openshift-monitoring.apps.cluster.basedomain.com
grafana-openshift-monitoring.apps.cluster.basedomain.com
prometheus-k8s-openshift-monitoring.apps.cluster.basedomain.com
```

## 6.4.22. Completing an Azure Stack Hub installation on user-provisioned infrastructure

After you start the OpenShift Container Platform installation on Microsoft Azure Stack Hub user-provisioned infrastructure, you can monitor the cluster events until the cluster is ready.

### Prerequisites

- Deploy the bootstrap machine for an OpenShift Container Platform cluster on user-provisioned Azure Stack Hub infrastructure.
- Install the **oc** CLI and log in.

### Procedure

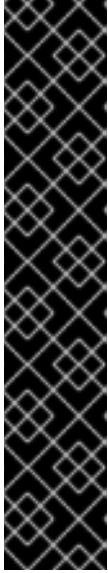
- Complete the cluster installation:

```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

### Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.



## IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service.

## CHAPTER 7. INSTALLING ON GCP

### 7.1. PREPARING TO INSTALL ON GCP

#### 7.1.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).

#### 7.1.2. Requirements for installing OpenShift Container Platform on GCP

Before installing OpenShift Container Platform on Google Cloud Platform (GCP), you must create a service account and configure a GCP project. See [Configuring a GCP project](#) for details about creating a project, enabling API services, configuring DNS, GCP account limits, and supported GCP regions.

If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, see [Manually creating IAM for GCP](#) for other options.

#### 7.1.3. Choosing a method to install OpenShift Container Platform on GCP

You can install OpenShift Container Platform on installer-provisioned or user-provisioned infrastructure. The default installation type uses installer-provisioned infrastructure, where the installation program provisions the underlying infrastructure for the cluster. You can also install OpenShift Container Platform on infrastructure that you provision. If you do not use infrastructure that the installation program provisions, you must manage and maintain the cluster resources yourself.

See [Installation process](#) for more information about installer-provisioned and user-provisioned installation processes.

##### 7.1.3.1. Installing a cluster on installer-provisioned infrastructure

You can install a cluster on GCP infrastructure that is provisioned by the OpenShift Container Platform installation program, by using one of the following methods:

- **Installing a cluster quickly on GCP** You can install OpenShift Container Platform on GCP infrastructure that is provisioned by the OpenShift Container Platform installation program. You can install a cluster quickly by using the default configuration options.
- **Installing a customized cluster on GCP** You can install a customized cluster on GCP infrastructure that the installation program provisions. The installation program allows for some customization to be applied at the installation stage. Many other customization options are available [post-installation](#).
- **Installing a cluster on GCP with network customizations** You can customize your OpenShift Container Platform network configuration during installation, so that your cluster can coexist with your existing IP address allocations and adhere to your network requirements.
- **Installing a cluster on GCP in a restricted network** You can install OpenShift Container Platform on GCP on installer-provisioned infrastructure by using an internal mirror of the installation release content. You can use this method to install a cluster that does not require an

active internet connection to obtain the software components. While you can install OpenShift Container Platform by using the mirrored content, your cluster still requires internet access to use the GCP APIs.

- **Installing a cluster into an existing Virtual Private Cloud** You can install OpenShift Container Platform on an existing GCP Virtual Private Cloud (VPC). You can use this installation method if you have constraints set by the guidelines of your company, such as limits on creating new accounts or infrastructure.
- **Installing a private cluster on an existing VPC** You can install a private cluster on an existing GCP VPC. You can use this method to deploy OpenShift Container Platform on an internal network that is not visible to the internet.

### 7.1.3.2. Installing a cluster on user-provisioned infrastructure

You can install a cluster on GCP infrastructure that you provision, by using one of the following methods:

- **Installing a cluster on GCP with user-provisioned infrastructure** You can install OpenShift Container Platform on GCP infrastructure that you provide. You can use the provided Deployment Manager templates to assist with the installation.
- **Installing a cluster with shared VPC on user-provisioned infrastructure in GCP** You can use the provided Deployment Manager templates to create GCP resources in a shared VPC infrastructure.
- **Installing a cluster on GCP in a restricted network with user-provisioned infrastructure** You can install OpenShift Container Platform on GCP in a restricted network with user-provisioned infrastructure. By creating an internal mirror of the installation release content, you can install a cluster that does not require an active internet connection to obtain the software components. You can also use this installation method to ensure that your clusters only use container images that satisfy your organizational controls on external content.

### 7.1.4. Next steps

- [Configuring a GCP project](#)

## 7.2. CONFIGURING A GCP PROJECT

Before you can install OpenShift Container Platform, you must configure a Google Cloud Platform (GCP) project to host it.

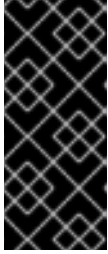
### 7.2.1. Creating a GCP project

To install OpenShift Container Platform, you must create a project in your Google Cloud Platform (GCP) account to host the cluster.

#### Procedure

- Create a project to host your OpenShift Container Platform cluster. See [Creating and Managing Projects](#) in the GCP documentation.





## IMPORTANT

Your GCP project must use the Premium Network Service Tier if you are using installer-provisioned infrastructure. The Standard Network Service Tier is not supported for clusters installed using the installation program. The installation program configures internal load balancing for the **api-int.<cluster\_name>.<base\_domain>** URL; the Premium Tier is required for internal load balancing.

### 7.2.2. Enabling API services in GCP

Your Google Cloud Platform (GCP) project requires access to several API services to complete OpenShift Container Platform installation.

#### Prerequisites

- You created a project to host your cluster.

#### Procedure

- Enable the following required API services in the project that hosts your cluster. See [Enabling services](#) in the GCP documentation.

**Table 7.1. Required API services**

API service	Console service name
Compute Engine API	<b>compute.googleapis.com</b>
Google Cloud APIs	<b>cloudapis.googleapis.com</b>
Cloud Resource Manager API	<b>cloudresourcemanager.googleapis.com</b>
Google DNS API	<b>dns.googleapis.com</b>
IAM Service Account Credentials API	<b>iamcredentials.googleapis.com</b>
Identity and Access Management (IAM) API	<b>iam.googleapis.com</b>
Service Management API	<b>servicemanagement.googleapis.com</b>
Service Usage API	<b>serviceusage.googleapis.com</b>
Google Cloud Storage JSON API	<b>storage-api.googleapis.com</b>
Cloud Storage	<b>storage-component.googleapis.com</b>

### 7.2.3. Configuring DNS for GCP

To install OpenShift Container Platform, the Google Cloud Platform (GCP) account you use must have a dedicated public hosted zone in the same project that you host the OpenShift Container Platform

cluster. This zone must be authoritative for the domain. The DNS service provides cluster DNS resolution and name lookup for external connections to the cluster.

## Procedure

1. Identify your domain, or subdomain, and registrar. You can transfer an existing domain and registrar or obtain a new one through GCP or another source.



### NOTE

If you purchase a new domain, it can take time for the relevant DNS changes to propagate. For more information about purchasing domains through Google, see [Google Domains](#).

2. Create a public hosted zone for your domain or subdomain in your GCP project. See [Creating public zones](#) in the GCP documentation. Use an appropriate root domain, such as **openshiftcorp.com**, or subdomain, such as **clusters.openshiftcorp.com**.
3. Extract the new authoritative name servers from the hosted zone records. See [Look up your Cloud DNS name servers](#) in the GCP documentation. You typically have four name servers.
4. Update the registrar records for the name servers that your domain uses. For example, if you registered your domain to Google Domains, see the following topic in the Google Domains Help: [How to switch to custom name servers](#).
5. If you migrated your root domain to Google Cloud DNS, migrate your DNS records. See [Migrating to Cloud DNS](#) in the GCP documentation.
6. If you use a subdomain, follow your company's procedures to add its delegation records to the parent domain. This process might include a request to your company's IT department or the division that controls the root domain and DNS services for your company.

## 7.2.4. GCP account limits

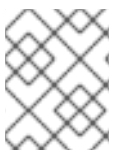
The OpenShift Container Platform cluster uses a number of Google Cloud Platform (GCP) components, but the default [Quotas](#) do not affect your ability to install a default OpenShift Container Platform cluster.

A default cluster, which contains three compute and three control plane machines, uses the following resources. Note that some resources are required only during the bootstrap process and are removed after the cluster deploys.

**Table 7.2. GCP resources used in a default cluster**

Service	Component	Location	Total resources required	Resources removed after bootstrap
Service account	IAM	Global	5	0
Firewall rules	Compute	Global	11	1

Service	Component	Location	Total resources required	Resources removed after bootstrap
Forwarding rules	Compute	Global	2	0
In-use global IP addresses	Compute	Global	4	1
Health checks	Compute	Global	3	0
Images	Compute	Global	1	0
Networks	Compute	Global	2	0
Static IP addresses	Compute	Region	4	1
Routers	Compute	Global	1	0
Routes	Compute	Global	2	0
Subnetworks	Compute	Global	2	0
Target pools	Compute	Global	3	0
CPUs	Compute	Region	28	4
Persistent disk SSD (GB)	Compute	Region	896	128



## NOTE

If any of the quotas are insufficient during installation, the installation program displays an error that states both which quota was exceeded and the region.

Be sure to consider your actual cluster size, planned cluster growth, and any usage from other clusters that are associated with your account. The CPU, static IP addresses, and persistent disk SSD (storage) quotas are the ones that are most likely to be insufficient.

If you plan to deploy your cluster in one of the following regions, you will exceed the maximum storage quota and are likely to exceed the CPU quota limit:

- **asia-east2**
- **asia-northeast2**
- **asia-south1**
- **australia-southeast1**

- **europa-north1**
- **europa-west2**
- **europa-west3**
- **europa-west6**
- **northamerica-northeast1**
- **southamerica-east1**
- **us-west2**

You can increase resource quotas from the [GCP console](#), but you might need to file a support ticket. Be sure to plan your cluster size early so that you can allow time to resolve the support ticket before you install your OpenShift Container Platform cluster.

## 7.2.5. Creating a service account in GCP

OpenShift Container Platform requires a Google Cloud Platform (GCP) service account that provides authentication and authorization to access data in the Google APIs. If you do not have an existing IAM service account that contains the required roles in your project, you must create one.

### Prerequisites

- You created a project to host your cluster.

### Procedure

1. Create a service account in the project that you use to host your OpenShift Container Platform cluster. See [Creating a service account](#) in the GCP documentation.
2. Grant the service account the appropriate permissions. You can either grant the individual permissions that follow or assign the **Owner** role to it. See [Granting roles to a service account for specific resources](#).



### NOTE

While making the service account an owner of the project is the easiest way to gain the required permissions, it means that service account has complete control over the project. You must determine if the risk that comes from offering that power is acceptable.

3. Create the service account key in JSON format. See [Creating service account keys](#) in the GCP documentation.  
The service account key is required to create a cluster.

### 7.2.5.1. Required GCP permissions

When you attach the **Owner** role to the service account that you create, you grant that service account all permissions, including those that are required to install OpenShift Container Platform. To deploy an OpenShift Container Platform cluster, the service account requires the following permissions. If you deploy your cluster into an existing VPC, the service account does not require certain networking permissions, which are noted in the following lists:

### Required roles for the installation program

- Compute Admin
- Security Admin
- Service Account Admin
- Service Account User
- Storage Admin

### Required roles for creating network resources during installation

- DNS Administrator

### Optional roles

For the cluster to create new limited credentials for its Operators, add the following role:

- Service Account Key Admin

The roles are applied to the service accounts that the control plane and compute machines use:

**Table 7.3. GCP service account permissions**

Account	Roles
Control Plane	<b>roles/compute.instanceAdmin</b>
	<b>roles/compute.networkAdmin</b>
	<b>roles/compute.securityAdmin</b>
	<b>roles/storage.admin</b>
	<b>roles/iam.serviceAccountUser</b>
Compute	<b>roles/compute.viewer</b>
	<b>roles/storage.admin</b>

### 7.2.6. Supported GCP regions

You can deploy an OpenShift Container Platform cluster to the following Google Cloud Platform (GCP) regions:

- **asia-east1** (Changhua County, Taiwan)
- **asia-east2** (Hong Kong)
- **asia-northeast1** (Tokyo, Japan)
- **asia-northeast2** (Osaka, Japan)

- **asia-northeast3** (Seoul, South Korea)
- **asia-south1** (Mumbai, India)
- **asia-southeast1** (Jurong West, Singapore)
- **asia-southeast2** (Jakarta, Indonesia)
- **australia-southeast1** (Sydney, Australia)
- **europa-central2** (Warsaw, Poland)
- **europa-north1** (Hamina, Finland)
- **europa-west1** (St. Ghislain, Belgium)
- **europa-west2** (London, England, UK)
- **europa-west3** (Frankfurt, Germany)
- **europa-west4** (Eemshaven, Netherlands)
- **europa-west6** (Zürich, Switzerland)
- **northamerica-northeast1** (Montréal, Québec, Canada)
- **southamerica-east1** (São Paulo, Brazil)
- **us-central1** (Council Bluffs, Iowa, USA)
- **us-east1** (Moncks Corner, South Carolina, USA)
- **us-east4** (Ashburn, Northern Virginia, USA)
- **us-west1** (The Dalles, Oregon, USA)
- **us-west2** (Los Angeles, California, USA)
- **us-west3** (Salt Lake City, Utah, USA)
- **us-west4** (Las Vegas, Nevada, USA)

### 7.2.7. Next steps

- Install an OpenShift Container Platform cluster on GCP. You can [install a customized cluster](#) or [quickly install a cluster](#) with default options.

## 7.3. MANUALLY CREATING IAM FOR GCP

In environments where the cloud identity and access management (IAM) APIs are not reachable, or the administrator prefers not to store an administrator-level credential secret in the cluster **kube-system** namespace, you can put the Cloud Credential Operator (CCO) into manual mode before you install the cluster.

### 7.3.1. Alternatives to storing administrator-level secrets in the kube-system project

The Cloud Credential Operator (CCO) manages cloud provider credentials as Kubernetes custom resource definitions (CRDs). You can configure the CCO to suit the security requirements of your organization by setting different values for the **credentialsMode** parameter in the **install-config.yaml** file.

If you prefer not to store an administrator-level credential secret in the cluster **kube-system** project, you can choose one of the following options when installing OpenShift Container Platform:

- **Manage cloud credentials manually.**

You can set the **credentialsMode** parameter for the CCO to **Manual** to manage cloud credentials manually. Using manual mode allows each cluster component to have only the permissions it requires, without storing an administrator-level credential in the cluster. You can also use this mode if your environment does not have connectivity to the cloud provider public IAM endpoint. However, you must manually reconcile permissions with new release images for every upgrade. You must also manually supply credentials for every component that requests them.

- **Remove the administrator-level credential secret after installing OpenShift Container Platform with mint mode:**

If you are using the CCO with the **credentialsMode** parameter set to **Mint**, you can remove or rotate the administrator-level credential after installing OpenShift Container Platform. Mint mode is the default configuration for the CCO. This option requires the presence of the administrator-level credential during an installation. The administrator-level credential is used during the installation to mint other credentials with some permissions granted. The original credential secret is not stored in the cluster permanently.



#### NOTE

Prior to a non z-stream upgrade, you must reinstate the credential secret with the administrator-level credential. If the credential is not present, the upgrade might be blocked.

#### Additional resources

- [Rotating or removing cloud provider credentials.](#)

For a detailed description of all available CCO credential modes and their supported platforms, see [About the Cloud Credential Operator](#).

### 7.3.2. Manually create IAM

The Cloud Credential Operator (CCO) can be put into manual mode prior to installation in environments where the cloud identity and access management (IAM) APIs are not reachable, or the administrator prefers not to store an administrator-level credential secret in the cluster **kube-system** namespace.

#### Procedure

1. Change to the directory that contains the installation program and create the **install-config.yaml** file by running the following command:

```
$ openshift-install create install-config --dir <installation_directory>
```

where **<installation\_directory>** is the directory in which the installation program creates files.

2. Edit the **install-config.yaml** configuration file so that it contains the **credentialsMode** parameter set to **Manual**.

### Example install-config.yaml configuration file

```
apiVersion: v1
baseDomain: cluster1.example.com
credentialsMode: Manual 1
compute:
- architecture: amd64
  hyperthreading: Enabled
...
```

- 1** This line is added to set the **credentialsMode** parameter to **Manual**.

3. To generate the manifests, run the following command from the directory that contains the installation program:

```
$ openshift-install create manifests --dir <installation_directory>
```

where **<installation\_directory>** is the directory in which the installation program creates files.

4. From the directory that contains the installation program, obtain details of the OpenShift Container Platform release image that your **openshift-install** binary is built to use by running the following command:

```
$ openshift-install version
```

### Example output

```
release image quay.io/openshift-release-dev/ocp-release:4.y.z-x86_64
```

5. Locate all **CredentialsRequest** objects in this release image that target the cloud you are deploying on by running the following command:

```
$ oc adm release extract quay.io/openshift-release-dev/ocp-release:4.y.z-x86_64 \
--credentials-requests \
--cloud=gcp
```

This command creates a YAML file for each **CredentialsRequest** object.

### Sample CredentialsRequest object

```
apiVersion: cloudcredential.openshift.io/v1
kind: CredentialsRequest
metadata:
  name: <component-credentials-request>
  namespace: openshift-cloud-credential-operator
...
spec:
  providerSpec:
    apiVersion: cloudcredential.openshift.io/v1
    kind: GCPProviderSpec
```



```

predefinedRoles:
- roles/storage.admin
- roles/iam.serviceAccountUser
skipServiceCheck: true
...

```

6. Create YAML files for secrets in the **openshift-install** manifests directory that you generated previously. The secrets must be stored using the namespace and secret name defined in the **spec.secretRef** for each **CredentialsRequest** object.

### Sample CredentialsRequest object with secrets

```

apiVersion: cloudcredential.openshift.io/v1
kind: CredentialsRequest
metadata:
  name: <component-credentials-request>
  namespace: openshift-cloud-credential-operator
  ...
spec:
  providerSpec:
    apiVersion: cloudcredential.openshift.io/v1
    ...
  secretRef:
    name: <component-secret>
    namespace: <component-namespace>
  ...

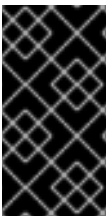
```

### Sample Secret object

```

apiVersion: v1
kind: Secret
metadata:
  name: <component-secret>
  namespace: <component-namespace>
data:
  service_account.json: <base64_encoded_gcp_service_account_file>

```



### IMPORTANT

Before upgrading a cluster that uses manually maintained credentials, you must ensure that the CCO is in an upgradeable state. For details, see the "Upgrading clusters with manually maintained credentials" section of the installation content for your cloud provider.

### 7.3.3. Upgrading clusters with manually maintained credentials

The Cloud Credential Operator (CCO) **Upgradable** status for a cluster with manually maintained credentials is **False** by default.

- For minor releases, for example, from 4.8 to 4.9, this status prevents you from upgrading until you have addressed any updated permissions and annotated the **CloudCredential** resource to indicate that the permissions are updated as needed for the next version. This annotation changes the **Upgradable** status to **True**.

- For z-stream releases, for example, from 4.9.0 to 4.9.1, no permissions are added or changed, so the upgrade is not blocked.

Before upgrading a cluster with manually maintained credentials, you must create any new credentials for the release image that you are upgrading to. Additionally, you must review the required permissions for existing credentials and accommodate any new permissions requirements in the new release for those components.

## Procedure

1. Extract and examine the **CredentialsRequest** custom resource for the new release. The "Manually creating IAM" section of the installation content for your cloud provider explains how to obtain and use the credentials required for your cloud.
2. Update the manually maintained credentials on your cluster:
  - Create new secrets for any **CredentialsRequest** custom resources that are added by the new release image.
  - If the **CredentialsRequest** custom resources for any existing credentials that are stored in secrets have changed their permissions requirements, update the permissions as required.
3. When all of the secrets are correct for the new release, indicate that the cluster is ready to upgrade:
  - a. Log in to the OpenShift Container Platform CLI as a user with the **cluster-admin** role.
  - b. Edit the **CloudCredential** resource to add an **upgradeable-to** annotation within the **metadata** field:

```
$ oc edit cloudcredential cluster
```

### Text to add

```
...
  metadata:
    annotations:
      cloudcredential.openshift.io/upgradeable-to: <version_number>
  ...
```

Where **<version\_number>** is the version you are upgrading to, in the format **x.y.z**. For example, **4.8.2** for OpenShift Container Platform 4.8.2.

It may take several minutes after adding the annotation for the upgradeable status to change.

4. Verify that the CCO is upgradeable:
  - a. In the **Administrator** perspective of the web console, navigate to **Administration** → **Cluster Settings**.
  - b. To view the CCO status details, click **cloud-credential** in the **Cluster Operators** list.
  - c. If the **Upgradeable** status in the **Conditions** section is **False**, verify that the **upgradeable-to** annotation is free of typographical errors.

When the **Upgradeable** status in the **Conditions** section is **True**, you can begin the OpenShift Container Platform upgrade.

:\_content-type: CONCEPT

### 7.3.4. Mint mode

Mint mode is the default Cloud Credential Operator (CCO) credentials mode for OpenShift Container Platform. In this mode, the CCO uses the provided administrator-level cloud credential to run the cluster. Mint mode is supported for AWS and GCP.

In mint mode, the **admin** credential is stored in the **kube-system** namespace and then used by the CCO to process the **CredentialsRequest** objects in the cluster and create users for each with specific permissions.

The benefits of mint mode include:

- Each cluster component has only the permissions it requires
- Automatic, on-going reconciliation for cloud credentials, including additional credentials or permissions that might be required for upgrades

One drawback is that mint mode requires **admin** credential storage in a cluster **kube-system** secret.

### 7.3.5. Mint mode with removal or rotation of the administrator-level credential

Currently, this mode is only supported on AWS and GCP.

In this mode, a user installs OpenShift Container Platform with an administrator-level credential just like the normal mint mode. However, this process removes the administrator-level credential secret from the cluster post-installation.

The administrator can have the Cloud Credential Operator make its own request for a read-only credential that allows it to verify if all **CredentialsRequest** objects have their required permissions, thus the administrator-level credential is not required unless something needs to be changed. After the associated credential is removed, it can be deleted or deactivated on the underlying cloud, if desired.



#### NOTE

Prior to a non z-stream upgrade, you must reinstate the credential secret with the administrator-level credential. If the credential is not present, the upgrade might be blocked.

The administrator-level credential is not stored in the cluster permanently.

Following these steps still requires the administrator-level credential in the cluster for brief periods of time. It also requires manually re-instating the secret with administrator-level credentials for each upgrade.

### 7.3.6. Next steps

- Install an OpenShift Container Platform cluster:

- [Installing a cluster quickly on GCP](#) with default options on installer-provisioned infrastructure
- [Install a cluster with cloud customizations on installer-provisioned infrastructure](#)
- [Install a cluster with network customizations on installer-provisioned infrastructure](#)

## 7.4. INSTALLING A CLUSTER QUICKLY ON GCP

In OpenShift Container Platform version 4.9, you can install a cluster on Google Cloud Platform (GCP) that uses the default configuration options.

### 7.4.1. Prerequisites

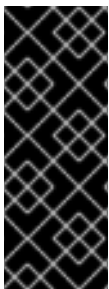
- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You [configured a GCP project](#) to host the cluster.
- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can [manually create and maintain IAM credentials](#).

### 7.4.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



#### IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

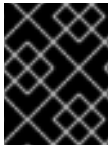
### 7.4.3. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes

through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.



### IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



### NOTE

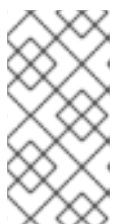
You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

## Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.



### NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.

**NOTE**

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

**Example output**

```
Agent pid 31874
```

**NOTE**

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1** Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

**Example output**

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

5. Set the **GOOGLE\_APPLICATION\_CREDENTIALS** environment variable to the full path to your service account private key file.

```
$ export GOOGLE_APPLICATION_CREDENTIALS="<your_service_account_file>"
```

6. Verify that the credentials were applied.

```
$ gcloud auth list
```

**Next steps**

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

**7.4.4. Obtaining the installation program**

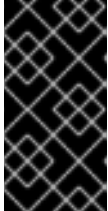
Before you install OpenShift Container Platform, download the installation file on a local computer.

**Prerequisites**

- You have a computer that runs Linux or macOS, with 500 MB of local disk space

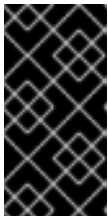
## Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



### IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



### IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#) . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

## 7.4.5. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



### IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

## Prerequisites

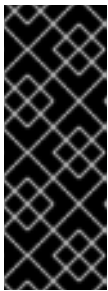
- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

## Procedure

1. Remove any existing GCP credentials that do not use the service account key for the GCP account that you configured for your cluster and that are stored in the following locations:
  - The **GOOGLE\_CREDENTIALS**, **GOOGLE\_CLOUD\_KEYFILE\_JSON**, or **GKLOUD\_KEYFILE\_JSON** environment variables
  - The `~/.gcp/osServiceAccount.json` file
  - The **gcloud cli** default credentials
2. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
--log-level=info 2
```

- 1** For `<installation_directory>`, specify the directory name to store the files that the installation program creates.
- 2** To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.



### IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

Provide values at the prompts:

- a. Optional: Select an SSH key to use to access your cluster machines.



### NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

- b. Select **gcp** as the platform to target.
- c. If you have not configured the service account key for your GCP account on your computer, you must obtain it from GCP and paste the contents of the file or enter the absolute path to the file.
- d. Select the project ID to provision the cluster in. The default value is specified by the service account that you configured.
- e. Select the region to deploy the cluster to.
- f. Select the base domain to deploy the cluster to. The base domain corresponds to the public DNS zone that you created for your cluster.



- g. Enter a descriptive name for your cluster. If you provide a name that is longer than 6 characters, only the first 6 characters will be used in the infrastructure ID that is generated from the cluster name.
- h. Paste the [pull secret from the Red Hat OpenShift Cluster Manager](#) .



### NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

When the cluster deployment completes, directions for accessing your cluster, including a link to its web console and credentials for the **kubeadmin** user, display in your terminal.

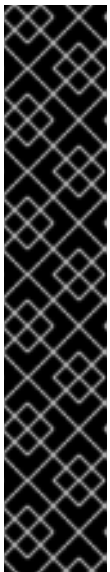
### Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Ee6gm-ymBZj-
Wt5AL"
INFO Time elapsed: 36m22s
```



### NOTE

The cluster access and credential information also outputs to **<installation\_directory>/openshift\_install.log** when an installation succeeds.



### IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.



### IMPORTANT

You must not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

- Optional: You can reduce the number of permissions for the service account that you used to install the cluster.
  - If you assigned the **Owner** role to your service account, you can remove that role and replace it with the **Viewer** role.
  - If you included the **Service Account Key Admin** role, you can remove it.

### 7.4.6. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



#### IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

#### Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

##### Procedure

- Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
- Select the appropriate version in the **Version** drop-down menu.
- Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
- Unpack the archive:

```
$ tar xvf <file>
```

- Place the **oc** binary in a directory that is on your **PATH**.  
To check your **PATH**, execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

#### Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

##### Procedure

- Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
- Select the appropriate version in the **Version** drop-down menu.
- Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.

4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

### Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### 7.4.7. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

#### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

#### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1 For `<installation_directory>`, specify the path to the directory that you stored the installation files in.

2. Verify you can run `oc` commands successfully using the exported configuration:

```
$ oc whoami
```

#### Example output

```
system:admin
```

#### Additional resources

- See [Accessing the web console](#) for more details about accessing and understanding the OpenShift Container Platform web console.

### 7.4.8. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

#### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

### 7.4.9. Next steps

- [Customize your cluster](#).
- If necessary, you can [opt out of remote health reporting](#).

## 7.5. INSTALLING A CLUSTER ON GCP WITH CUSTOMIZATIONS

In OpenShift Container Platform version 4.9, you can install a customized cluster on infrastructure that the installation program provisions on Google Cloud Platform (GCP). To customize the installation, you modify parameters in the `install-config.yaml` file before you install the cluster.

### 7.5.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You [configured a GCP project](#) to host the cluster.

- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can [manually create and maintain IAM credentials](#).

## 7.5.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



### IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

## 7.5.3. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.



### IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



### NOTE

You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

## Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.



### NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.



### NOTE

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

### Example output

```
Agent pid 31874
```



### NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

■

```
$ ssh-add <path>/<file_name> 1
```

- 1 Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

### Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

5. Set the **GOOGLE\_APPLICATION\_CREDENTIALS** environment variable to the full path to your service account private key file.

```
$ export GOOGLE_APPLICATION_CREDENTIALS="<your_service_account_file>"
```

6. Verify that the credentials were applied.

```
$ gcloud auth list
```

### Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

## 7.5.4. Obtaining the installation program

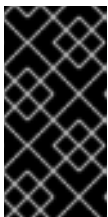
Before you install OpenShift Container Platform, download the installation file on a local computer.

### Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space

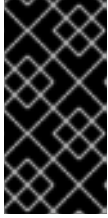
### Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



### IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



## IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#) . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

### 7.5.5. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Google Cloud Platform (GCP).

#### Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

#### Procedure

1. Create the **install-config.yaml** file.
  - a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

- 1** For **<installation\_directory>**, specify the directory name to store the files that the installation program creates.



## IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

- b. At the prompts, provide the configuration details for your cloud:



- i. Optional: Select an SSH key to use to access your cluster machines.



#### NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

- ii. Select **gcp** as the platform to target.
  - iii. If you have not configured the service account key for your GCP account on your computer, you must obtain it from GCP and paste the contents of the file or enter the absolute path to the file.
  - iv. Select the project ID to provision the cluster in. The default value is specified by the service account that you configured.
  - v. Select the region to deploy the cluster to.
  - vi. Select the base domain to deploy the cluster to. The base domain corresponds to the public DNS zone that you created for your cluster.
  - vii. Enter a descriptive name for your cluster.
  - viii. Paste the [pull secret from the Red Hat OpenShift Cluster Manager](#) .
2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.
  3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



#### IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

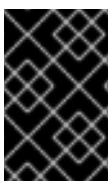
### 7.5.5.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.



#### NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.



#### IMPORTANT

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

## 7.5.5.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 7.4. Required parameters

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;</b> . <b>&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}</b> . <b>{{.baseDomain}}</b> .	String of lowercase letters, hyphens (-), and periods (.), such as <b>dev</b> .
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws</b> , <b>baremetal</b> , <b>azure</b> , <b>gcp</b> , <b>openstack</b> , <b>ovirt</b> , <b>vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object


Parameter	Description	Values
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } }</pre>


### 7.5.5.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

Table 7.5. Network parameters


Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	Object <div style="display: flex; align-items: center; margin-top: 10px;">  <div> <p><b>NOTE</b></p> <p>You cannot modify parameters specified by the <b>networking</b> object after installation.</p> </div> </div>
<b>networking.networkType</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .


Parameter	Description	Values
<b>networking.clusterNetwork</b>	<p>The IP address blocks for pods.</p> <p>The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b>.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   clusterNetwork:     - cidr: 10.128.0.0/14       hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	<p>Required if you use <b>networking.clusterNetwork</b>. An IP address block.</p> <p>An IPv4 network.</p>	<p>An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b>.</p>
<b>networking.clusterNetwork.hostPrefix</b>	<p>The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b>. A <b>hostPrefix</b> value of <b>23</b> provides 510 (<math>2^{(32 - 23)} - 2</math>) pod IP addresses.</p>	<p>A subnet prefix.</p> <p>The default value is <b>23</b>.</p>
<b>networking.serviceNetwork</b>	<p>The IP address block for services. The default value is <b>172.30.0.0/16</b>.</p> <p>The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.</p>	<p>An array with an IP address block in CIDR format. For example:</p> <pre>networking:   serviceNetwork:     - 172.30.0.0/16</pre>
<b>networking.machineNetwork</b>	<p>The IP address blocks for machines.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   machineNetwork:     - cidr: 10.0.0.0/16</pre>
<b>networking.machineNetwork.cidr</b>	<p>Required if you use <b>networking.machineNetwork</b>. An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b>.</p>	<p>An IP network block in CIDR notation.</p> <p>For example, <b>10.0.0.0/16</b>.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p> </div> </div>



## 7.5.5.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

Table 7.6. Optional parameters


Parameter	Description	Values
<b>additionalTrustBundle</b>	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
<b>compute</b>	The configuration for the machines that comprise the compute nodes.	Array of <b>MachinePool</b> objects.
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String
<b>compute.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>

Parameter	Description	Values
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String
<b>controlPlane.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div data-bbox="486 1093 593 1411" style="background-color: black; color: white; padding: 5px; display: inline-block; font-size: 0.8em; margin-bottom: 10px;">  </div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platform</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b>
<b>controlPlane.replicas</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.

Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported. If you are installing on GCP into a shared virtual private cloud (VPC), <b>credentialsMode</b> must be set to <b>Passthrough</b>.</p> <p> <b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators reference</i> content.</p> <p> <b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p>	<b>Mint, Passthrough, Manual</b> or an empty string ("").

Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start;"> <div style="width: 40px; height: 40px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 40px; height: 40px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<b>Internal</b> or <b>External</b> . To deploy a private cluster, which cannot be accessed from the internet, set <b>publish</b> to <b>Internal</b> . The default value is <b>External</b> .




Parameter	Description	Values
<b>sshKey</b>	<p>The SSH key or keys to authenticate access your cluster machines.</p>  <p><b>NOTE</b></p> <p>For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.</p>	<p>One or more keys. For example:</p> <pre>sshKey:   &lt;key1&gt;   &lt;key2&gt;   &lt;key3&gt;</pre>

#### 7.5.5.1.4. Additional Google Cloud Platform (GCP) configuration parameters

Additional GCP configuration parameters are described in the following table:

Table 7.7. Additional GCP parameters

Parameter	Description	Values
<b>platform.gcp.network</b>	The name of the existing VPC that you want to deploy your cluster to.	String.
<b>platform.gcp.region</b>	The name of the GCP region that hosts your cluster.	Any valid region name, such as <b>us-central1</b> .
<b>platform.gcp.type</b>	The <a href="#">GCP machine type</a> .	The GCP machine type.
<b>platform.gcp.zones</b>	The availability zones where the installation program creates machines for the specified MachinePool.	A list of valid <a href="#">GCP availability zones</a> , such as <b>us-central1-a</b> , in a <a href="#">YAML sequence</a> .
<b>platform.gcp.controlPlaneSubnet</b>	The name of the existing subnet in your VPC that you want to deploy your control plane machines to.	The subnet name.

Parameter	Description	Values
<code>platform.gcp.computeSubnet</code>	The name of the existing subnet in your VPC that you want to deploy your compute machines to.	The subnet name.
<code>platform.gcp.licenses</code>	<p>A list of license URLs that must be applied to the compute images.</p>  <p><b>IMPORTANT</b></p> <p>The <b>licenses</b> parameter is a deprecated field and nested virtualization is enabled by default. It is not recommended to use this field.</p>	Any license available with the <a href="#">license API</a> , such as the license to enable <a href="#">nested virtualization</a> . You cannot use this parameter with a mechanism that generates pre-built images. Using a license URL forces the installer to copy the source image before use.
<code>platform.gcp.osDiskSizeGB</code>	The size of the disk in gigabytes (GB).	Any size between 16 GB and 65536 GB.
<code>platform.gcp.osDiskType</code>	The type of disk.	Either the default <b>pd-ssd</b> or the <b>pd-standard</b> disk type. The control plane nodes must be the <b>pd-ssd</b> disk type. The worker nodes can be either type.
<code>controlPlane.platform.gcp.osDiskEncryptionKey.kmsKeyName</code>	The name of the customer managed encryption key to be used for control plane machine disk encryption.	The encryption key name.

Parameter	Description	Values
<b>controlPlane.platform.gcp.osDisk.encryptionKey.kmsKeyRing</b>	For control plane machines, the name of the KMS key ring to which the KMS key belongs.	The KMS key ring name.
<b>controlPlane.platform.gcp.osDisk.encryptionKey.kmsKeyLocation</b>	For control plane machines, the GCP location in which the key ring exists. For more information on KMS locations, see Google's documentation on <a href="#">Cloud KMS locations</a> .	The GCP location for the key ring.
<b>controlPlane.platform.gcp.osDisk.encryptionKey.projectID</b>	For control plane machines, the ID of the project in which the KMS key ring exists. This value defaults to the VM project ID if not set.	The GCP project ID.
<b>computePlatform.gcp.osDisk.encryptionKey.kmsKeyName</b>	The name of the customer managed encryption key to be used for compute machine disk encryption.	The encryption key name.

Parameter	Description	Values
<code>compute.platform.gcp.ossDisk.encryptionKey.kmsKeyRing</code>	For compute machines, the name of the KMS key ring to which the KMS key belongs.	The KMS key ring name.
<code>compute.platform.gcp.ossDisk.encryptionKey.kmsKeyLocation</code>	For compute machines, the GCP location in which the key ring exists. For more information on KMS locations, see Google's documentation on <a href="#">Cloud KMS locations</a> .	The GCP location for the key ring.
<code>compute.platform.gcp.ossDisk.encryptionKey.kmsKeyProjectID</code>	For compute machines, the ID of the project in which the KMS key ring exists. This value defaults to the VM project ID if not set.	The GCP project ID.

### 7.5.5.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 7.8. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Compute	RHCOS, RHEL 7.9, or RHEL 8.4 [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.

### 7.5.5.3. Using custom machine types

Using a custom machine type to install a OpenShift Container Platform cluster is supported.

Consider the following when using a custom machine type:

- Similar to predefined instance types, custom machine types must meet the minimum resource requirements for control plane and compute machines. For more information, see "Minimum resource requirements for cluster installation".
- The name of the custom machine type must adhere to the following syntax:  
**custom-<number\_of\_cpus>-<amount\_of\_memory\_in\_mb>**

For example, **custom-6-20480**.

As part of the installation process, you specify the custom machine type in the **install-config.yaml** file.

#### Sample install-config.yaml file with a custom machine type

```
compute:
- architecture: amd64
  hyperthreading: Enabled
  name: worker
  platform:
    gcp:
      type: custom-6-20480
  replicas: 2
controlPlane:
  architecture: amd64
  hyperthreading: Enabled
  name: master
  platform:
```

```

gcp:
  type: custom-6-20480
  replicas: 3

```

#### 7.5.5.4. Sample customized install-config.yaml file for GCP

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.



#### IMPORTANT

This sample YAML file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program and modify it.

```

apiVersion: v1
baseDomain: example.com 1
controlPlane: 2 3
  hyperthreading: Enabled 4
  name: master
  platform:
    gcp:
      type: n2-standard-4
      zones:
      - us-central1-a
      - us-central1-c
    osDisk:
      diskType: pd-ssd
      diskSizeGB: 1024
      encryptionKey: 5
      kmsKey:
        name: worker-key
        keyRing: test-machine-keys
        location: global
        projectID: project-id
  replicas: 3
compute: 6 7
  - hyperthreading: Enabled 8
  name: worker
  platform:
    gcp:
      type: n2-standard-4
      zones:
      - us-central1-a
      - us-central1-c
    osDisk:
      diskType: pd-standard
      diskSizeGB: 128
      encryptionKey: 9
      kmsKey:
        name: worker-key
        keyRing: test-machine-keys
        location: global
        projectID: project-id

```

```

replicas: 3
metadata:
  name: test-cluster 10
networking:
  clusterNetwork:
    - cidr: 10.128.0.0/14
      hostPrefix: 23
  machineNetwork:
    - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
    - 172.30.0.0/16
platform:
  gcp:
    projectID: openshift-production 11
    region: us-central1 12
  pullSecret: '{"auths": ...}' 13
  fips: false 14
  sshKey: ssh-ed25519 AAAA... 15

```

- 1 10 11 12 13** Required. The installation program prompts you for this value.
- 2 6** If you do not provide these parameters and values, the installation program provides the default value.
- 3 7** The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. Only one control plane pool is used.
- 4 8** Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.



### IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger machine types, such as **n1-standard-8**, for your machines if you disable simultaneous multithreading.

- 5 9** Optional: The custom encryption key section to encrypt both virtual machines and persistent volumes. Your default compute service account must have the permissions granted to use your KMS key and have the correct IAM role assigned. The default service account name follows the **service-`<project_number>`@compute-system.iam.gserviceaccount.com** pattern. For more information on granting the correct permissions for your service account, see "Machine management" → "Creating machine sets" → "Creating a machine set on GCP".
- 14** Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

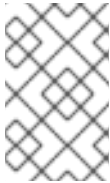


## IMPORTANT

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

**15**

You can optionally provide the **sshKey** value that you use to access the machines in your cluster.



## NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

### Additional resources

- [Enabling customer-managed encryption keys for a machine set](#)

### 7.5.5.5. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

### Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



## NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

### Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```

apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2

```



```
noProxy: example.com 3
additionalTrustBundle: | 4
  -----BEGIN CERTIFICATE-----
  <MY_TRUSTED_CA_CERT>
  -----END CERTIFICATE-----
...

```

- 1** A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2** A proxy URL to use for creating HTTPS connections outside the cluster.
- 3** A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations.
- 4** If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.



#### NOTE

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



#### NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

### 7.5.6. Using a GCP Marketplace image

If you want to deploy an OpenShift Container Platform cluster using a GCP Marketplace image, you must create the manifests and edit the compute machine set definitions to specify the GCP Marketplace image.

#### Prerequisites

- You have the OpenShift Container Platform installation program and the pull secret for your cluster.

#### Procedure

1. Generate the installation manifests by running the following command:

```
$ openshift-install create manifests --dir <installation_dir>
```

2. Locate the following files:

- `<installation_dir>/openshift/99_openshift-cluster-api_worker-machineset-0.yaml`
- `<installation_dir>/openshift/99_openshift-cluster-api_worker-machineset-1.yaml`
- `<installation_dir>/openshift/99_openshift-cluster-api_worker-machineset-2.yaml`

3. In each file, edit the `.spec.template.spec.providerSpec.value.disks[0].image` property to reference the offer to use:

#### OpenShift Container Platform

```
projects/redhat-marketplace-public/global/images/redhat-coreos-ocp-48-x86-64-202210040145
```

#### OpenShift Platform Plus

```
projects/redhat-marketplace-public/global/images/redhat-coreos-opp-48-x86-64-202206140145
```

#### OpenShift Kubernetes Engine

```
projects/redhat-marketplace-public/global/images/redhat-coreos-oke-48-x86-64-202206140145
```

### Example compute machine set with the GCP Marketplace image

```
deletionProtection: false
disks:
- autoDelete: true
  boot: true
  image: projects/redhat-marketplace-public/global/images/redhat-coreos-ocp-48-x86-64-202210040145
  labels: null
  sizeGb: 128
  type: pd-ssd
kind: GCPMachineProviderSpec
machineType: n2-standard-4
```

## 7.5.7. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



### IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

### Prerequisites

- Configure an account with the cloud platform that hosts your cluster.

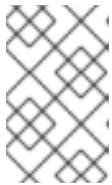
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

## Procedure

1. Remove any existing GCP credentials that do not use the service account key for the GCP account that you configured for your cluster and that are stored in the following locations:
  - The **GOOGLE\_CREDENTIALS**, **GOOGLE\_CLOUD\_KEYFILE\_JSON**, or **GKLOUD\_KEYFILE\_JSON** environment variables
  - The `~/.gcp/osServiceAccount.json` file
  - The **gcloud cli** default credentials
2. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
--log-level=info 2
```

- 1 For `<installation_directory>`, specify the location of your customized `./install-config.yaml` file.
- 2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.



### NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

When the cluster deployment completes, directions for accessing your cluster, including a link to its web console and credentials for the **kubeadmin** user, display in your terminal.

## Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Ee6gm-ymBZj-
Wt5AL"
INFO Time elapsed: 36m22s
```

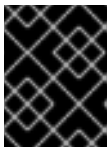


### NOTE

The cluster access and credential information also outputs to `<installation_directory>/openshift_install.log` when an installation succeeds.

**IMPORTANT**

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

**IMPORTANT**

You must not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

3. Optional: You can reduce the number of permissions for the service account that you used to install the cluster.
  - If you assigned the **Owner** role to your service account, you can remove that role and replace it with the **Viewer** role.
  - If you included the **Service Account Key Admin** role, you can remove it.

### 7.5.8. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

**IMPORTANT**

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

#### Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

```
$ tar xvf <file>
```

- 5. Place the **oc** binary in a directory that is on your **PATH**.  
To check your **PATH**, execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

### Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your **PATH**.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### 7.5.9. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

#### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

#### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

#### Example output

```
system:admin
```

#### Additional resources

- See [Accessing the web console](#) for more details about accessing and understanding the OpenShift Container Platform web console.

### 7.5.10. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

#### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

### 7.5.11. Next steps

- [Customize your cluster](#).
- If necessary, you can [opt out of remote health reporting](#) .

## 7.6. INSTALLING A CLUSTER ON GCP WITH NETWORK CUSTOMIZATIONS

In OpenShift Container Platform version 4.9, you can install a cluster with a customized network configuration on infrastructure that the installation program provisions on Google Cloud Platform (GCP). By customizing your network configuration, your cluster can coexist with existing IP address allocations in your environment and integrate with existing MTU and VXLAN configurations. To customize the installation, you modify parameters in the **install-config.yaml** file before you install the cluster.

You must set most of the network configuration parameters during installation, and you can modify only **kubeProxy** configuration parameters in a running cluster.

### 7.6.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You [configured a GCP project](#) to host the cluster.
- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can [manually create and maintain IAM credentials](#) .

### 7.6.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

**IMPORTANT**

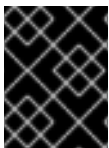
If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

**7.6.3. Generating a key pair for cluster node SSH access**

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.

**IMPORTANT**

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

**NOTE**

You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

**Procedure**

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.

**NOTE**

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.



- View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

- Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.



#### NOTE

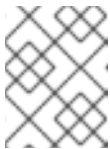
On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- If the `ssh-agent` process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

#### Example output

```
Agent pid 31874
```



#### NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

- Add your SSH private key to the `ssh-agent`:

```
$ ssh-add <path>/<file_name> 1
```

- 1** Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

#### Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

- Set the `GOOGLE_APPLICATION_CREDENTIALS` environment variable to the full path to your service account private key file.

```
$ export GOOGLE_APPLICATION_CREDENTIALS="<your_service_account_file>"
```

- Verify that the credentials were applied.

```
$ gcloud auth list
```

## Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

## 7.6.4. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

### Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space

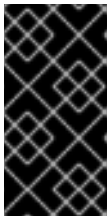
### Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



### IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



### IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#) . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

## 7.6.5. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Google Cloud Platform (GCP).

## Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

## Procedure

1. Create the **install-config.yaml** file.
  - a. Change to the directory that contains the installation program and run the following command:

```
$. /openshift-install create install-config --dir <installation_directory> 1
```

- 1** For **<installation\_directory>**, specify the directory name to store the files that the installation program creates.



### IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

- b. At the prompts, provide the configuration details for your cloud:
  - i. Optional: Select an SSH key to use to access your cluster machines.



### NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

- ii. Select **gcp** as the platform to target.
- iii. If you have not configured the service account key for your GCP account on your computer, you must obtain it from GCP and paste the contents of the file or enter the absolute path to the file.
- iv. Select the project ID to provision the cluster in. The default value is specified by the service account that you configured.
- v. Select the region to deploy the cluster to.
- vi. Select the base domain to deploy the cluster to. The base domain corresponds to the public DNS zone that you created for your cluster.
- vii. Enter a descriptive name for your cluster.

- viii. Paste the [pull secret from the Red Hat OpenShift Cluster Manager](#) .
2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.
3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



### IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

#### 7.6.5.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.



### NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.



### IMPORTANT

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

##### 7.6.5.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 7.9. Required parameters

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String

Parameter	Description	Values
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;</b> . <b>&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}</b> . <b>{{.baseDomain}}</b> .	String of lowercase letters, hyphens (-), and periods (.), such as <b>dev</b> .
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws, baremetal, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object


Parameter	Description	Values
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } }</pre>


### 7.6.5.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

Table 7.10. Network parameters

Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	Object  <p><b>NOTE</b></p> <p>You cannot modify parameters specified by the <b>networking</b> object after installation.</p>
<b>networking.networkType</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .

Parameter	Description	Values
<b>networking.clusterNetwork</b>	<p>The IP address blocks for pods.</p> <p>The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b>.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   clusterNetwork:     - cidr: 10.128.0.0/14       hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	<p>Required if you use <b>networking.clusterNetwork</b>. An IP address block.</p> <p>An IPv4 network.</p>	<p>An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b>.</p>
<b>networking.clusterNetwork.hostPrefix</b>	<p>The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b>. A <b>hostPrefix</b> value of <b>23</b> provides 510 (<math>2^{(32 - 23)} - 2</math>) pod IP addresses.</p>	<p>A subnet prefix.</p> <p>The default value is <b>23</b>.</p>
<b>networking.serviceNetwork</b>	<p>The IP address block for services. The default value is <b>172.30.0.0/16</b>.</p> <p>The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.</p>	<p>An array with an IP address block in CIDR format. For example:</p> <pre>networking:   serviceNetwork:     - 172.30.0.0/16</pre>
<b>networking.machineNetwork</b>	<p>The IP address blocks for machines.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   machineNetwork:     - cidr: 10.0.0.0/16</pre>
<b>networking.machineNetwork.cidr</b>	<p>Required if you use <b>networking.machineNetwork</b>. An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b>.</p>	<p>An IP network block in CIDR notation.</p> <p>For example, <b>10.0.0.0/16</b>.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p> </div> </div>

## 7.6.5.1.3. Optional configuration parameters



Optional installation configuration parameters are described in the following table:

Table 7.11. Optional parameters


Parameter	Description	Values
<b>additionalTrustBundle</b>	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
<b>compute</b>	The configuration for the machines that comprise the compute nodes.	Array of <b>MachinePool</b> objects.
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String
<b>compute.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: flex-start;"> <div style="background-color: black; width: 20px; height: 100px; margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>



Parameter	Description	Values
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String
<b>controlPlane.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div data-bbox="485 1093 592 1411" style="background-color: black; color: white; padding: 5px; width: 60px; height: 140px; margin-bottom: 10px;"> </div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platform</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>controlPlane.replicas</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.

Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported. If you are installing on GCP into a shared virtual private cloud (VPC), <b>credentialsMode</b> must be set to <b>Passthrough</b>.</p> <p> <b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators reference</i> content.</p> <p> <b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p>	<b>Mint, Passthrough, Manual</b> or an empty string ("").

Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start;"> <div style="width: 60px; height: 60px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 60px; height: 60px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<b>Internal</b> or <b>External</b> . To deploy a private cluster, which cannot be accessed from the internet, set <b>publish</b> to <b>Internal</b> . The default value is <b>External</b> .


Parameter	Description	Values
<b>sshKey</b>	<p>The SSH key or keys to authenticate access your cluster machines.</p>  <p><b>NOTE</b></p> <p>For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.</p>	<p>One or more keys. For example:</p> <pre>sshKey:   &lt;key1&gt;   &lt;key2&gt;   &lt;key3&gt;</pre>

#### 7.6.5.1.4. Additional Google Cloud Platform (GCP) configuration parameters

Additional GCP configuration parameters are described in the following table:

Table 7.12. Additional GCP parameters

Parameter	Description	Values
<b>platform.gcp.network</b>	The name of the existing VPC that you want to deploy your cluster to.	String.
<b>platform.gcp.region</b>	The name of the GCP region that hosts your cluster.	Any valid region name, such as <b>us-central1</b> .
<b>platform.gcp.type</b>	The <a href="#">GCP machine type</a> .	The GCP machine type.
<b>platform.gcp.zones</b>	The availability zones where the installation program creates machines for the specified MachinePool.	A list of valid <a href="#">GCP availability zones</a> , such as <b>us-central1-a</b> , in a <a href="#">YAML sequence</a> .
<b>platform.gcp.controlPlaneSubnet</b>	The name of the existing subnet in your VPC that you want to deploy your control plane machines to.	The subnet name.

Parameter	Description	Values
<code>platform.gcp.computeSubnet</code>	The name of the existing subnet in your VPC that you want to deploy your compute machines to.	The subnet name.
<code>platform.gcp.licenses</code>	<p>A list of license URLs that must be applied to the compute images.</p>  <p><b>IMPORTANT</b></p> <p>The <b>licenses</b> parameter is a deprecated field and nested virtualization is enabled by default. It is not recommended to use this field.</p>	Any license available with the <a href="#">license API</a> , such as the license to enable <a href="#">nested virtualization</a> . You cannot use this parameter with a mechanism that generates pre-built images. Using a license URL forces the installer to copy the source image before use.
<code>platform.gcp.osDiskSizeGB</code>	The size of the disk in gigabytes (GB).	Any size between 16 GB and 65536 GB.
<code>platform.gcp.osDiskType</code>	The type of disk.	Either the default <b>pd-ssd</b> or the <b>pd-standard</b> disk type. The control plane nodes must be the <b>pd-ssd</b> disk type. The worker nodes can be either type.
<code>controlPlane.platform.gcp.osDiskEncryptionKey.kmsKeyName</code>	The name of the customer managed encryption key to be used for control plane machine disk encryption.	The encryption key name.

Parameter	Description	Values
<code>controlplane.platform.gcp.osDiskEncryptionKey.kmsKeyRing</code>	For control plane machines, the name of the KMS key ring to which the KMS key belongs.	The KMS key ring name.
<code>controlplane.platform.gcp.osDiskEncryptionKey.kmsLocation</code>	For control plane machines, the GCP location in which the key ring exists. For more information on KMS locations, see Google's documentation on <a href="#">Cloud KMS locations</a> .	The GCP location for the key ring.
<code>controlplane.platform.gcp.osDiskEncryptionKey.projectID</code>	For control plane machines, the ID of the project in which the KMS key ring exists. This value defaults to the VM project ID if not set.	The GCP project ID.
<code>compute.platform.gcp.osDiskEncryptionKey.kmsKeyName</code>	The name of the customer managed encryption key to be used for compute machine disk encryption.	The encryption key name.

Parameter	Description	Values
<code>compute.platform.gcp.ossDisk.encryptionKey.kmsKeyRing</code>	For compute machines, the name of the KMS key ring to which the KMS key belongs.	The KMS key ring name.
<code>compute.platform.gcp.ossDisk.encryptionKey.kmsKeyLocation</code>	For compute machines, the GCP location in which the key ring exists. For more information on KMS locations, see Google's documentation on <a href="#">Cloud KMS locations</a> .	The GCP location for the key ring.
<code>compute.platform.gcp.ossDisk.encryptionKey.kmsKeyProjectID</code>	For compute machines, the ID of the project in which the KMS key ring exists. This value defaults to the VM project ID if not set.	The GCP project ID.

### 7.6.5.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 7.13. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Compute	RHCOS, RHEL 7.9, or RHEL 8.4 [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.

### 7.6.5.3. Using custom machine types

Using a custom machine type to install a OpenShift Container Platform cluster is supported.

Consider the following when using a custom machine type:

- Similar to predefined instance types, custom machine types must meet the minimum resource requirements for control plane and compute machines. For more information, see "Minimum resource requirements for cluster installation".
- The name of the custom machine type must adhere to the following syntax:  
**custom-<number\_of\_cpus>-<amount\_of\_memory\_in\_mb>**

For example, **custom-6-20480**.

As part of the installation process, you specify the custom machine type in the **install-config.yaml** file.

#### Sample install-config.yaml file with a custom machine type

```
compute:
- architecture: amd64
  hyperthreading: Enabled
  name: worker
  platform:
    gcp:
      type: custom-6-20480
  replicas: 2
controlPlane:
  architecture: amd64
  hyperthreading: Enabled
  name: master
  platform:
```



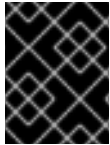
```

gcp:
  type: custom-6-20480
  replicas: 3

```

#### 7.6.5.4. Sample customized install-config.yaml file for GCP

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.



#### IMPORTANT

This sample YAML file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program and modify it.

```

apiVersion: v1
baseDomain: example.com 1
controlPlane: 2 3
  hyperthreading: Enabled 4
  name: master
  platform:
    gcp:
      type: n2-standard-4
      zones:
      - us-central1-a
      - us-central1-c
    osDisk:
      diskType: pd-ssd
      diskSizeGB: 1024
      encryptionKey: 5
      kmsKey:
        name: worker-key
        keyRing: test-machine-keys
        location: global
        projectID: project-id
  replicas: 3
compute: 6 7
  - hyperthreading: Enabled 8
  name: worker
  platform:
    gcp:
      type: n2-standard-4
      zones:
      - us-central1-a
      - us-central1-c
    osDisk:
      diskType: pd-standard
      diskSizeGB: 128
      encryptionKey: 9
      kmsKey:
        name: worker-key
        keyRing: test-machine-keys
        location: global
        projectID: project-id

```

```

replicas: 3
metadata:
  name: test-cluster 10
networking: 11
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
  gcp:
    projectID: openshift-production 12
    region: us-central1 13
  pullSecret: '{"auths": ...}' 14
  fips: false 15
  sshKey: ssh-ed25519 AAAA... 16

```

**1 10 12 13 14** Required. The installation program prompts you for this value.

**2 6 11** If you do not provide these parameters and values, the installation program provides the default value.

**3 7** The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

**4 8** Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.



### IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger machine types, such as **n1-standard-8**, for your machines if you disable simultaneous multithreading.

**5 9** Optional: The custom encryption key section to encrypt both virtual machines and persistent volumes. Your default compute service account must have the permissions granted to use your KMS key and have the correct IAM role assigned. The default service account name follows the **service-`<project_number>`@compute-system.iam.gserviceaccount.com** pattern. For more information on granting the correct permissions for your service account, see "Machine management" → "Creating machine sets" → "Creating a machine set on GCP".

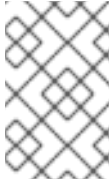
**15** Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

**IMPORTANT**

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

**16**

You can optionally provide the **sshKey** value that you use to access the machines in your cluster.

**NOTE**

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

**7.6.6. Additional resources**

- [Enabling customer-managed encryption keys for a machine set](#)

**7.6.6.1. Configuring the cluster-wide proxy during installation**

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

**Prerequisites**

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

**NOTE**

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

**Procedure**

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

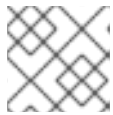
```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
```

```

httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
noProxy: example.com 3
additionalTrustBundle: | 4
  -----BEGIN CERTIFICATE-----
  <MY_TRUSTED_CA_CERT>
  -----END CERTIFICATE-----
...

```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations.
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.



#### NOTE

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



#### NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

### 7.6.7. Network configuration phases

There are two phases prior to OpenShift Container Platform installation where you can customize the network configuration.

#### Phase 1

You can customize the following network-related fields in the **install-config.yaml** file before you create the manifest files:

- **networking.networkType**

- **networking.clusterNetwork**
- **networking.serviceNetwork**
- **networking.machineNetwork**

For more information on these fields, refer to *Installation configuration parameters*.



#### NOTE

Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

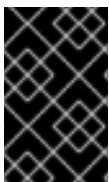
### Phase 2

After creating the manifest files by running **openshift-install create manifests**, you can define a customized Cluster Network Operator manifest with only the fields you want to modify. You can use the manifest to specify advanced network configuration.

You cannot override the values specified in phase 1 in the **install-config.yaml** file during phase 2. However, you can further customize the cluster network provider during phase 2.

### 7.6.8. Specifying advanced network configuration

You can use advanced network configuration for your cluster network provider to integrate your cluster into your existing network environment. You can specify advanced network configuration only before you install the cluster.



#### IMPORTANT

Customizing your network configuration by modifying the OpenShift Container Platform manifest files created by the installation program is not supported. Applying a manifest file that you create, as in the following procedure, is supported.

#### Prerequisites

- You have created the **install-config.yaml** file and completed any modifications to it.

#### Procedure

1. Change to the directory that contains the installation program and create the manifests:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

- 1** **<installation\_directory>** specifies the name of the directory that contains the **install-config.yaml** file for your cluster.

2. Create a stub manifest file for the advanced network configuration that is named **cluster-network-03-config.yml** in the **<installation\_directory>/manifests/** directory:

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
```

```
name: cluster
spec:
```

- Specify the advanced network configuration for your cluster in the **cluster-network-03-config.yml** file, such as in the following examples:

#### Specify a different VXLAN port for the OpenShift SDN network provider

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    openshiftSDNConfig:
      vxlanPort: 4800
```

#### Enable IPsec for the OVN-Kubernetes network provider

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    ovnKubernetesConfig:
      ipsecConfig: {}
```

- Optional: Back up the **manifests/cluster-network-03-config.yml** file. The installation program consumes the **manifests/** directory when you create the Ignition config files.

## 7.6.9. Cluster Network Operator configuration

The configuration for the cluster network is specified as part of the Cluster Network Operator (CNO) configuration and stored in a custom resource (CR) object that is named **cluster**. The CR specifies the fields for the **Network** API in the **operator.openshift.io** API group.

The CNO configuration inherits the following fields during cluster installation from the **Network** API in the **Network.config.openshift.io** API group and these fields cannot be changed:

### **clusterNetwork**

IP address pools from which pod IP addresses are allocated.

### **serviceNetwork**

IP address pool for services.

### **defaultNetwork.type**

Cluster network provider, such as OpenShift SDN or OVN-Kubernetes.

You can specify the cluster network provider configuration for your cluster by setting the fields for the **defaultNetwork** object in the CNO object named **cluster**.

### 7.6.9.1. Cluster Network Operator configuration object

The fields for the Cluster Network Operator (CNO) are described in the following table:

**Table 7.14. Cluster Network Operator configuration object**


Field	Type	Description
<b>metadata.name</b>	<b>string</b>	The name of the CNO object. This name is always <b>cluster</b> .
<b>spec.clusterNetwork</b>	<b>array</b>	<p>A list specifying the blocks of IP addresses from which pod IP addresses are allocated and the subnet prefix length assigned to each individual node in the cluster. For example:</p> <pre>spec:   clusterNetwork:   - cidr: 10.128.0.0/19     hostPrefix: 23   - cidr: 10.128.32.0/19     hostPrefix: 23</pre> <p>You can customize this field only in the <b>install-config.yaml</b> file before you create the manifests. The value is read-only in the manifest file.</p>
<b>spec.serviceNetwork</b>	<b>array</b>	<p>A block of IP addresses for services. The OpenShift SDN and OVN-Kubernetes Container Network Interface (CNI) network providers support only a single IP address block for the service network. For example:</p> <pre>spec:   serviceNetwork:   - 172.30.0.0/14</pre> <p>You can customize this field only in the <b>install-config.yaml</b> file before you create the manifests. The value is read-only in the manifest file.</p>
<b>spec.defaultNetwork</b>	<b>object</b>	Configures the Container Network Interface (CNI) cluster network provider for the cluster network.
<b>spec.kubeProxy</b> <b>Config</b>	<b>object</b>	The fields for this object specify the kube-proxy configuration. If you are using the OVN-Kubernetes cluster network provider, the kube-proxy configuration has no effect.

#### defaultNetwork object configuration

The values for the **defaultNetwork** object are defined in the following table:

**Table 7.15. defaultNetwork object**

Field	Type	Description
-------	------	-------------

Field	Type	Description
<b>type</b>	<b>string</b>	<p>Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b>. The cluster network provider is selected during installation. This value cannot be changed after cluster installation.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>OpenShift Container Platform uses the OpenShift SDN Container Network Interface (CNI) cluster network provider by default.</p> </div> </div>
<b>openshiftSDNConfig</b>	<b>object</b>	This object is only valid for the OpenShift SDN cluster network provider.
<b>ovnKubernetesConfig</b>	<b>object</b>	This object is only valid for the OVN-Kubernetes cluster network provider.

### Configuration for the OpenShift SDN CNI cluster network provider

The following table describes the configuration fields for the OpenShift SDN Container Network Interface (CNI) cluster network provider.

Table 7.16. **openshiftSDNConfig** object

Field	Type	Description
<b>mode</b>	<b>string</b>	<p>Configures the network isolation mode for OpenShift SDN. The default value is <b>NetworkPolicy</b>.</p> <p>The values <b>Multitenant</b> and <b>Subnet</b> are available for backwards compatibility with OpenShift Container Platform 3.x but are not recommended. This value cannot be changed after cluster installation.</p>
<b>mtu</b>	<b>integer</b>	<p>The maximum transmission unit (MTU) for the VXLAN overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU.</p> <p>If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes.</p> <p>If your cluster requires different MTU values for different nodes, you must set this value to <b>50</b> less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of <b>9001</b>, and some have an MTU of <b>1500</b>, you must set this value to <b>1450</b>.</p> <p>This value cannot be changed after cluster installation.</p>



Field	Type	Description
<b>vxlanPort</b>	<b>integer</b>	<p>The port to use for all VXLAN packets. The default value is <b>4789</b>. This value cannot be changed after cluster installation.</p> <p>If you are running in a virtualized environment with existing nodes that are part of another VXLAN network, then you might be required to change this. For example, when running an OpenShift SDN overlay on top of VMware NSX-T, you must select an alternate port for the VXLAN, because both SDNs use the same default VXLAN port number.</p> <p>On Amazon Web Services (AWS), you can select an alternate port for the VXLAN between port <b>9000</b> and port <b>9999</b>.</p>

### Example OpenShift SDN configuration

```
defaultNetwork:
  type: OpenShiftSDN
  openshiftSDNConfig:
    mode: NetworkPolicy
    mtu: 1450
    vxlanPort: 4789
```

### Configuration for the OVN-Kubernetes CNI cluster network provider

The following table describes the configuration fields for the OVN-Kubernetes CNI cluster network provider.

Table 7.17. `ovnKubernetesConfig` object

Field	Type	Description
<b>mtu</b>	<b>integer</b>	<p>The maximum transmission unit (MTU) for the Geneve (Generic Network Virtualization Encapsulation) overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU.</p> <p>If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes.</p> <p>If your cluster requires different MTU values for different nodes, you must set this value to <b>100</b> less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of <b>9001</b>, and some have an MTU of <b>1500</b>, you must set this value to <b>1400</b>.</p> <p>This value cannot be changed after cluster installation.</p>
<b>genevePort</b>	<b>integer</b>	<p>The port to use for all Geneve packets. The default value is <b>6081</b>. This value cannot be changed after cluster installation.</p>

Field	Type	Description
<b>ipsecConfig</b>	<b>object</b>	Specify an empty object to enable IPsec encryption. This value cannot be changed after cluster installation.
<b>policyAuditConfig</b>	<b>object</b>	Specify a configuration object for customizing network policy audit logging. If unset, the defaults audit log settings are used.

Table 7.18. **policyAuditConfig** object

Field	Type	Description
<b>rateLimit</b>	integer	The maximum number of messages to generate every second per node. The default value is <b>20</b> messages per second.
<b>maxFileSize</b>	integer	The maximum size for the audit log in bytes. The default value is <b>50000000</b> or 50 MB.
<b>destination</b>	string	One of the following additional audit log targets: <ul style="list-style-type: none"> <li><b>libc</b> The libc <b>syslog()</b> function of the journald process on the host.</li> <li><b>udp:&lt;host&gt;:&lt;port&gt;</b> A syslog server. Replace <b>&lt;host&gt;:&lt;port&gt;</b> with the host and port of the syslog server.</li> <li><b>unix:&lt;file&gt;</b> A Unix Domain Socket file specified by <b>&lt;file&gt;</b>.</li> <li><b>null</b> Do not send the audit logs to any additional target.</li> </ul>
<b>syslogFacility</b>	string	The syslog facility, such as <b>kern</b> , as defined by RFC5424. The default value is <b>local0</b> .


### Example OVN-Kubernetes configuration

```
defaultNetwork:
  type: OVNKubernetes
  ovnKubernetesConfig:
    mtu: 1400
    genevePort: 6081
    ipsecConfig: {}
```

### kubeProxyConfig object configuration

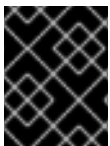
The values for the **kubeProxyConfig** object are defined in the following table:

Table 7.19. **kubeProxyConfig** object

Field	Type	Description
<b>iptablesSyncPeriod</b>	<b>string</b>	<p>The refresh period for <b>iptables</b> rules. The default value is <b>30s</b>. Valid suffixes include <b>s</b>, <b>m</b>, and <b>h</b> and are described in the <a href="#">Go time package</a> documentation.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>Because of performance improvements introduced in OpenShift Container Platform 4.3 and greater, adjusting the <b>iptablesSyncPeriod</b> parameter is no longer necessary.</p> </div> </div>
<b>proxyArguments.iptables-min-sync-period</b>	<b>array</b>	<p>The minimum duration before refreshing <b>iptables</b> rules. This field ensures that the refresh does not happen too frequently. Valid suffixes include <b>s</b>, <b>m</b>, and <b>h</b> and are described in the <a href="#">Go time package</a>. The default value is:</p> <pre>kubeProxyConfig:   proxyArguments:     iptables-min-sync-period:       - 0s</pre>

## 7.6.10. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



### IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

### Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

### Procedure

1. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
--log-level=info 2
```

- 1 For `<installation_directory>`, specify the
- 2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.



#### NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

When the cluster deployment completes, directions for accessing your cluster, including a link to its web console and credentials for the **kubeadmin** user, display in your terminal.

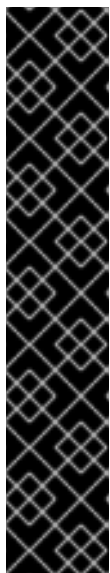
#### Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Ee6gm-ymBZj-
Wt5AL"
INFO Time elapsed: 36m22s
```



#### NOTE

The cluster access and credential information also outputs to `<installation_directory>/openshift_install.log` when an installation succeeds.



#### IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

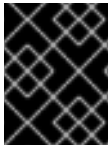


#### IMPORTANT

You must not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

### 7.6.11. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



#### IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

#### Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

##### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

```
$ tar xvf <file>
```

5. Place the **oc** binary in a directory that is on your **PATH**.  
To check your **PATH**, execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

#### Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

##### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

### Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### 7.6.12. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

#### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

#### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

## Example output

```
system:admin
```

### Additional resources

- See [Accessing the web console](#) for more details about accessing and understanding the OpenShift Container Platform web console.

### 7.6.13. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

### Additional resources

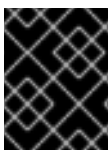
- See [About remote health monitoring](#) for more information about the Telemetry service

### 7.6.14. Next steps

- [Customize your cluster](#).
- If necessary, you can [opt out of remote health reporting](#).

## 7.7. INSTALLING A CLUSTER ON GCP IN A RESTRICTED NETWORK

In OpenShift Container Platform 4.9, you can install a cluster on Google Cloud Platform (GCP) in a restricted network by creating an internal mirror of the installation release content on an existing Google Virtual Private Cloud (VPC).

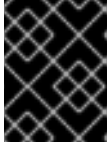


### IMPORTANT

You can install an OpenShift Container Platform cluster by using mirrored installation release content, but your cluster will require internet access to use the GCP APIs.

### 7.7.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You [mirrored the images for a disconnected installation](#) to your registry and obtained the **imageContentSources** data for your version of OpenShift Container Platform.



## IMPORTANT

Because the installation media is on the mirror host, you can use that computer to complete all installation steps.

- You have an existing VPC in GCP. While installing a cluster in a restricted network that uses installer-provisioned infrastructure, you cannot use the installer-provisioned VPC. You must use a user-provisioned VPC that satisfies one of the following requirements:
  - Contains the mirror registry
  - Has firewall rules or a peering connection to access the mirror registry hosted elsewhere
- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to. While you might need to grant access to more sites, you must grant access to **\*.googleapis.com** and **accounts.google.com**.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can [manually create and maintain IAM credentials](#).

### 7.7.2. About installations in restricted networks

In OpenShift Container Platform 4.9, you can perform an installation that does not require an active connection to the internet to obtain software components. Restricted network installations can be completed using installer-provisioned infrastructure or user-provisioned infrastructure, depending on the cloud platform to which you are installing the cluster.

If you choose to perform a restricted network installation on a cloud platform, you still require access to its cloud APIs. Some cloud functions, like Amazon Web Service's Route 53 DNS and IAM services, require internet access. Depending on your network, you might require less internet access for an installation on bare metal hardware or on VMware vSphere.

To complete a restricted network installation, you must create a registry that mirrors the contents of the OpenShift Container Platform registry and contains the installation media. You can create this registry on a mirror host, which can access both the internet and your closed network, or by using other methods that meet your restrictions.

#### 7.7.2.1. Additional limits

Clusters in restricted networks have the following additional limitations and restrictions:

- The **ClusterVersion** status includes an **Unable to retrieve available updates** error.
- By default, you cannot use the contents of the Developer Catalog because you cannot access the required image stream tags.

### 7.7.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to obtain the images that are necessary to install your cluster.

You must have internet access to:



- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



### IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

#### 7.7.4. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.



### IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



### NOTE

You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

#### Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.

**NOTE**

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.

**NOTE**

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

**Example output**

```
Agent pid 31874
```

**NOTE**

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1** Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

**Example output**

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

5. Set the **GOOGLE\_APPLICATION\_CREDENTIALS** environment variable to the full path to your service account private key file.

```
$ export GOOGLE_APPLICATION_CREDENTIALS="<your_service_account_file>"
```

6. Verify that the credentials were applied.

```
$ gcloud auth list
```

### Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

## 7.7.5. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Google Cloud Platform (GCP).

### Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster. For a restricted network installation, these files are on your mirror host.
- Have the **imageContentSources** values that were generated during mirror registry creation.
- Obtain the contents of the certificate for your mirror registry.
- Obtain service principal permissions at the subscription level.

### Procedure

1. Create the **install-config.yaml** file.
  - a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

- 1** For **<installation\_directory>**, specify the directory name to store the files that the installation program creates.



### IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

- b. At the prompts, provide the configuration details for your cloud:
  - i. Optional: Select an SSH key to use to access your cluster machines.



**NOTE**

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

- ii. Select **gcp** as the platform to target.
  - iii. If you have not configured the service account key for your GCP account on your computer, you must obtain it from GCP and paste the contents of the file or enter the absolute path to the file.
  - iv. Select the project ID to provision the cluster in. The default value is specified by the service account that you configured.
  - v. Select the region to deploy the cluster to.
  - vi. Select the base domain to deploy the cluster to. The base domain corresponds to the public DNS zone that you created for your cluster.
  - vii. Enter a descriptive name for your cluster.
  - viii. Paste the [pull secret from the Red Hat OpenShift Cluster Manager](#) .
2. Edit the **install-config.yaml** file to provide the additional information that is required for an installation in a restricted network.
- a. Update the **pullSecret** value to contain the authentication information for your registry:

```
pullSecret: '{"auths":{"<mirror_host_name>:5000": {"auth": "<credentials>","email": "you@example.com"}}}'
```

For **<mirror\_host\_name>**, specify the registry domain name that you specified in the certificate for your mirror registry, and for **<credentials>**, specify the base64-encoded user name and password for your mirror registry.

- b. Add the **additionalTrustBundle** parameter and value.

```
additionalTrustBundle: |
  -----BEGIN CERTIFICATE-----
  /-----END CERTIFICATE-----
```

The value must be the contents of the certificate file that you used for your mirror registry, which can be an existing, trusted certificate authority or the self-signed certificate that you generated for the mirror registry.

- c. Define the network and subnets for the VPC to install the cluster in under the parent **platform.gcp** field:

```
network: <existing_vpc>
controlPlaneSubnet: <control_plane_subnet>
computeSubnet: <compute_subnet>
```

5. **platform.gcp.network** field is required only if you are installing on GCP VPC.

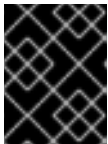
For **platform.gcp.network**, specify the name for the existing Google VPC. For **platform.gcp.controlPlaneSubnet** and **platform.gcp.computeSubnet**, specify the existing subnets to deploy the control plane machines and compute machines, respectively.

- d. Add the image content resources, which look like this excerpt:

```
imageContentSources:
- mirrors:
  - <mirror_host_name>:5000/<repo_name>/release
    source: quay.io/openshift-release-dev/ocp-release
- mirrors:
  - <mirror_host_name>:5000/<repo_name>/release
    source: registry.redhat.io/ocp/release
```

To complete these values, use the **imageContentSources** that you recorded during mirror registry creation.

3. Make any other modifications to the **install-config.yaml** file that you require. You can find more information about the available parameters in the **Installation configuration parameters** section.
4. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



#### IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

### 7.7.5.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.



#### NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.



#### IMPORTANT

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

#### 7.7.5.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

**Table 7.20. Required parameters**

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;</b> . <b>&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}</b> . <b>{{.baseDomain}}</b> .	String of lowercase letters, hyphens (-), and periods (.), such as <b>dev</b> .
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws</b> , <b>baremetal</b> , <b>azure</b> , <b>gcp</b> , <b>openstack</b> , <b>ovirt</b> , <b>vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object


Parameter	Description	Values
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } }</pre>


### 7.7.5.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

Table 7.21. Network parameters

Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	Object <div style="display: flex; align-items: center; margin-top: 10px;">  <div> <p><b>NOTE</b></p> <p>You cannot modify parameters specified by the <b>networking</b> object after installation.</p> </div> </div>
<b>networking.networkType</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .


Parameter	Description	Values
<b>networking.clusterNetwork</b>	<p>The IP address blocks for pods.</p> <p>The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b>.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   clusterNetwork:     - cidr: 10.128.0.0/14       hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	<p>Required if you use <b>networking.clusterNetwork</b>. An IP address block.</p> <p>An IPv4 network.</p>	<p>An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b>.</p>
<b>networking.clusterNetwork.hostPrefix</b>	<p>The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b>. A <b>hostPrefix</b> value of <b>23</b> provides 510 (<math>2^{(32 - 23)} - 2</math>) pod IP addresses.</p>	<p>A subnet prefix.</p> <p>The default value is <b>23</b>.</p>
<b>networking.serviceNetwork</b>	<p>The IP address block for services. The default value is <b>172.30.0.0/16</b>.</p> <p>The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.</p>	<p>An array with an IP address block in CIDR format. For example:</p> <pre>networking:   serviceNetwork:     - 172.30.0.0/16</pre>
<b>networking.machineNetwork</b>	<p>The IP address blocks for machines.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   machineNetwork:     - cidr: 10.0.0.0/16</pre>
<b>networking.machineNetwork.cidr</b>	<p>Required if you use <b>networking.machineNetwork</b>. An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b>.</p>	<p>An IP network block in CIDR notation.</p> <p>For example, <b>10.0.0.0/16</b>.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p> </div> </div>






## 7.7.5.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:


Table 7.22. Optional parameters

Parameter	Description	Values
<b>additionalTrustBundle</b>	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
<b>compute</b>	The configuration for the machines that comprise the compute nodes.	Array of <b>MachinePool</b> objects.
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String
<b>compute.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>

Parameter	Description	Values
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String
<b>controlPlane.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platform</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>controlPlane.replicas</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.

Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported. If you are installing on GCP into a shared virtual private cloud (VPC), <b>credentialsMode</b> must be set to <b>Passthrough</b>.</p> <p> <b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators</i> reference content.</p> <p> <b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p>	<b>Mint, Passthrough, Manual</b> or an empty string ("").

Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start;"> <div style="width: 60px; height: 60px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 60px; height: 60px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<b>Internal</b> or <b>External</b> . To deploy a private cluster, which cannot be accessed from the internet, set <b>publish</b> to <b>Internal</b> . The default value is <b>External</b> .


Parameter	Description	Values
<b>sshKey</b>	<p>The SSH key or keys to authenticate access your cluster machines.</p>  <p><b>NOTE</b></p> <p>For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.</p>	<p>One or more keys. For example:</p> <pre>sshKey:   &lt;key1&gt;   &lt;key2&gt;   &lt;key3&gt;</pre>

#### 7.7.5.1.4. Additional Google Cloud Platform (GCP) configuration parameters

Additional GCP configuration parameters are described in the following table:

Table 7.23. Additional GCP parameters

Parameter	Description	Values
<b>platform.gcp.network</b>	The name of the existing VPC that you want to deploy your cluster to.	String.
<b>platform.gcp.region</b>	The name of the GCP region that hosts your cluster.	Any valid region name, such as <b>us-central1</b> .
<b>platform.gcp.type</b>	The <a href="#">GCP machine type</a> .	The GCP machine type.
<b>platform.gcp.zones</b>	The availability zones where the installation program creates machines for the specified MachinePool.	A list of valid <a href="#">GCP availability zones</a> , such as <b>us-central1-a</b> , in a <a href="#">YAML sequence</a> .
<b>platform.gcp.controlPlaneSubnet</b>	The name of the existing subnet in your VPC that you want to deploy your control plane machines to.	The subnet name.

Parameter	Description	Values
<code>platform.gcp.computeSubnet</code>	The name of the existing subnet in your VPC that you want to deploy your compute machines to.	The subnet name.
<code>platform.gcp.licenses</code>	<p>A list of license URLs that must be applied to the compute images.</p>  <p><b>IMPORTANT</b></p> <p>The <b>licenses</b> parameter is a deprecated field and nested virtualization is enabled by default. It is not recommended to use this field.</p>	Any license available with the <a href="#">license API</a> , such as the license to enable <a href="#">nested virtualization</a> . You cannot use this parameter with a mechanism that generates pre-built images. Using a license URL forces the installer to copy the source image before use.
<code>platform.gcp.osDiskSizeGB</code>	The size of the disk in gigabytes (GB).	Any size between 16 GB and 65536 GB.
<code>platform.gcp.osDiskType</code>	The type of disk.	Either the default <b>pd-ssd</b> or the <b>pd-standard</b> disk type. The control plane nodes must be the <b>pd-ssd</b> disk type. The worker nodes can be either type.
<code>controlPlane.platform.gcp.osDiskEncryptionKey.kmsKeyName</code>	The name of the customer managed encryption key to be used for control plane machine disk encryption.	The encryption key name.

Parameter	Description	Values
<b>controlPlane.platform.gcp.osDisk.encryptionKey.kmsKeyRing</b>	For control plane machines, the name of the KMS key ring to which the KMS key belongs.	The KMS key ring name.
<b>controlPlane.platform.gcp.osDisk.encryptionKey.location</b>	For control plane machines, the GCP location in which the key ring exists. For more information on KMS locations, see Google's documentation on <a href="#">Cloud KMS locations</a> .	The GCP location for the key ring.
<b>controlPlane.platform.gcp.osDisk.encryptionKey.projectID</b>	For control plane machines, the ID of the project in which the KMS key ring exists. This value defaults to the VM project ID if not set.	The GCP project ID.
<b>computePlatform.gcp.osDisk.encryptionKey.kmsKeyName</b>	The name of the customer managed encryption key to be used for compute machine disk encryption.	The encryption key name.

Parameter	Description	Values
<code>compute.platform.gcp.ossDisk.encryptionKey.kmsKeyRing</code>	For compute machines, the name of the KMS key ring to which the KMS key belongs.	The KMS key ring name.
<code>compute.platform.gcp.ossDisk.encryptionKey.kmsKeyLocation</code>	For compute machines, the GCP location in which the key ring exists. For more information on KMS locations, see Google's documentation on <a href="#">Cloud KMS locations</a> .	The GCP location for the key ring.
<code>compute.platform.gcp.ossDisk.encryptionKey.kmsKeyProjectID</code>	For compute machines, the ID of the project in which the KMS key ring exists. This value defaults to the VM project ID if not set.	The GCP project ID.

### 7.7.5.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 7.24. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300



Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Compute	RHCOS, RHEL 7.9, or RHEL 8.4 [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.

### 7.7.5.3. Using custom machine types

Using a custom machine type to install a OpenShift Container Platform cluster is supported.

Consider the following when using a custom machine type:

- Similar to predefined instance types, custom machine types must meet the minimum resource requirements for control plane and compute machines. For more information, see "Minimum resource requirements for cluster installation".
- The name of the custom machine type must adhere to the following syntax:  
**custom-<number\_of\_cpus>-<amount\_of\_memory\_in\_mb>**

For example, **custom-6-20480**.

As part of the installation process, you specify the custom machine type in the **install-config.yaml** file.

#### Sample install-config.yaml file with a custom machine type

```
compute:
- architecture: amd64
  hyperthreading: Enabled
  name: worker
  platform:
    gcp:
      type: custom-6-20480
  replicas: 2
controlPlane:
  architecture: amd64
  hyperthreading: Enabled
  name: master
  platform:
```

```

gcp:
  type: custom-6-20480
  replicas: 3

```

#### 7.7.5.4. Sample customized install-config.yaml file for GCP

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.



#### IMPORTANT

This sample YAML file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program and modify it.

```

apiVersion: v1
baseDomain: example.com 1
controlPlane: 2 3
  hyperthreading: Enabled 4
  name: master
  platform:
    gcp:
      type: n2-standard-4
      zones:
      - us-central1-a
      - us-central1-c
    osDisk:
      diskType: pd-ssd
      diskSizeGB: 1024
      encryptionKey: 5
      kmsKey:
        name: worker-key
        keyRing: test-machine-keys
        location: global
        projectID: project-id
  replicas: 3
compute: 6 7
  - hyperthreading: Enabled 8
  name: worker
  platform:
    gcp:
      type: n2-standard-4
      zones:
      - us-central1-a
      - us-central1-c
    osDisk:
      diskType: pd-standard
      diskSizeGB: 128
      encryptionKey: 9
      kmsKey:
        name: worker-key
        keyRing: test-machine-keys
        location: global
        projectID: project-id

```

```

replicas: 3
metadata:
  name: test-cluster 10
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
  gcp:
  projectID: openshift-production 11
  region: us-central1 12
  network: existing_vpc 13
  controlPlaneSubnet: control_plane_subnet 14
  computeSubnet: compute_subnet 15
pullSecret: '{"auths":{"<local_registry>":{"auth": "<credentials>","email": "you@example.com"}}}' 16
fips: false 17
sshKey: ssh-ed25519 AAAA... 18
additionalTrustBundle: | 19
  -----BEGIN CERTIFICATE-----
  <MY_TRUSTED_CA_CERT>
  -----END CERTIFICATE-----
imageContentSources: 20
- mirrors:
  - <local_registry>/<local_repository_name>/release
  source: quay.io/openshift-release-dev/ocp-release
- mirrors:
  - <local_registry>/<local_repository_name>/release
  source: quay.io/openshift-release-dev/ocp-v4.0-art-dev

```

**1 10 11 12** Required. The installation program prompts you for this value.

**2 6** If you do not provide these parameters and values, the installation program provides the default value.

**3 7** The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

**4 8** Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.



### IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger machine types, such as **n1-standard-8**, for your machines if you disable simultaneous multithreading.

- 5 9 Optional: The custom encryption key section to encrypt both virtual machines and persistent volumes. Your default compute service account must have the permissions granted to use your KMS key and have the correct IAM role assigned. The default service account name follows the **service-`<project_number>`@compute-system.iam.gserviceaccount.com** pattern. For more information on granting the correct permissions for your service account, see "Machine management" → "Creating machine sets" → "Creating a machine set on GCP".
- 13 Specify the name of an existing VPC.
- 14 Specify the name of the existing subnet to deploy the control plane machines to. The subnet must belong to the VPC that you specified.
- 15 Specify the name of the existing subnet to deploy the compute machines to. The subnet must belong to the VPC that you specified.
- 16 For **<local\_registry>**, specify the registry domain name, and optionally the port, that your mirror registry uses to serve content. For example, **registry.example.com** or **registry.example.com:5000**. For **<credentials>**, specify the base64-encoded user name and password for your mirror registry.
- 17 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.



### IMPORTANT

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

- 18 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.



### NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

- 19 Provide the contents of the certificate file that you used for your mirror registry.
- 20 Provide the **imageContentSources** section from the output of the command to mirror the repository.

#### 7.7.5.5. Create an Ingress Controller with global access on GCP

You can create an Ingress Controller that has global access to a Google Cloud Platform (GCP) cluster. Global access is only available to Ingress Controllers using internal load balancers.

## Prerequisites

- You created the **install-config.yaml** and complete any modifications to it.

## Procedure

Create an Ingress Controller with global access on a new GCP cluster.

- Change to the directory that contains the installation program and create a manifest file:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

- For **<installation\_directory>**, specify the name of the directory that contains the **install-config.yaml** file for your cluster.

- Create a file that is named **cluster-ingress-default-ingresscontroller.yaml** in the **<installation\_directory>/manifests/** directory:

```
$ touch <installation_directory>/manifests/cluster-ingress-default-ingresscontroller.yaml 1
```

- For **<installation\_directory>**, specify the directory name that contains the **manifests/** directory for your cluster.

After creating the file, several network configuration files are in the **manifests/** directory, as shown:

```
$ ls <installation_directory>/manifests/cluster-ingress-default-ingresscontroller.yaml
```

## Example output

```
cluster-ingress-default-ingresscontroller.yaml
```

- Open the **cluster-ingress-default-ingresscontroller.yaml** file in an editor and enter a custom resource (CR) that describes the Operator configuration you want:

## Sample clientAccess configuration to Global

```
apiVersion: operator.openshift.io/v1
kind: IngressController
metadata:
  name: default
  namespace: openshift-ingress-operator
spec:
  endpointPublishingStrategy:
    loadBalancer:
      providerParameters:
        gcp:
          clientAccess: Global 1
```

```

type: GCP
scope: Internal
type: LoadBalancerService

```

- 1 Set `gcp.clientAccess` to **Global**.
- 2 Global access is only available to Ingress Controllers using internal load balancers.

### 7.7.5.6. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the `install-config.yaml` file.

#### Prerequisites

- You have an existing `install-config.yaml` file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's `spec.noProxy` field to bypass the proxy if necessary.



#### NOTE

The **Proxy** object `status.noProxy` field is populated with the values of the `networking.machineNetwork[].cidr`, `networking.clusterNetwork[].cidr`, and `networking.serviceNetwork[]` fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object `status.noProxy` field is also populated with the instance metadata endpoint (`169.254.169.254`).

#### Procedure

1. Edit your `install-config.yaml` file and add the proxy settings. For example:

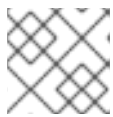
```

apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port>
  httpsProxy: https://<username>:<pswd>@<ip>:<port>
  noProxy: example.com
  additionalTrustBundle: |
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
...

```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.

- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with `.` to match subdomains only. For example, `.y.com` matches `x.y.com`, but not `y.com`. Use `*` to bypass the proxy for all destinations.
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

**NOTE**

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

**NOTE**

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

### 7.7.6. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.

**IMPORTANT**

You can run the **create cluster** command of the installation program only once, during initial installation.

#### Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

#### Procedure

1. Remove any existing GCP credentials that do not use the service account key for the GCP account that you configured for your cluster and that are stored in the following locations:

- The **GOOGLE\_CREDENTIALS**, **GOOGLE\_CLOUD\_KEYFILE\_JSON**, or **GKLOUD\_KEYFILE\_JSON** environment variables
  - The `~/gcp/osServiceAccount.json` file
  - The **gcloud cli** default credentials
2. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
--log-level=info 2
```

- 1** For `<installation_directory>`, specify the location of your customized `./install-config.yaml` file.
- 2** To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.



#### NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

When the cluster deployment completes, directions for accessing your cluster, including a link to its web console and credentials for the **kubeadmin** user, display in your terminal.

#### Example output

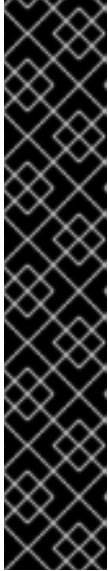
```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Ee6gm-ymBZj-
Wt5AL"
INFO Time elapsed: 36m22s
```



#### NOTE

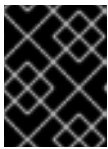
The cluster access and credential information also outputs to `<installation_directory>/openshift_install.log` when an installation succeeds.





### IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.



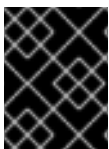
### IMPORTANT

You must not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

3. Optional: You can reduce the number of permissions for the service account that you used to install the cluster.
  - If you assigned the **Owner** role to your service account, you can remove that role and replace it with the **Viewer** role.
  - If you included the **Service Account Key Admin** role, you can remove it.

### 7.7.7. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



### IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

#### Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

```
$ tar xvf <file>
```

- 5. Place the **oc** binary in a directory that is on your **PATH**.  
To check your **PATH**, execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

### Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your **PATH**.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### 7.7.8. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

#### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

#### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

#### Example output

```
system:admin
```

### 7.7.9. Disabling the default OperatorHub sources

Operator catalogs that source content provided by Red Hat and community projects are configured for OperatorHub by default during an OpenShift Container Platform installation. In a restricted network environment, you must disable the default catalogs as a cluster administrator.

#### Procedure

- Disable the sources for the default catalogs by adding **disableAllDefaultSources: true** to the **OperatorHub** object:

```
$ oc patch OperatorHub cluster --type json \
  -p [{"op": "add", "path": "/spec/disableAllDefaultSources", "value": true}]
```

#### TIP

Alternatively, you can use the web console to manage catalog sources. From the **Administration** → **Cluster Settings** → **Configuration** → **OperatorHub** page, click the **Sources** tab, where you can create, delete, disable, and enable individual sources.

## 7.7.10. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

## 7.7.11. Next steps

- [Validate an installation.](#)
- [Customize your cluster.](#)
- [Configure image streams](#) for the Cluster Samples Operator and the **must-gather** tool.
- Learn how to [use Operator Lifecycle Manager \(OLM\) on restricted networks](#) .
- If the mirror registry that you used to install your cluster has a trusted CA, add it to the cluster by [configuring additional trust stores](#).
- If necessary, you can [opt out of remote health reporting](#) .

## 7.8. INSTALLING A CLUSTER ON GCP INTO AN EXISTING VPC

In OpenShift Container Platform version 4.9, you can install a cluster into an existing Virtual Private Cloud (VPC) on Google Cloud Platform (GCP). The installation program provisions the rest of the required infrastructure, which you can further customize. To customize the installation, you modify parameters in the **install-config.yaml** file before you install the cluster.

### 7.8.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You [configured a GCP project](#) to host the cluster.
- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can [manually create and maintain IAM credentials](#) .

### 7.8.2. About using a custom VPC

In OpenShift Container Platform 4.9, you can deploy a cluster into existing subnets in an existing Virtual

Private Cloud (VPC) in Google Cloud Platform (GCP). By deploying OpenShift Container Platform into an existing GCP VPC, you might be able to avoid limit constraints in new accounts or more easily abide by the operational constraints that your company's guidelines set. If you cannot obtain the infrastructure creation permissions that are required to create the VPC yourself, use this installation option. You must configure networking for the subnets.

### 7.8.2.1. Requirements for using your VPC

The union of the VPC CIDR block and the machine network CIDR must be non-empty. The subnets must be within the machine network.

The installation program does not create the following components:

- NAT gateways
- Subnets
- Route tables
- VPC network



#### NOTE

The installation program requires that you use the cloud-provided DNS server. Using a custom DNS server is not supported and causes the installation to fail.

### 7.8.2.2. VPC validation

To ensure that the subnets that you provide are suitable, the installation program confirms the following data:

- All the subnets that you specify exist.
- You provide one subnet for control-plane machines and one subnet for compute machines.
- The subnet's CIDRs belong to the machine CIDR that you specified.

### 7.8.2.3. Division of permissions

Some individuals can create different resource in your clouds than others. For example, you might be able to create application-specific items, like instances, buckets, and load balancers, but not networking-related components such as VPCs, subnets, or ingress rules.

### 7.8.2.4. Isolation between clusters

If you deploy OpenShift Container Platform to an existing network, the isolation of cluster services is reduced in the following ways:

- You can install multiple OpenShift Container Platform clusters in the same VPC.
- ICMP ingress is allowed to the entire network.
- TCP 22 ingress (SSH) is allowed to the entire network.
- Control plane TCP 6443 ingress (Kubernetes API) is allowed to the entire network.

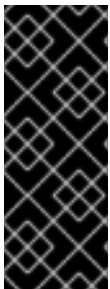
- Control plane TCP 22623 ingress (MCS) is allowed to the entire network.

### 7.8.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



#### IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

### 7.8.4. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.



#### IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



#### NOTE

You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

#### Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.



#### NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.



#### NOTE

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

#### Example output

```
Agent pid 31874
```



#### NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1 Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

### Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

5. Set the **GOOGLE\_APPLICATION\_CREDENTIALS** environment variable to the full path to your service account private key file.

```
$ export GOOGLE_APPLICATION_CREDENTIALS="<your_service_account_file>"
```

6. Verify that the credentials were applied.

```
$ gcloud auth list
```

### Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

## 7.8.5. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

### Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space

### Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



### IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



### IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.



4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#). This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

## 7.8.6. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Google Cloud Platform (GCP).

### Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

### Procedure

1. Create the **install-config.yaml** file.
  - a. Change to the directory that contains the installation program and run the following command:

```
./openshift-install create install-config --dir <installation_directory> 1
```

- 1** For **<installation\_directory>**, specify the directory name to store the files that the installation program creates.



### IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

- b. At the prompts, provide the configuration details for your cloud:
  - i. Optional: Select an SSH key to use to access your cluster machines.



### NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

- ii. Select **gcp** as the platform to target.
  - iii. If you have not configured the service account key for your GCP account on your computer, you must obtain it from GCP and paste the contents of the file or enter the absolute path to the file.
  - iv. Select the project ID to provision the cluster in. The default value is specified by the service account that you configured.
  - v. Select the region to deploy the cluster to.
  - vi. Select the base domain to deploy the cluster to. The base domain corresponds to the public DNS zone that you created for your cluster.
  - vii. Enter a descriptive name for your cluster.
  - viii. Paste the [pull secret from the Red Hat OpenShift Cluster Manager](#) .
2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.
  3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



### IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

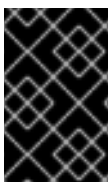
#### 7.8.6.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.



### NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.



### IMPORTANT

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

#### 7.8.6.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 7.25. Required parameters

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;</b> . <b>&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}</b> . <b>{{.baseDomain}}</b> .	String of lowercase letters, hyphens (-), and periods (.), such as <b>dev</b> .
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws</b> , <b>baremetal</b> , <b>azure</b> , <b>gcp</b> , <b>openstack</b> , <b>ovirt</b> , <b>vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object


Parameter	Description	Values
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } }</pre>


### 7.8.6.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

Table 7.26. Network parameters


Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	Object <div style="display: flex; align-items: center; margin-top: 10px;">  <div> <p><b>NOTE</b></p> <p>You cannot modify parameters specified by the <b>networking</b> object after installation.</p> </div> </div>
<b>networking.networkType</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .

Parameter	Description	Values
<b>networking.clusterNetwork</b>	<p>The IP address blocks for pods.</p> <p>The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b>.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   clusterNetwork:     - cidr: 10.128.0.0/14       hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	<p>Required if you use <b>networking.clusterNetwork</b>. An IP address block.</p> <p>An IPv4 network.</p>	<p>An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b>.</p>
<b>networking.clusterNetwork.hostPrefix</b>	<p>The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b>. A <b>hostPrefix</b> value of <b>23</b> provides 510 (<math>2^{(32 - 23)} - 2</math>) pod IP addresses.</p>	<p>A subnet prefix.</p> <p>The default value is <b>23</b>.</p>
<b>networking.serviceNetwork</b>	<p>The IP address block for services. The default value is <b>172.30.0.0/16</b>.</p> <p>The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.</p>	<p>An array with an IP address block in CIDR format. For example:</p> <pre>networking:   serviceNetwork:     - 172.30.0.0/16</pre>
<b>networking.machineNetwork</b>	<p>The IP address blocks for machines.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   machineNetwork:     - cidr: 10.0.0.0/16</pre>
<b>networking.machineNetwork.cidr</b>	<p>Required if you use <b>networking.machineNetwork</b>. An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b>.</p>	<p>An IP network block in CIDR notation.</p> <p>For example, <b>10.0.0.0/16</b>.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p> </div> </div>



## 7.8.6.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

Table 7.27. Optional parameters


Parameter	Description	Values
<b>additionalTrustBundle</b>	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
<b>compute</b>	The configuration for the machines that comprise the compute nodes.	Array of <b>MachinePool</b> objects.
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String
<b>compute.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>

Parameter	Description	Values
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String
<b>controlPlane.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div data-bbox="485 1093 592 1411" style="background-color: black; width: 67px; height: 142px; margin-bottom: 10px;"></div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platform</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>controlPlane.replicas</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.

Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported. If you are installing on GCP into a shared virtual private cloud (VPC), <b>credentialsMode</b> must be set to <b>Passthrough</b>.</p> <p> <b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators reference</i> content.</p> <p> <b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p>	<b>Mint, Passthrough, Manual</b> or an empty string ("").



Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start; gap: 10px;"> <div style="width: 60px; height: 150px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px);"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; gap: 10px; margin-top: 10px;"> <div style="width: 60px; height: 80px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px);"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<b>Internal</b> or <b>External</b> . To deploy a private cluster, which cannot be accessed from the internet, set <b>publish</b> to <b>Internal</b> . The default value is <b>External</b> .


Parameter	Description	Values
<b>sshKey</b>	<p>The SSH key or keys to authenticate access your cluster machines.</p>  <p><b>NOTE</b></p> <p>For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.</p>	<p>One or more keys. For example:</p> <pre>sshKey:   &lt;key1&gt;   &lt;key2&gt;   &lt;key3&gt;</pre>

#### 7.8.6.1.4. Additional Google Cloud Platform (GCP) configuration parameters

Additional GCP configuration parameters are described in the following table:

Table 7.28. Additional GCP parameters

Parameter	Description	Values
<b>platform.gcp.network</b>	The name of the existing VPC that you want to deploy your cluster to.	String.
<b>platform.gcp.region</b>	The name of the GCP region that hosts your cluster.	Any valid region name, such as <b>us-central1</b> .
<b>platform.gcp.type</b>	The <a href="#">GCP machine type</a> .	The GCP machine type.
<b>platform.gcp.zones</b>	The availability zones where the installation program creates machines for the specified MachinePool.	A list of valid <a href="#">GCP availability zones</a> , such as <b>us-central1-a</b> , in a <a href="#">YAML sequence</a> .
<b>platform.gcp.controlPlaneSubnet</b>	The name of the existing subnet in your VPC that you want to deploy your control plane machines to.	The subnet name.

Parameter	Description	Values
<code>platform.gcp.computeSubnet</code>	The name of the existing subnet in your VPC that you want to deploy your compute machines to.	The subnet name.
<code>platform.gcp.licenses</code>	<p>A list of license URLs that must be applied to the compute images.</p>  <p><b>IMPORTANT</b></p> <p>The <b>licenses</b> parameter is a deprecated field and nested virtualization is enabled by default. It is not recommended to use this field.</p>	Any license available with the <a href="#">license API</a> , such as the license to enable <a href="#">nested virtualization</a> . You cannot use this parameter with a mechanism that generates pre-built images. Using a license URL forces the installer to copy the source image before use.
<code>platform.gcp.osDiskSizeGB</code>	The size of the disk in gigabytes (GB).	Any size between 16 GB and 65536 GB.
<code>platform.gcp.osDiskType</code>	The type of disk.	Either the default <b>pd-ssd</b> or the <b>pd-standard</b> disk type. The control plane nodes must be the <b>pd-ssd</b> disk type. The worker nodes can be either type.
<code>controlPlane.platform.gcp.osDiskEncryptionKey.kmsKeyName</code>	The name of the customer managed encryption key to be used for control plane machine disk encryption.	The encryption key name.

Parameter	Description	Values
<code>controlPlane.platform.gcp.osDisk.encryptionKey.kmsKeyRing</code>	For control plane machines, the name of the KMS key ring to which the KMS key belongs.	The KMS key ring name.
<code>controlPlane.platform.gcp.osDisk.encryptionKey.location</code>	For control plane machines, the GCP location in which the key ring exists. For more information on KMS locations, see Google's documentation on <a href="#">Cloud KMS locations</a> .	The GCP location for the key ring.
<code>controlPlane.platform.gcp.osDisk.encryptionKey.projectID</code>	For control plane machines, the ID of the project in which the KMS key ring exists. This value defaults to the VM project ID if not set.	The GCP project ID.
<code>compute.platform.gcp.osDisk.encryptionKey.kmsKeyName</code>	The name of the customer managed encryption key to be used for compute machine disk encryption.	The encryption key name.

Parameter	Description	Values
<code>compute.platform.gcp.ossDisk.encryptionKey.kmsKey.keyRing</code>	For compute machines, the name of the KMS key ring to which the KMS key belongs.	The KMS key ring name.
<code>compute.platform.gcp.ossDisk.encryptionKey.kmsKey.location</code>	For compute machines, the GCP location in which the key ring exists. For more information on KMS locations, see Google's documentation on <a href="#">Cloud KMS locations</a> .	The GCP location for the key ring.
<code>compute.platform.gcp.ossDisk.encryptionKey.kmsKey.projectID</code>	For compute machines, the ID of the project in which the KMS key ring exists. This value defaults to the VM project ID if not set.	The GCP project ID.

### 7.8.6.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 7.29. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Compute	RHCOS, RHEL 7.9, or RHEL 8.4 [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.

### 7.8.6.3. Using custom machine types

Using a custom machine type to install a OpenShift Container Platform cluster is supported.

Consider the following when using a custom machine type:

- Similar to predefined instance types, custom machine types must meet the minimum resource requirements for control plane and compute machines. For more information, see "Minimum resource requirements for cluster installation".
- The name of the custom machine type must adhere to the following syntax:  
**custom-<number\_of\_cpus>-<amount\_of\_memory\_in\_mb>**

For example, **custom-6-20480**.

As part of the installation process, you specify the custom machine type in the **install-config.yaml** file.

#### Sample install-config.yaml file with a custom machine type

```
compute:
- architecture: amd64
  hyperthreading: Enabled
  name: worker
  platform:
    gcp:
      type: custom-6-20480
  replicas: 2
controlPlane:
  architecture: amd64
  hyperthreading: Enabled
  name: master
  platform:
```

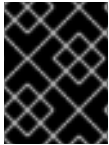
```

gcp:
  type: custom-6-20480
  replicas: 3

```

#### 7.8.6.4. Sample customized install-config.yaml file for GCP

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.



#### IMPORTANT

This sample YAML file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program and modify it.

```

apiVersion: v1
baseDomain: example.com 1
controlPlane: 2 3
  hyperthreading: Enabled 4
  name: master
  platform:
    gcp:
      type: n2-standard-4
      zones:
      - us-central1-a
      - us-central1-c
    osDisk:
      diskType: pd-ssd
      diskSizeGB: 1024
      encryptionKey: 5
      kmsKey:
        name: worker-key
        keyRing: test-machine-keys
        location: global
        projectID: project-id
  replicas: 3
compute: 6 7
  - hyperthreading: Enabled 8
  name: worker
  platform:
    gcp:
      type: n2-standard-4
      zones:
      - us-central1-a
      - us-central1-c
    osDisk:
      diskType: pd-standard
      diskSizeGB: 128
      encryptionKey: 9
      kmsKey:
        name: worker-key
        keyRing: test-machine-keys
        location: global
        projectID: project-id

```

```

replicas: 3
metadata:
  name: test-cluster 10
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
  gcp:
  projectID: openshift-production 11
  region: us-central1 12
  network: existing_vpc 13
  controlPlaneSubnet: control_plane_subnet 14
  computeSubnet: compute_subnet 15
pullSecret: '{"auths": ...}' 16
fips: false 17
sshKey: ssh-ed25519 AAAA... 18

```

**1 10 11 12 16** Required. The installation program prompts you for this value.

**2 6** If you do not provide these parameters and values, the installation program provides the default value.

**3 7** The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

**4 8** Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.



### IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger machine types, such as **n1-standard-8**, for your machines if you disable simultaneous multithreading.

**5 9** Optional: The custom encryption key section to encrypt both virtual machines and persistent volumes. Your default compute service account must have the permissions granted to use your KMS key and have the correct IAM role assigned. The default service account name follows the **service-<project\_number>@compute-system.iam.gserviceaccount.com** pattern. For more information on granting the correct permissions for your service account, see "Machine management" → "Creating machine sets" → "Creating a machine set on GCP".

**13** Specify the name of an existing VPC.



- 14 Specify the name of the existing subnet to deploy the control plane machines to. The subnet must belong to the VPC that you specified.
- 15 Specify the name of the existing subnet to deploy the compute machines to. The subnet must belong to the VPC that you specified.
- 17 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.



### IMPORTANT

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

- 18 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.



### NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

#### 7.8.6.5. Create an Ingress Controller with global access on GCP

You can create an Ingress Controller that has global access to a Google Cloud Platform (GCP) cluster. Global access is only available to Ingress Controllers using internal load balancers.

#### Prerequisites

- You created the **install-config.yaml** and complete any modifications to it.

#### Procedure

Create an Ingress Controller with global access on a new GCP cluster.

1. Change to the directory that contains the installation program and create a manifest file:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

- 1 For **<installation\_directory>**, specify the name of the directory that contains the **install-config.yaml** file for your cluster.

2. Create a file that is named **cluster-ingress-default-ingresscontroller.yaml** in the **<installation\_directory>/manifests/** directory:

```
$ touch <installation_directory>/manifests/cluster-ingress-default-ingresscontroller.yaml 1
```

- 1 For **<installation\_directory>**, specify the directory name that contains the **manifests/** directory for your cluster.

After creating the file, several network configuration files are in the **manifests/** directory, as shown:

```
$ ls <installation_directory>/manifests/cluster-ingress-default-ingresscontroller.yaml
```

### Example output

```
cluster-ingress-default-ingresscontroller.yaml
```

3. Open the **cluster-ingress-default-ingresscontroller.yaml** file in an editor and enter a custom resource (CR) that describes the Operator configuration you want:

### Sample `clientAccess` configuration to Global

```
apiVersion: operator.openshift.io/v1
kind: IngressController
metadata:
  name: default
  namespace: openshift-ingress-operator
spec:
  endpointPublishingStrategy:
    loadBalancer:
      providerParameters:
        gcp:
          clientAccess: Global 1
          type: GCP
          scope: Internal 2
          type: LoadBalancerService
```

- 1** Set `gcp.clientAccess` to **Global**.
- 2** Global access is only available to Ingress Controllers using internal load balancers.

## 7.8.7. Additional resources

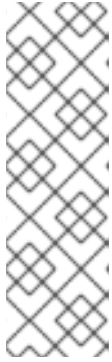
- [Enabling customer-managed encryption keys for a machine set](#)

### 7.8.7.1. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

#### Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



## NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

## Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
  additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
  ...
```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations.
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.



## NOTE

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



#### NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

### 7.8.8. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



#### IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

#### Prerequisites

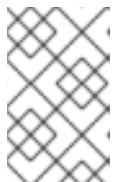
- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

#### Procedure

1. Remove any existing GCP credentials that do not use the service account key for the GCP account that you configured for your cluster and that are stored in the following locations:
  - The **GOOGLE\_CREDENTIALS**, **GOOGLE\_CLOUD\_KEYFILE\_JSON**, or **GKLOUD\_KEYFILE\_JSON** environment variables
  - The `~/gcp/osServiceAccount.json` file
  - The **gcloud cli** default credentials
2. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
--log-level=info 2
```

- 1** For **<installation\_directory>**, specify the location of your customized **./install-config.yaml** file.
- 2** To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.



#### NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

When the cluster deployment completes, directions for accessing your cluster, including a link to its web console and credentials for the **kubeadmin** user, display in your terminal.

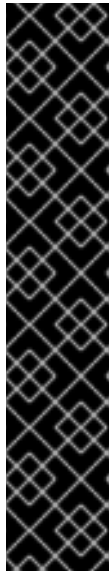
### Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Ee6gm-ymBZj-
Wt5AL"
INFO Time elapsed: 36m22s
```



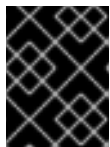
### NOTE

The cluster access and credential information also outputs to **<installation\_directory>/openshift\_install.log** when an installation succeeds.



### IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.



### IMPORTANT

You must not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

- Optional: You can reduce the number of permissions for the service account that you used to install the cluster.
  - If you assigned the **Owner** role to your service account, you can remove that role and replace it with the **Viewer** role.
  - If you included the **Service Account Key Admin** role, you can remove it.

### 7.8.9. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



## IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

### Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

```
$ tar xvf <file>
```

5. Place the **oc** binary in a directory that is on your **PATH**.  
To check your **PATH**, execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

## Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your **PATH**.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### 7.8.10. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

#### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

#### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

#### Example output

```
system:admin
```

### Additional resources

- See [Accessing the web console](#) for more details about accessing and understanding the OpenShift Container Platform web console.

## 7.8.11. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

## 7.8.12. Next steps

- [Customize your cluster](#).
- If necessary, you can [opt out of remote health reporting](#).

## 7.9. INSTALLING A PRIVATE CLUSTER ON GCP

In OpenShift Container Platform version 4.9, you can install a private cluster into an existing VPC on Google Cloud Platform (GCP). The installation program provisions the rest of the required infrastructure, which you can further customize. To customize the installation, you modify parameters in the **install-config.yaml** file before you install the cluster.

### 7.9.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You [configured a GCP project](#) to host the cluster.
- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can [manually create and maintain IAM credentials](#).

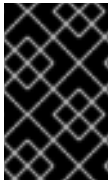
### 7.9.2. Private clusters

You can deploy a private OpenShift Container Platform cluster that does not expose external endpoints. Private clusters are accessible from only an internal network and are not visible to the internet.

By default, OpenShift Container Platform is provisioned to use publicly-accessible DNS and endpoints.



A private cluster sets the DNS, Ingress Controller, and API server to private when you deploy your cluster. This means that the cluster resources are only accessible from your internal network and are not visible to the internet.



## IMPORTANT

If the cluster has any public subnets, load balancer services created by administrators might be publicly accessible. To ensure cluster security, verify that these services are explicitly annotated as private.

To deploy a private cluster, you must:

- Use existing networking that meets your requirements. Your cluster resources might be shared between other clusters on the network.
- Deploy from a machine that has access to:
  - The API services for the cloud to which you provision.
  - The hosts on the network that you provision.
  - The internet to obtain installation media.

You can use any machine that meets these access requirements and follows your company's guidelines. For example, this machine can be a bastion host on your cloud network or a machine that has access to the network through a VPN.

### 7.9.2.1. Private clusters in GCP

To create a private cluster on Google Cloud Platform (GCP), you must provide an existing private VPC and subnets to host the cluster. The installation program must also be able to resolve the DNS records that the cluster requires. The installation program configures the Ingress Operator and API server for only internal traffic.

The cluster still requires access to internet to access the GCP APIs.

The following items are not required or created when you install a private cluster:

- Public subnets
- Public network load balancers, which support public ingress
- A public DNS zone that matches the **baseDomain** for the cluster

The installation program does use the **baseDomain** that you specify to create a private DNS zone and the required records for the cluster. The cluster is configured so that the Operators do not create public records for the cluster and all cluster machines are placed in the private subnets that you specify.

Because it is not possible to limit access to external load balancers based on source tags, the private cluster uses only internal load balancers to allow access to internal instances.

The internal load balancer relies on instance groups rather than the target pools that the network load balancers use. The installation program creates instance groups for each zone, even if there is no instance in that group.

- The cluster IP address is internal only.

- One forwarding rule manages both the Kubernetes API and machine config server ports.
- The backend service is comprised of each zone's instance group and, while it exists, the bootstrap instance group.
- The firewall uses a single rule that is based on only internal source ranges.

#### 7.9.2.1.1. Limitations

No health check for the Machine config server, `/healthz`, runs because of a difference in load balancer functionality. Two internal load balancers cannot share a single IP address, but two network load balancers can share a single external IP address. Instead, the health of an instance is determined entirely by the `/readyz` check on port 6443.

### 7.9.3. About using a custom VPC

In OpenShift Container Platform 4.9, you can deploy a cluster into an existing VPC in Google Cloud Platform (GCP). If you do, you must also use existing subnets within the VPC and routing rules.

By deploying OpenShift Container Platform into an existing GCP VPC, you might be able to avoid limit constraints in new accounts or more easily abide by the operational constraints that your company's guidelines set. This is a good option to use if you cannot obtain the infrastructure creation permissions that are required to create the VPC yourself.

#### 7.9.3.1. Requirements for using your VPC

The installation program will no longer create the following components:

- VPC
- Subnets
- Cloud router
- Cloud NAT
- NAT IP addresses

If you use a custom VPC, you must correctly configure it and its subnets for the installation program and the cluster to use. The installation program cannot subdivide network ranges for the cluster to use, set route tables for the subnets, or set VPC options like DHCP, so you must do so before you install the cluster.

Your VPC and subnets must meet the following characteristics:

- The VPC must be in the same GCP project that you deploy the OpenShift Container Platform cluster to.
- To allow access to the internet from the control plane and compute machines, you must configure cloud NAT on the subnets to allow egress to it. These machines do not have a public address. Even if you do not require access to the internet, you must allow egress to the VPC network to obtain the installation program and images. Because multiple cloud NATs cannot be configured on the shared subnets, the installation program cannot configure it.

To ensure that the subnets that you provide are suitable, the installation program confirms the following data:

- All the subnets that you specify exist and belong to the VPC that you specified.
- The subnet CIDRs belong to the machine CIDR.
- You must provide a subnet to deploy the cluster control plane and compute machines to. You can use the same subnet for both machine types.

If you destroy a cluster that uses an existing VPC, the VPC is not deleted.

### 7.9.3.2. Division of permissions

Starting with OpenShift Container Platform 4.3, you do not need all of the permissions that are required for an installation program-provisioned infrastructure cluster to deploy a cluster. This change mimics the division of permissions that you might have at your company: some individuals can create different resources in your clouds than others. For example, you might be able to create application-specific items, like instances, buckets, and load balancers, but not networking-related components such as VPCs, subnets, or Ingress rules.

The GCP credentials that you use when you create your cluster do not need the networking permissions that are required to make VPCs and core networking components within the VPC, such as subnets, routing tables, internet gateways, NAT, and VPN. You still need permission to make the application resources that the machines within the cluster require, such as load balancers, security groups, storage, and nodes.

### 7.9.3.3. Isolation between clusters

If you deploy OpenShift Container Platform to an existing network, the isolation of cluster services is preserved by firewall rules that reference the machines in your cluster by the cluster's infrastructure ID. Only traffic within the cluster is allowed.

If you deploy multiple clusters to the same VPC, the following components might share access between clusters:

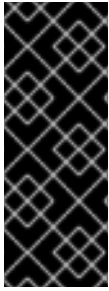
- The API, which is globally available with an external publishing strategy or available throughout the network in an internal publishing strategy
- Debugging tools, such as ports on VM instances that are open to the machine CIDR for SSH and ICMP access

### 7.9.4. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

**IMPORTANT**

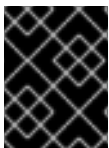
If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

**7.9.5. Generating a key pair for cluster node SSH access**

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.

**IMPORTANT**

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

**NOTE**

You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

**Procedure**

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.

**NOTE**

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

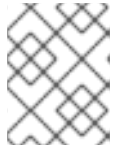
- View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

- Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.



#### NOTE

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- If the `ssh-agent` process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

#### Example output

```
Agent pid 31874
```



#### NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

- Add your SSH private key to the `ssh-agent`:

```
$ ssh-add <path>/<file_name> 1
```

- 1** Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

#### Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

- Set the `GOOGLE_APPLICATION_CREDENTIALS` environment variable to the full path to your service account private key file.

```
$ export GOOGLE_APPLICATION_CREDENTIALS="<your_service_account_file>"
```

- Verify that the credentials were applied.

```
$ gcloud auth list
```

## Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

## 7.9.6. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

### Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space

### Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



#### IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



#### IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#) . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

## 7.9.7. Manually creating the installation configuration file

For installations of a private OpenShift Container Platform cluster that are only accessible from an internal network and are not visible to the internet, you must manually generate your installation configuration file.

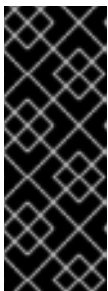
## Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

## Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```



### IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation\_directory>**.



### NOTE

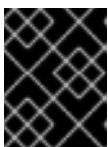
You must name this configuration file **install-config.yaml**.



### NOTE

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation\_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



### IMPORTANT

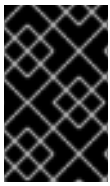
The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

### 7.9.7.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.

**NOTE**

After installation, you cannot modify these parameters in the **install-config.yaml** file.

**IMPORTANT**

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

**7.9.7.1.1. Required configuration parameters**

Required installation configuration parameters are described in the following table:

**Table 7.30. Required parameters**

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;.&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}</b> . <b>{{.baseDomain}}</b> .	String of lowercase letters, hyphens (-), and periods (.), such as <b>dev</b> .




Parameter	Description	Values
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws</b> , <b>baremetal</b> , <b>azure</b> , <b>gcp</b> , <b>openstack</b> , <b>ovirt</b> , <b>vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } }</pre>

### 7.9.7.1.2. Network configuration parameters


You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

Table 7.31. Network parameters

Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	<p>Object</p>  <p><b>NOTE</b></p> <p>You cannot modify parameters specified by the <b>networking</b> object after installation.</p>

Parameter	Description	Values
<b>networking.networkType</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .
<b>networking.clusterNetwork</b>	The IP address blocks for pods.  The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b> .  If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example:  <pre>networking:   clusterNetwork:     - cidr: 10.128.0.0/14       hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	Required if you use <b>networking.clusterNetwork</b> . An IP address block.  An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b> .
<b>networking.clusterNetwork.hostPrefix</b>	The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b> . A <b>hostPrefix</b> value of <b>23</b> provides 510 ( $2^{(32 - 23)} - 2$ ) pod IP addresses.	A subnet prefix.  The default value is <b>23</b> .
<b>networking.serviceNetwork</b>	The IP address block for services. The default value is <b>172.30.0.0/16</b> .  The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example:  <pre>networking:   serviceNetwork:     - 172.30.0.0/16</pre>
<b>networking.machineNetwork</b>	The IP address blocks for machines.  If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example:  <pre>networking:   machineNetwork:     - cidr: 10.0.0.0/16</pre>

Parameter	Description	Values
<b>networking.machineNetwork.cidr</b>	Required if you use <b>networking.machineNetwork</b> . An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b> .	An IP network block in CIDR notation. For example, <b>10.0.0.0/16</b> .  <b>NOTE</b> Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.


### 7.9.7.1.3. Optional configuration parameters



Optional installation configuration parameters are described in the following table:

Table 7.32. Optional parameters


Parameter	Description	Values
<b>additionalTrustBundle</b>	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
<b>compute</b>	The configuration for the machines that comprise the compute nodes.	Array of <b>MachinePool</b> objects.
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String

Parameter	Description	Values
<b>compute.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b>
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String

Parameter	Description	Values
<b>controlPlane.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platform</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>controlPlane.replicas</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.

Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported. If you are installing on GCP into a shared virtual private cloud (VPC), <b>credentialsMode</b> must be set to <b>Passthrough</b>.</p> <p> <b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators reference</i> content.</p> <p> <b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p>	<b>Mint, Passthrough, Manual</b> or an empty string ("").

Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start;"> <div style="width: 60px; height: 150px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 60px; height: 80px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<b>Internal</b> or <b>External</b> . To deploy a private cluster, which cannot be accessed from the internet, set <b>publish</b> to <b>Internal</b> . The default value is <b>External</b> .

Parameter	Description	Values
<b>sshKey</b>	<p>The SSH key or keys to authenticate access your cluster machines.</p>  <p><b>NOTE</b></p> <p>For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.</p>	<p>One or more keys. For example:</p> <pre>sshKey:   &lt;key1&gt;   &lt;key2&gt;   &lt;key3&gt;</pre>


#### 7.9.7.1.4. Additional Google Cloud Platform (GCP) configuration parameters

Additional GCP configuration parameters are described in the following table:

Table 7.33. Additional GCP parameters

Parameter	Description	Values
<b>platform.gcp.network</b>	The name of the existing VPC that you want to deploy your cluster to.	String.
<b>platform.gcp.region</b>	The name of the GCP region that hosts your cluster.	Any valid region name, such as <b>us-central1</b> .
<b>platform.gcp.type</b>	The <a href="#">GCP machine type</a> .	The GCP machine type.
<b>platform.gcp.zones</b>	The availability zones where the installation program creates machines for the specified MachinePool.	A list of valid <a href="#">GCP availability zones</a> , such as <b>us-central1-a</b> , in a <a href="#">YAML sequence</a> .
<b>platform.gcp.controlPlaneSubnet</b>	The name of the existing subnet in your VPC that you want to deploy your control plane machines to.	The subnet name.



Parameter	Description	Values
<code>platform.gcp.computeSubnet</code>	The name of the existing subnet in your VPC that you want to deploy your compute machines to.	The subnet name.
<code>platform.gcp.licenses</code>	<p>A list of license URLs that must be applied to the compute images.</p>  <p><b>IMPORTANT</b></p> <p>The <b>licenses</b> parameter is a deprecated field and nested virtualization is enabled by default. It is not recommended to use this field.</p>	Any license available with the <a href="#">license API</a> , such as the license to enable <a href="#">nested virtualization</a> . You cannot use this parameter with a mechanism that generates pre-built images. Using a license URL forces the installer to copy the source image before use.
<code>platform.gcp.osDiskSizeGB</code>	The size of the disk in gigabytes (GB).	Any size between 16 GB and 65536 GB.
<code>platform.gcp.osDiskType</code>	The type of disk.	Either the default <b>pd-ssd</b> or the <b>pd-standard</b> disk type. The control plane nodes must be the <b>pd-ssd</b> disk type. The worker nodes can be either type.
<code>controlPlane.platform.gcp.osDiskEncryptionKey.kmsKeyName</code>	The name of the customer managed encryption key to be used for control plane machine disk encryption.	The encryption key name.

Parameter	Description	Values
<code>controlPlane.platform.gcp.osDisk.encryptionKey.kmsKeyRing</code>	For control plane machines, the name of the KMS key ring to which the KMS key belongs.	The KMS key ring name.
<code>controlPlane.platform.gcp.osDisk.encryptionKey.location</code>	For control plane machines, the GCP location in which the key ring exists. For more information on KMS locations, see Google's documentation on <a href="#">Cloud KMS locations</a> .	The GCP location for the key ring.
<code>controlPlane.platform.gcp.osDisk.encryptionKey.projectID</code>	For control plane machines, the ID of the project in which the KMS key ring exists. This value defaults to the VM project ID if not set.	The GCP project ID.
<code>compute.platform.gcp.osDisk.encryptionKey.kmsKeyName</code>	The name of the customer managed encryption key to be used for compute machine disk encryption.	The encryption key name.

Parameter	Description	Values
<code>compute.platform.gcp.ossDisk.encryptionKey.kmsKeyRing</code>	For compute machines, the name of the KMS key ring to which the KMS key belongs.	The KMS key ring name.
<code>compute.platform.gcp.ossDisk.encryptionKey.kmsKeyLocation</code>	For compute machines, the GCP location in which the key ring exists. For more information on KMS locations, see Google's documentation on <a href="#">Cloud KMS locations</a> .	The GCP location for the key ring.
<code>compute.platform.gcp.ossDisk.encryptionKey.kmsKeyProjectID</code>	For compute machines, the ID of the project in which the KMS key ring exists. This value defaults to the VM project ID if not set.	The GCP project ID.

### 7.9.7.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

Table 7.34. Minimum resource requirements

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Compute	RHCOS, RHEL 7.9, or RHEL 8.4 [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.

### 7.9.7.3. Using custom machine types

Using a custom machine type to install a OpenShift Container Platform cluster is supported.

Consider the following when using a custom machine type:

- Similar to predefined instance types, custom machine types must meet the minimum resource requirements for control plane and compute machines. For more information, see "Minimum resource requirements for cluster installation".
- The name of the custom machine type must adhere to the following syntax:  
**custom-<number\_of\_cpus>-<amount\_of\_memory\_in\_mb>**

For example, **custom-6-20480**.

As part of the installation process, you specify the custom machine type in the **install-config.yaml** file.

#### Sample install-config.yaml file with a custom machine type

```
compute:
- architecture: amd64
  hyperthreading: Enabled
  name: worker
  platform:
    gcp:
      type: custom-6-20480
  replicas: 2
controlPlane:
  architecture: amd64
  hyperthreading: Enabled
  name: master
  platform:
```

```

gcp:
  type: custom-6-20480
  replicas: 3

```

#### 7.9.7.4. Sample customized install-config.yaml file for GCP

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.



#### IMPORTANT

This sample YAML file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program and modify it.

```

apiVersion: v1
baseDomain: example.com 1
controlPlane: 2 3
  hyperthreading: Enabled 4
  name: master
  platform:
    gcp:
      type: n2-standard-4
      zones:
      - us-central1-a
      - us-central1-c
    osDisk:
      diskType: pd-ssd
      diskSizeGB: 1024
      encryptionKey: 5
      kmsKey:
        name: worker-key
        keyRing: test-machine-keys
        location: global
        projectID: project-id
  replicas: 3
compute: 6 7
  - hyperthreading: Enabled 8
  name: worker
  platform:
    gcp:
      type: n2-standard-4
      zones:
      - us-central1-a
      - us-central1-c
    osDisk:
      diskType: pd-standard
      diskSizeGB: 128
      encryptionKey: 9
      kmsKey:
        name: worker-key
        keyRing: test-machine-keys
        location: global
        projectID: project-id

```

```

replicas: 3
metadata:
  name: test-cluster 10
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
  gcp:
    projectID: openshift-production 11
    region: us-central1 12
    network: existing_vpc 13
    controlPlaneSubnet: control_plane_subnet 14
    computeSubnet: compute_subnet 15
  pullSecret: '{"auths": ...}' 16
  fips: false 17
  sshKey: ssh-ed25519 AAAA... 18
  publish: Internal 19

```

- 1 10 11 12 16** Required. The installation program prompts you for this value.
- 2 6** If you do not provide these parameters and values, the installation program provides the default value.
- 3 7** The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. Only one control plane pool is used.
- 4 8** Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.



### IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger machine types, such as **n1-standard-8**, for your machines if you disable simultaneous multithreading.

- 5 9** Optional: The custom encryption key section to encrypt both virtual machines and persistent volumes. Your default compute service account must have the permissions granted to use your KMS key and have the correct IAM role assigned. The default service account name follows the **service-`<project_number>`@compute-system.iam.gserviceaccount.com** pattern. For more information on granting the correct permissions for your service account, see "Machine management" → "Creating machine sets" → "Creating a machine set on GCP".
- 13** Specify the name of an existing VPC.

- 14 Specify the name of the existing subnet to deploy the control plane machines to. The subnet must belong to the VPC that you specified.
- 15 Specify the name of the existing subnet to deploy the compute machines to. The subnet must belong to the VPC that you specified.
- 17 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.



### IMPORTANT

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

- 18 You can optionally provide the **sshKey** value that you use to access the machines in your cluster.



### NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

- 19 How to publish the user-facing endpoints of your cluster. Set **publish** to **Internal** to deploy a private cluster, which cannot be accessed from the internet. The default value is **External**.

#### 7.9.7.5. Create an Ingress Controller with global access on GCP

You can create an Ingress Controller that has global access to a Google Cloud Platform (GCP) cluster. Global access is only available to Ingress Controllers using internal load balancers.

#### Prerequisites

- You created the **install-config.yaml** and complete any modifications to it.

#### Procedure

Create an Ingress Controller with global access on a new GCP cluster.

1. Change to the directory that contains the installation program and create a manifest file:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

- 1 For **<installation\_directory>**, specify the name of the directory that contains the **install-config.yaml** file for your cluster.

2. Create a file that is named **cluster-ingress-default-ingresscontroller.yaml** in the **<installation\_directory>/manifests/** directory:

```
$ touch <installation_directory>/manifests/cluster-ingress-default-ingresscontroller.yaml 1
```

- 1 For **<installation\_directory>**, specify the directory name that contains the **manifests/** directory for your cluster.

After creating the file, several network configuration files are in the **manifests/** directory, as shown:

```
$ ls <installation_directory>/manifests/cluster-ingress-default-ingresscontroller.yaml
```

### Example output

```
cluster-ingress-default-ingresscontroller.yaml
```

3. Open the **cluster-ingress-default-ingresscontroller.yaml** file in an editor and enter a custom resource (CR) that describes the Operator configuration you want:

### Sample **clientAccess** configuration to **Global**

```
apiVersion: operator.openshift.io/v1
kind: IngressController
metadata:
  name: default
  namespace: openshift-ingress-operator
spec:
  endpointPublishingStrategy:
    loadBalancer:
      providerParameters:
        gcp:
          clientAccess: Global 1
          type: GCP
          scope: Internal 2
          type: LoadBalancerService
```

- 1 Set **gcp.clientAccess** to **Global**.
- 2 Global access is only available to Ingress Controllers using internal load balancers.

## 7.9.8. Additional resources

- [Enabling customer-managed encryption keys for a machine set](#)

### 7.9.8.1. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

#### Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to



hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



## NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

## Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
  additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
...

```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations.
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.



## NOTE

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



#### NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

### 7.9.9. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



#### IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

#### Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

#### Procedure

1. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
--log-level=info 2
```

**1** For **<installation\_directory>**, specify the

**2** To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.



#### NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

When the cluster deployment completes, directions for accessing your cluster, including a link to its web console and credentials for the **kubeadmin** user, display in your terminal.

#### Example output

```
...
INFO Install complete!
```

```

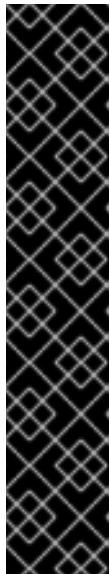
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Ee6gm-ymBZj-
Wt5AL"
INFO Time elapsed: 36m22s

```



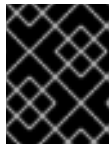
## NOTE

The cluster access and credential information also outputs to `<installation_directory>/openshift_install.log` when an installation succeeds.



## IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

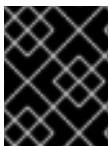


## IMPORTANT

You must not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

### 7.9.10. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



## IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

#### Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.

3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

```
$ tar xvf <file>
```

5. Place the **oc** binary in a directory that is on your **PATH**.  
To check your **PATH**, execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

### Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your **PATH**.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### 7.9.11. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

#### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

#### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

#### Example output

```
system:admin
```

#### Additional resources

- See [Accessing the web console](#) for more details about accessing and understanding the OpenShift Container Platform web console.

### 7.9.12. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

## Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

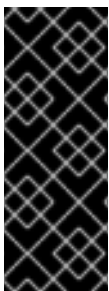
### 7.9.13. Next steps

- [Customize your cluster.](#)
- If necessary, you can [opt out of remote health reporting](#) .

## 7.10. INSTALLING A CLUSTER ON USER-PROVISIONED INFRASTRUCTURE IN GCP BY USING DEPLOYMENT MANAGER TEMPLATES

In OpenShift Container Platform version 4.9, you can install a cluster on Google Cloud Platform (GCP) that uses infrastructure that you provide.

The steps for performing a user-provided infrastructure install are outlined here. Several [Deployment Manager](#) templates are provided to assist in completing these steps or to help model your own. You are also free to create the required resources through other methods.



### IMPORTANT

The steps for performing a user-provisioned infrastructure installation are provided as an example only. Installing a cluster with infrastructure you provide requires knowledge of the cloud provider and the installation process of OpenShift Container Platform. Several Deployment Manager templates are provided to assist in completing these steps or to help model your own. You are also free to create the required resources through other methods; the templates are just an example.

### 7.10.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- If you use a firewall and plan to use the Telemetry service, you [configured the firewall to allow the sites](#) that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can [manually create and maintain IAM credentials](#) .



### NOTE

Be sure to also review this site list if you are configuring a proxy.

### 7.10.2. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The

**machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

### 7.10.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



#### IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

### 7.10.4. Configuring your GCP project

Before you can install OpenShift Container Platform, you must configure a Google Cloud Platform (GCP) project to host it.

#### 7.10.4.1. Creating a GCP project

To install OpenShift Container Platform, you must create a project in your Google Cloud Platform (GCP) account to host the cluster.

#### Procedure

- Create a project to host your OpenShift Container Platform cluster. See [Creating and Managing Projects](#) in the GCP documentation.



#### IMPORTANT

Your GCP project must use the Premium Network Service Tier if you are using installer-provisioned infrastructure. The Standard Network Service Tier is not supported for clusters installed using the installation program. The installation program configures internal load balancing for the **api-int.<cluster\_name>.<base\_domain>** URL; the Premium Tier is required for internal load balancing.

#### 7.10.4.2. Enabling API services in GCP

Your Google Cloud Platform (GCP) project requires access to several API services to complete OpenShift Container Platform installation.

### Prerequisites

- You created a project to host your cluster.

### Procedure

- Enable the following required API services in the project that hosts your cluster. See [Enabling services](#) in the GCP documentation.

**Table 7.35. Required API services**

API service	Console service name
Cloud Deployment Manager V2 API	<b>deploymentmanager.googleapis.com</b>
Compute Engine API	<b>compute.googleapis.com</b>
Google Cloud APIs	<b>cloudapis.googleapis.com</b>
Cloud Resource Manager API	<b>cloudresourcemanager.googleapis.com</b>
Google DNS API	<b>dns.googleapis.com</b>
IAM Service Account Credentials API	<b>iamcredentials.googleapis.com</b>
Identity and Access Management (IAM) API	<b>iam.googleapis.com</b>
Service Management API	<b>servicemanagement.googleapis.com</b>
Service Usage API	<b>serviceusage.googleapis.com</b>
Google Cloud Storage JSON API	<b>storage-api.googleapis.com</b>
Cloud Storage	<b>storage-component.googleapis.com</b>

#### 7.10.4.3. Configuring DNS for GCP

To install OpenShift Container Platform, the Google Cloud Platform (GCP) account you use must have a dedicated public hosted zone in the same project that you host the OpenShift Container Platform cluster. This zone must be authoritative for the domain. The DNS service provides cluster DNS resolution and name lookup for external connections to the cluster.

### Procedure

1. Identify your domain, or subdomain, and registrar. You can transfer an existing domain and registrar or obtain a new one through GCP or another source.



**NOTE**

If you purchase a new domain, it can take time for the relevant DNS changes to propagate. For more information about purchasing domains through Google, see [Google Domains](#).

2. Create a public hosted zone for your domain or subdomain in your GCP project. See [Creating public zones](#) in the GCP documentation.  
Use an appropriate root domain, such as **openshiftcorp.com**, or subdomain, such as **clusters.openshiftcorp.com**.
3. Extract the new authoritative name servers from the hosted zone records. See [Look up your Cloud DNS name servers](#) in the GCP documentation.  
You typically have four name servers.
4. Update the registrar records for the name servers that your domain uses. For example, if you registered your domain to Google Domains, see the following topic in the Google Domains Help: [How to switch to custom name servers](#).
5. If you migrated your root domain to Google Cloud DNS, migrate your DNS records. See [Migrating to Cloud DNS](#) in the GCP documentation.
6. If you use a subdomain, follow your company's procedures to add its delegation records to the parent domain. This process might include a request to your company's IT department or the division that controls the root domain and DNS services for your company.

**7.10.4.4. GCP account limits**

The OpenShift Container Platform cluster uses a number of Google Cloud Platform (GCP) components, but the default [Quotas](#) do not affect your ability to install a default OpenShift Container Platform cluster.

A default cluster, which contains three compute and three control plane machines, uses the following resources. Note that some resources are required only during the bootstrap process and are removed after the cluster deploys.

**Table 7.36. GCP resources used in a default cluster**

Service	Component	Location	Total resources required	Resources removed after bootstrap
Service account	IAM	Global	5	0
Firewall rules	Networking	Global	11	1
Forwarding rules	Compute	Global	2	0
Health checks	Compute	Global	2	0
Images	Compute	Global	1	0
Networks	Networking	Global	1	0

Service	Component	Location	Total resources required	Resources removed after bootstrap
Routers	Networking	Global	1	0
Routes	Networking	Global	2	0
Subnetworks	Compute	Global	2	0
Target pools	Networking	Global	2	0

**NOTE**

If any of the quotas are insufficient during installation, the installation program displays an error that states both which quota was exceeded and the region.

Be sure to consider your actual cluster size, planned cluster growth, and any usage from other clusters that are associated with your account. The CPU, static IP addresses, and persistent disk SSD (storage) quotas are the ones that are most likely to be insufficient.

If you plan to deploy your cluster in one of the following regions, you will exceed the maximum storage quota and are likely to exceed the CPU quota limit:

- **asia-east2**
- **asia-northeast2**
- **asia-south1**
- **australia-southeast1**
- **europa-north1**
- **europa-west2**
- **europa-west3**
- **europa-west6**
- **northamerica-northeast1**
- **southamerica-east1**
- **us-west2**

You can increase resource quotas from the [GCP console](#), but you might need to file a support ticket. Be sure to plan your cluster size early so that you can allow time to resolve the support ticket before you install your OpenShift Container Platform cluster.

#### 7.10.4.5. Creating a service account in GCP

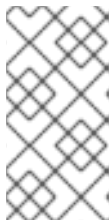
OpenShift Container Platform requires a Google Cloud Platform (GCP) service account that provides authentication and authorization to access data in the Google APIs. If you do not have an existing IAM service account that contains the required roles in your project, you must create one.

### Prerequisites

- You created a project to host your cluster.

### Procedure

1. Create a service account in the project that you use to host your OpenShift Container Platform cluster. See [Creating a service account](#) in the GCP documentation.
2. Grant the service account the appropriate permissions. You can either grant the individual permissions that follow or assign the **Owner** role to it. See [Granting roles to a service account for specific resources](#).



#### NOTE

While making the service account an owner of the project is the easiest way to gain the required permissions, it means that service account has complete control over the project. You must determine if the risk that comes from offering that power is acceptable.

3. Create the service account key in JSON format. See [Creating service account keys](#) in the GCP documentation.  
The service account key is required to create a cluster.

#### 7.10.4.5.1. Required GCP permissions

When you attach the **Owner** role to the service account that you create, you grant that service account all permissions, including those that are required to install OpenShift Container Platform. To deploy an OpenShift Container Platform cluster, the service account requires the following permissions. If you deploy your cluster into an existing VPC, the service account does not require certain networking permissions, which are noted in the following lists:

##### Required roles for the installation program

- Compute Admin
- Security Admin
- Service Account Admin
- Service Account User
- Storage Admin

##### Required roles for creating network resources during installation

- DNS Administrator

##### Required roles for user-provisioned GCP infrastructure

- Deployment Manager Editor

- Service Account Key Admin

### Optional roles

For the cluster to create new limited credentials for its Operators, add the following role:

- Service Account Key Admin

The roles are applied to the service accounts that the control plane and compute machines use:

**Table 7.37. GCP service account permissions**

Account	Roles
Control Plane	<b>roles/compute.instanceAdmin</b>
	<b>roles/compute.networkAdmin</b>
	<b>roles/compute.securityAdmin</b>
	<b>roles/storage.admin</b>
	<b>roles/iam.serviceAccountUser</b>
Compute	<b>roles/compute.viewer</b>
	<b>roles/storage.admin</b>

#### 7.10.4.6. Supported GCP regions

You can deploy an OpenShift Container Platform cluster to the following Google Cloud Platform (GCP) regions:

- **asia-east1** (Changhua County, Taiwan)
- **asia-east2** (Hong Kong)
- **asia-northeast1** (Tokyo, Japan)
- **asia-northeast2** (Osaka, Japan)
- **asia-northeast3** (Seoul, South Korea)
- **asia-south1** (Mumbai, India)
- **asia-southeast1** (Jurong West, Singapore)
- **asia-southeast2** (Jakarta, Indonesia)
- **australia-southeast1** (Sydney, Australia)
- **europa-central2** (Warsaw, Poland)
- **europa-north1** (Hamina, Finland)

- **europa-west1** (St. Ghislain, Belgium)
- **europa-west2** (London, England, UK)
- **europa-west3** (Frankfurt, Germany)
- **europa-west4** (Eemshaven, Netherlands)
- **europa-west6** (Zürich, Switzerland)
- **northamerica-northeast1** (Montréal, Québec, Canada)
- **southamerica-east1** (São Paulo, Brazil)
- **us-central1** (Council Bluffs, Iowa, USA)
- **us-east1** (Moncks Corner, South Carolina, USA)
- **us-east4** (Ashburn, Northern Virginia, USA)
- **us-west1** (The Dalles, Oregon, USA)
- **us-west2** (Los Angeles, California, USA)
- **us-west3** (Salt Lake City, Utah, USA)
- **us-west4** (Las Vegas, Nevada, USA)

#### 7.10.4.7. Installing and configuring CLI tools for GCP

To install OpenShift Container Platform on Google Cloud Platform (GCP) using user-provisioned infrastructure, you must install and configure the CLI tools for GCP.

##### Prerequisites

- You created a project to host your cluster.
- You created a service account and granted it the required permissions.

##### Procedure

1. Install the following binaries in **\$PATH**:

- **gcloud**
- **gsutil**

See [Install the latest Cloud SDK version](#) in the GCP documentation.

2. Authenticate using the **gcloud** tool with your configured service account.  
See [Authorizing with a service account](#) in the GCP documentation.

#### 7.10.5. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

### 7.10.5.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

**Table 7.38. Minimum required hosts**

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.



#### IMPORTANT

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 7.9, or RHEL 8.4.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See [Red Hat Enterprise Linux technology capabilities and limits](#).

### 7.10.5.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

**Table 7.39. Minimum resource requirements**

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 7.9, or RHEL 8.4 [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio:  $(\text{threads per core} \times \text{cores}) \times \text{sockets} = \text{vCPUs}$ .
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.

### 7.10.5.3. Using custom machine types

Using a custom machine type to install a OpenShift Container Platform cluster is supported.

Consider the following when using a custom machine type:

- Similar to predefined instance types, custom machine types must meet the minimum resource requirements for control plane and compute machines. For more information, see "Minimum resource requirements for cluster installation".
- The name of the custom machine type must adhere to the following syntax:  
**custom-`<number_of_cpus>-<amount_of_memory_in_mb>`**

For example, **custom-6-20480**.

### 7.10.6. Creating the installation files for GCP

To install OpenShift Container Platform on Google Cloud Platform (GCP) using user-provisioned infrastructure, you must generate the files that the installation program needs to deploy your cluster and modify them so that the cluster creates only the machines that it will use. You generate and customize the **install-config.yaml** file, Kubernetes manifests, and Ignition config files. You also have the option to first set up a separate **var** partition during the preparation phases of installation.

#### 7.10.6.1. Optional: Creating a separate **/var** partition

It is recommended that disk partitioning for OpenShift Container Platform be left to the installer. However, there are cases where you might want to create separate partitions in a part of the filesystem that you expect to grow.

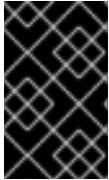
OpenShift Container Platform supports the addition of a single partition to attach storage to either the **/var** partition or a subdirectory of **/var**. For example:

- **/var/lib/containers**: Holds container-related content that can grow as more images and containers are added to a system.
- **/var/lib/etcd**: Holds data that you might want to keep separate for purposes such as performance optimization of etcd storage.
- **/var**: Holds data that you might want to keep separate for purposes such as auditing.

Storing the contents of a **/var** directory separately makes it easier to grow storage for those areas as

needed and reinstall OpenShift Container Platform at a later date and keep that data intact. With this method, you will not have to pull all your containers again, nor will you have to copy massive log files when you update systems.

Because **/var** must be in place before a fresh installation of Red Hat Enterprise Linux CoreOS (RHCOS), the following procedure sets up the separate **/var** partition by creating a machine config manifest that is inserted during the **openshift-install** preparation phases of an OpenShift Container Platform installation.



## IMPORTANT

If you follow the steps to create a separate **/var** partition in this procedure, it is not necessary to create the Kubernetes manifest and Ignition config files again as described later in this section.

## Procedure

1. Create a directory to hold the OpenShift Container Platform installation files:

```
$ mkdir $HOME/clusterconfig
```

2. Run **openshift-install** to create a set of files in the **manifest** and **openshift** subdirectories. Answer the system questions as you are prompted:

```
$ openshift-install create manifests --dir $HOME/clusterconfig
```

## Example output

```
? SSH Public Key ...  
INFO Credentials loaded from the "myprofile" profile in file "/home/myuser/.aws/credentials"  
INFO Consuming Install Config from target directory  
INFO Manifests created in: $HOME/clusterconfig/manifests and  
$HOME/clusterconfig/openshift
```

3. Optional: Confirm that the installation program created manifests in the **clusterconfig/openshift** directory:

```
$ ls $HOME/clusterconfig/openshift/
```

## Example output

```
99_kubeadmin-password-secret.yaml  
99_openshift-cluster-api_master-machines-0.yaml  
99_openshift-cluster-api_master-machines-1.yaml  
99_openshift-cluster-api_master-machines-2.yaml  
...
```

4. Create a Butane config that configures the additional partition. For example, name the file **\$HOME/clusterconfig/98-var-partition.bu**, change the disk device name to the name of the storage device on the **worker** systems, and set the storage size as appropriate. This example places the **/var** directory on a separate partition:

```
variant: openshift
```

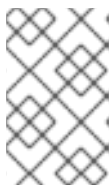


```

version: 4.9.0
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 98-var-partition
storage:
  disks:
    - device: /dev/<device_name> ❶
      partitions:
        - label: var
          start_mib: <partition_start_offset> ❷
          size_mib: <partition_size> ❸
      filesystems:
        - device: /dev/disk/by-partlabel/var
          path: /var
          format: xfs
          mount_options: [defaults, prjquota] ❹
          with_mount_unit: true

```

- ❶ The storage device name of the disk that you want to partition.
- ❷ When adding a data partition to the boot disk, a minimum value of 25000 MiB (Mebibytes) is recommended. The root file system is automatically resized to fill all available space up to the specified offset. If no value is specified, or if the specified value is smaller than the recommended minimum, the resulting root file system will be too small, and future reinstalls of RHCOS might overwrite the beginning of the data partition.
- ❸ The size of the data partition in mebibytes.
- ❹ The **prjquota** mount option must be enabled for filesystems used for container storage.



#### NOTE

When creating a separate **/var** partition, you cannot use different instance types for worker nodes, if the different instance types do not have the same device name.

5. Create a manifest from the Butane config and save it to the **clusterconfig/openshift** directory. For example, run the following command:

```
$ butane $HOME/clusterconfig/98-var-partition.bu -o $HOME/clusterconfig/openshift/98-var-partition.yaml
```

6. Run **openshift-install** again to create Ignition configs from a set of files in the **manifest** and **openshift** subdirectories:

```
$ openshift-install create ignition-configs --dir $HOME/clusterconfig
$ ls $HOME/clusterconfig/
auth bootstrap.ign master.ign metadata.json worker.ign
```

Now you can use the Ignition config files as input to the installation procedures to install Red Hat Enterprise Linux CoreOS (RHCOS) systems.

### 7.10.6.2. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Google Cloud Platform (GCP).

#### Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

#### Procedure

1. Create the **install-config.yaml** file.
  - a. Change to the directory that contains the installation program and run the following command:

```
$. /openshift-install create install-config --dir <installation_directory> 1
```

- 1** For **<installation\_directory>**, specify the directory name to store the files that the installation program creates.



#### IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

- b. At the prompts, provide the configuration details for your cloud:
  - i. Optional: Select an SSH key to use to access your cluster machines.



#### NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

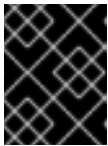
- ii. Select **gcp** as the platform to target.
- iii. If you have not configured the service account key for your GCP account on your computer, you must obtain it from GCP and paste the contents of the file or enter the absolute path to the file.
- iv. Select the project ID to provision the cluster in. The default value is specified by the service account that you configured.
- v. Select the region to deploy the cluster to.

- vi. Select the base domain to deploy the cluster to. The base domain corresponds to the public DNS zone that you created for your cluster.
  - vii. Enter a descriptive name for your cluster.
  - viii. Paste the [pull secret from the Red Hat OpenShift Cluster Manager](#).
- c. Optional: If you do not want the cluster to provision compute machines, empty the compute pool by editing the resulting **install-config.yaml** file to set **replicas** to **0** for the **compute** pool:

```
compute:
- hyperthreading: Enabled
  name: worker
  platform: {}
  replicas: 0 1
```

**1** Set to **0**.

2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.
3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



### IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

#### 7.10.6.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

#### Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



### NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

## Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```

apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
  additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
...

```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations.
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.



### NOTE

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



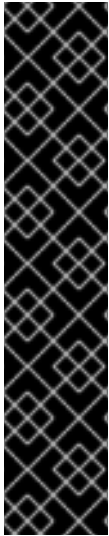
### NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

## 7.10.6.4. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.



## IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

## Prerequisites

- You obtained the OpenShift Container Platform installation program.
- You created the **install-config.yaml** installation configuration file.

## Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

- 1** For **<installation\_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

2. Remove the Kubernetes manifest files that define the control plane machines:

```
$ rm -f <installation_directory>/openshift/99_openshift-cluster-api_master-machines-*.yaml
```

By removing these files, you prevent the cluster from automatically generating control plane machines.

3. Optional: If you do not want the cluster to provision compute machines, remove the Kubernetes manifest files that define the worker machines:

```
$ rm -f <installation_directory>/openshift/99_openshift-cluster-api_worker-machineset-*.yaml
```

Because you create and manage the worker machines yourself, you do not need to initialize these machines.

4. Check that the **mastersSchedulable** parameter in the `<installation_directory>/manifests/cluster-scheduler-02-config.yml` Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:
  - a. Open the `<installation_directory>/manifests/cluster-scheduler-02-config.yml` file.
  - b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.
  - c. Save and exit the file.
5. Optional: If you do not want [the Ingress Operator](#) to create DNS records on your behalf, remove the **privateZone** and **publicZone** sections from the `<installation_directory>/manifests/cluster-dns-02-config.yml` DNS configuration file:

```

apiVersion: config.openshift.io/v1
kind: DNS
metadata:
  creationTimestamp: null
  name: cluster
spec:
  baseDomain: example.openshift.com
  privateZone: ❶
    id: mycluster-100419-private-zone
  publicZone: ❷
    id: example.openshift.com
status: {}

```

- ❶ ❷ Remove this section completely.

If you do so, you must add ingress DNS records manually in a later step.

6. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> ❶
```

- ❶ For `<installation_directory>`, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the `./<installation_directory>/auth` directory:

```

.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign

```

## Additional resources

- [Optional: Adding the ingress DNS records](#)

## 7.10.7. Exporting common variables

### 7.10.7.1. Extracting the infrastructure name

The Ignition config files contain a unique cluster identifier that you can use to uniquely identify your cluster in Google Cloud Platform (GCP). The infrastructure name is also used to locate the appropriate GCP resources during an OpenShift Container Platform installation. The provided Deployment Manager templates contain references to this infrastructure name, so you must extract it.

#### Prerequisites

- You obtained the OpenShift Container Platform installation program and the pull secret for your cluster.
- You generated the Ignition config files for your cluster.
- You installed the **jq** package.

#### Procedure

- To extract and view the infrastructure name from the Ignition config file metadata, run the following command:

```
$ jq -r .infraID <installation_directory>/metadata.json 1
```

- 1 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

#### Example output

```
openshift-vw9j6 1
```

- 1 The output of this command is your cluster name and a random string.

### 7.10.7.2. Exporting common variables for Deployment Manager templates

You must export a common set of variables that are used with the provided Deployment Manager templates used to assist in completing a user-provided infrastructure install on Google Cloud Platform (GCP).



#### NOTE

Specific Deployment Manager templates can also require additional exported variables, which are detailed in their related procedures.

#### Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

- Generate the Ignition config files for your cluster.
- Install the **jq** package.

## Procedure

1. Export the following common variables to be used by the provided Deployment Manager templates:

```
$ export BASE_DOMAIN='<base_domain>'
$ export BASE_DOMAIN_ZONE_NAME='<base_domain_zone_name>'
$ export NETWORK_CIDR='10.0.0.0/16'
$ export MASTER_SUBNET_CIDR='10.0.0.0/17'
$ export WORKER_SUBNET_CIDR='10.0.128.0/17'

$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
$ export CLUSTER_NAME=`jq -r .clusterName <installation_directory>/metadata.json`
$ export INFRA_ID=`jq -r .infraID <installation_directory>/metadata.json`
$ export PROJECT_NAME=`jq -r .gcp.projectID <installation_directory>/metadata.json`
$ export REGION=`jq -r .gcp.region <installation_directory>/metadata.json`
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

### 7.10.8. Creating a VPC in GCP

You must create a VPC in Google Cloud Platform (GCP) for your OpenShift Container Platform cluster to use. You can customize the VPC to meet your requirements. One way to create the VPC is to modify the provided Deployment Manager template.



#### NOTE

If you do not use the provided Deployment Manager template to create your GCP infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

## Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.

## Procedure

1. Copy the template from the **Deployment Manager template for the VPC** section of this topic and save it as **01\_vpc.py** on your computer. This template describes the VPC that your cluster requires.
2. Create a **01\_vpc.yaml** resource definition file:

```
$ cat <<EOF >01_vpc.yaml
imports:
```



```

- path: 01_vpc.py

resources:
- name: cluster-vpc
  type: 01_vpc.py
  properties:
    infra_id: '${INFRA_ID}' 1
    region: '${REGION}' 2
    master_subnet_cidr: '${MASTER_SUBNET_CIDR}' 3
    worker_subnet_cidr: '${WORKER_SUBNET_CIDR}' 4
EOF

```

- 1** `infra_id` is the `INFRA_ID` infrastructure name from the extraction step.
- 2** `region` is the region to deploy the cluster into, for example `us-central1`.
- 3** `master_subnet_cidr` is the CIDR for the master subnet, for example `10.0.0.0/17`.
- 4** `worker_subnet_cidr` is the CIDR for the worker subnet, for example `10.0.128.0/17`.

3. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-vpc --config 01_vpc.yaml
```

### 7.10.8.1. Deployment Manager template for the VPC

You can use the following Deployment Manager template to deploy the VPC that you need for your OpenShift Container Platform cluster:

#### Example 7.1. 01\_vpc.py Deployment Manager template

```

def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-network',
        'type': 'compute.v1.network',
        'properties': {
            'region': context.properties['region'],
            'autoCreateSubnetworks': False
        }
    }, {
        'name': context.properties['infra_id'] + '-master-subnet',
        'type': 'compute.v1.subnetwork',
        'properties': {
            'region': context.properties['region'],
            'network': '${ref.' + context.properties['infra_id'] + '-network.selfLink}',
            'ipCidrRange': context.properties['master_subnet_cidr']
        }
    }, {
        'name': context.properties['infra_id'] + '-worker-subnet',
        'type': 'compute.v1.subnetwork',
        'properties': {
            'region': context.properties['region'],
            'network': '${ref.' + context.properties['infra_id'] + '-network.selfLink}',

```

```

        'ipCidrRange': context.properties['worker_subnet_cidr']
    }
}, {
    'name': context.properties['infra_id'] + '-router',
    'type': 'compute.v1.router',
    'properties': {
        'region': context.properties['region'],
        'network': '$(ref.' + context.properties['infra_id'] + '-network.selfLink)',
        'nats': [{
            'name': context.properties['infra_id'] + '-nat-master',
            'natIppAllocateOption': 'AUTO_ONLY',
            'minPortsPerVm': 7168,
            'sourceSubnetworkIppRangesToNat': 'LIST_OF_SUBNETWORKS',
            'subnetworks': [{
                'name': '$(ref.' + context.properties['infra_id'] + '-master-subnet.selfLink)',
                'sourceIppRangesToNat': ['ALL_IP_RANGES']
            }]
        }]
    }, {
        'name': context.properties['infra_id'] + '-nat-worker',
        'natIppAllocateOption': 'AUTO_ONLY',
        'minPortsPerVm': 512,
        'sourceSubnetworkIppRangesToNat': 'LIST_OF_SUBNETWORKS',
        'subnetworks': [{
            'name': '$(ref.' + context.properties['infra_id'] + '-worker-subnet.selfLink)',
            'sourceIppRangesToNat': ['ALL_IP_RANGES']
        }]
    }
}
}
}
}

return {'resources': resources}

```

### 7.10.9. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

#### 7.10.9.1. Setting the cluster node hostnames through DHCP

On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

#### 7.10.9.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.



### IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

**Table 7.40. Ports used for all-machine to all-machine communications**

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	<b>1936</b>	Metrics
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> and the Cluster Version Operator on port <b>9099</b> .
	<b>10250-10259</b>	The default ports that Kubernetes reserves
	<b>10256</b>	openshift-sdn
UDP	<b>4789</b>	VXLAN and Geneve
	<b>6081</b>	VXLAN and Geneve
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> .
	<b>500</b>	IPsec IKE packets
	<b>4500</b>	IPsec NAT-T packets
TCP/UDP	<b>30000-32767</b>	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

**Table 7.41. Ports used for all-machine to control plane communications**

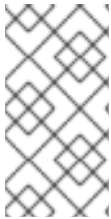
Protocol	Port	Description
TCP	<b>6443</b>	Kubernetes API

**Table 7.42. Ports used for control plane machine to control plane machine communications**

Protocol	Port	Description
TCP	<b>2379-2380</b>	etcd server and peer ports

### 7.10.10. Creating load balancers in GCP

You must configure load balancers in Google Cloud Platform (GCP) for your OpenShift Container Platform cluster to use. One way to create these components is to modify the provided Deployment Manager template.



#### NOTE

If you do not use the provided Deployment Manager template to create your GCP infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

#### Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.

#### Procedure

1. Copy the template from the **Deployment Manager template for the internal load balancer** section of this topic and save it as **02\_lb\_int.py** on your computer. This template describes the internal load balancing objects that your cluster requires.
2. For an external cluster, also copy the template from the **Deployment Manager template for the external load balancer** section of this topic and save it as **02\_lb\_ext.py** on your computer. This template describes the external load balancing objects that your cluster requires.
3. Export the variables that the deployment template uses:

- a. Export the cluster network location:

```
$ export CLUSTER_NETWORK=(`gcloud compute networks describe ${INFRA_ID}-network --format json | jq -r .selfLink`)
```

- b. Export the control plane subnet location:

```
$ export CONTROL_SUBNET=(`gcloud compute networks subnets describe ${INFRA_ID}-master-subnet --region=${REGION} --format json | jq -r .selfLink`)
```

- c. Export the three zones that the cluster uses:

```
$ export ZONE_0=(`gcloud compute regions describe ${REGION} --format=json | jq -r .zones[0] | cut -d "/" -f9`)
```

```
$ export ZONE_1=`gcloud compute regions describe ${REGION} --format=json | jq -r
.zones[1] | cut -d "/" -f9`
```

```
$ export ZONE_2=`gcloud compute regions describe ${REGION} --format=json | jq -r
.zones[2] | cut -d "/" -f9`
```

4. Create a **02\_infra.yaml** resource definition file:

```
$ cat <<EOF >02_infra.yaml
imports:
- path: 02_lb_ext.py
- path: 02_lb_int.py 1
resources:
- name: cluster-lb-ext 2
  type: 02_lb_ext.py
  properties:
    infra_id: '${INFRA_ID}' 3
    region: '${REGION}' 4
- name: cluster-lb-int
  type: 02_lb_int.py
  properties:
    cluster_network: '${CLUSTER_NETWORK}'
    control_subnet: '${CONTROL_SUBNET}' 5
    infra_id: '${INFRA_ID}'
    region: '${REGION}'
    zones: 6
    - '${ZONE_0}'
    - '${ZONE_1}'
    - '${ZONE_2}'
EOF
```

1 2 Required only when deploying an external cluster.

3 **infra\_id** is the **INFRA\_ID** infrastructure name from the extraction step.

4 **region** is the region to deploy the cluster into, for example **us-central1**.

5 **control\_subnet** is the URI to the control subnet.

6 **zones** are the zones to deploy the control plane instances into, like **us-east1-b**, **us-east1-c**, and **us-east1-d**.

5. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-infra --config 02_infra.yaml
```

6. Export the cluster IP address:

```
$ export CLUSTER_IP=`gcloud compute addresses describe ${INFRA_ID}-cluster-ip --
region=${REGION} --format json | jq -r .address`
```

7. For an external cluster, also export the cluster public IP address:

■

```
$ export CLUSTER_PUBLIC_IP=$(gcloud compute addresses describe ${INFRA_ID}-cluster-public-ip --region=${REGION} --format json | jq -r .address)
```

### 7.10.10.1. Deployment Manager template for the external load balancer

You can use the following Deployment Manager template to deploy the external load balancer that you need for your OpenShift Container Platform cluster:

#### Example 7.2. 02\_lb\_ext.py Deployment Manager template

```
def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-cluster-public-ip',
        'type': 'compute.v1.address',
        'properties': {
            'region': context.properties['region']
        }
    }, {
        # Refer to docs/dev/kube-apiserver-health-check.md on how to correctly setup health check
        probe for kube-apiserver
        'name': context.properties['infra_id'] + '-api-http-health-check',
        'type': 'compute.v1.httpHealthCheck',
        'properties': {
            'port': 6080,
            'requestPath': '/readyz'
        }
    }, {
        'name': context.properties['infra_id'] + '-api-target-pool',
        'type': 'compute.v1.targetPool',
        'properties': {
            'region': context.properties['region'],
            'healthChecks': ['$$(ref.' + context.properties['infra_id'] + '-api-http-health-check.selfLink)'],
            'instances': []
        }
    }, {
        'name': context.properties['infra_id'] + '-api-forwarding-rule',
        'type': 'compute.v1.forwardingRule',
        'properties': {
            'region': context.properties['region'],
            'IPAddress': '$(ref.' + context.properties['infra_id'] + '-cluster-public-ip.selfLink)',
            'target': '$(ref.' + context.properties['infra_id'] + '-api-target-pool.selfLink)',
            'portRange': '6443'
        }
    }
    ]

    return {'resources': resources}
```

### 7.10.10.2. Deployment Manager template for the internal load balancer

You can use the following Deployment Manager template to deploy the internal load balancer that you need for your OpenShift Container Platform cluster:

Example 7.3. `02_lb_int.py` Deployment Manager template

```

def GenerateConfig(context):

    backends = []
    for zone in context.properties['zones']:
        backends.append({
            'group': '$(ref.' + context.properties['infra_id'] + '-master-' + zone + '-instance-group' +
            '.selfLink)'
        })

    resources = [{
        'name': context.properties['infra_id'] + '-cluster-ip',
        'type': 'compute.v1.address',
        'properties': {
            'addressType': 'INTERNAL',
            'region': context.properties['region'],
            'subnetwork': context.properties['control_subnet']
        }
    }, {
        # Refer to docs/dev/kube-apiserver-health-check.md on how to correctly setup health check
        # probe for kube-apiserver
        'name': context.properties['infra_id'] + '-api-internal-health-check',
        'type': 'compute.v1.healthCheck',
        'properties': {
            'httpsHealthCheck': {
                'port': 6443,
                'requestPath': '/readyz'
            },
            'type': "HTTPS"
        }
    }, {
        'name': context.properties['infra_id'] + '-api-internal-backend-service',
        'type': 'compute.v1.regionBackendService',
        'properties': {
            'backends': backends,
            'healthChecks': ['$(ref.' + context.properties['infra_id'] + '-api-internal-health-
            check.selfLink)'],
            'loadBalancingScheme': 'INTERNAL',
            'region': context.properties['region'],
            'protocol': 'TCP',
            'timeoutSec': 120
        }
    }, {
        'name': context.properties['infra_id'] + '-api-internal-forwarding-rule',
        'type': 'compute.v1.forwardingRule',
        'properties': {
            'backendService': '$(ref.' + context.properties['infra_id'] + '-api-internal-backend-
            service.selfLink)',
            'IPAddress': '$(ref.' + context.properties['infra_id'] + '-cluster-ip.selfLink)',
            'loadBalancingScheme': 'INTERNAL',
            'ports': ['6443','22623'],
            'region': context.properties['region'],
            'subnetwork': context.properties['control_subnet']
        }
    }
    ]

```

```

for zone in context.properties['zones']:
    resources.append({
        'name': context.properties['infra_id'] + '-master-' + zone + '-instance-group',
        'type': 'compute.v1.instanceGroup',
        'properties': {
            'namedPorts': [
                {
                    'name': 'ignition',
                    'port': 22623
                }, {
                    'name': 'https',
                    'port': 6443
                }
            ],
            'network': context.properties['cluster_network'],
            'zone': zone
        }
    })

return {'resources': resources}

```

You will need this template in addition to the **02\_lb\_ext.py** template when you create an external cluster.

### 7.10.11. Creating a private DNS zone in GCP

You must configure a private DNS zone in Google Cloud Platform (GCP) for your OpenShift Container Platform cluster to use. One way to create this component is to modify the provided Deployment Manager template.



#### NOTE

If you do not use the provided Deployment Manager template to create your GCP infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

#### Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.

#### Procedure

1. Copy the template from the **Deployment Manager template for the private DNS** section of this topic and save it as **02\_dns.py** on your computer. This template describes the private DNS objects that your cluster requires.
2. Create a **02\_dns.yaml** resource definition file:



```
$ cat <<EOF >02_dns.yaml
imports:
- path: 02_dns.py

resources:
- name: cluster-dns
  type: 02_dns.py
  properties:
    infra_id: '${INFRA_ID}' 1
    cluster_domain: '${CLUSTER_NAME}.${BASE_DOMAIN}' 2
    cluster_network: '${CLUSTER_NETWORK}' 3
EOF
```

- 1** `infra_id` is the **INFRA\_ID** infrastructure name from the extraction step.
- 2** `cluster_domain` is the domain for the cluster, for example **openshift.example.com**.
- 3** `cluster_network` is the **selfLink** URL to the cluster network.

3. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-dns --config 02_dns.yaml
```

4. The templates do not create DNS entries due to limitations of Deployment Manager, so you must create them manually:
  - a. Add the internal DNS entries:

```
$ if [ -f transaction.yaml ]; then rm transaction.yaml; fi
$ gcloud dns record-sets transaction start --zone ${INFRA_ID}-private-zone
$ gcloud dns record-sets transaction add ${CLUSTER_IP} --name
api.${CLUSTER_NAME}.${BASE_DOMAIN}. --ttl 60 --type A --zone ${INFRA_ID}-
private-zone
$ gcloud dns record-sets transaction add ${CLUSTER_IP} --name api-
int.${CLUSTER_NAME}.${BASE_DOMAIN}. --ttl 60 --type A --zone ${INFRA_ID}-
private-zone
$ gcloud dns record-sets transaction execute --zone ${INFRA_ID}-private-zone
```

- b. For an external cluster, also add the external DNS entries:

```
$ if [ -f transaction.yaml ]; then rm transaction.yaml; fi
$ gcloud dns record-sets transaction start --zone ${BASE_DOMAIN_ZONE_NAME}
$ gcloud dns record-sets transaction add ${CLUSTER_PUBLIC_IP} --name
api.${CLUSTER_NAME}.${BASE_DOMAIN}. --ttl 60 --type A --zone
${BASE_DOMAIN_ZONE_NAME}
$ gcloud dns record-sets transaction execute --zone ${BASE_DOMAIN_ZONE_NAME}
```

### 7.10.11.1. Deployment Manager template for the private DNS

You can use the following Deployment Manager template to deploy the private DNS that you need for your OpenShift Container Platform cluster:

#### Example 7.4. `02_dns.py` Deployment Manager template

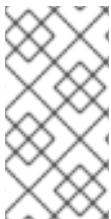
```
def GenerateConfig(context):
```

```
    resources = [{
        'name': context.properties['infra_id'] + '-private-zone',
        'type': 'dns.v1.managedZone',
        'properties': {
            'description': "",
            'dnsName': context.properties['cluster_domain'] + '.',
            'visibility': 'private',
            'privateVisibilityConfig': {
                'networks': [{
                    'networkUrl': context.properties['cluster_network']
                }]
            }
        }
    }]

    return {'resources': resources}
```

### 7.10.12. Creating firewall rules in GCP

You must create firewall rules in Google Cloud Platform (GCP) for your OpenShift Container Platform cluster to use. One way to create these components is to modify the provided Deployment Manager template.



#### NOTE

If you do not use the provided Deployment Manager template to create your GCP infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

#### Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.

#### Procedure

1. Copy the template from the **Deployment Manager template for firewall rules** section of this topic and save it as **03\_firewall.py** on your computer. This template describes the security groups that your cluster requires.
2. Create a **03\_firewall.yaml** resource definition file:

```
$ cat <<EOF >03_firewall.yaml
imports:
- path: 03_firewall.py

resources:
```

```

- name: cluster-firewall
  type: 03_firewall.py
  properties:
    allowed_external_cidr: '0.0.0.0/0' ❶
    infra_id: '${INFRA_ID}' ❷
    cluster_network: '${CLUSTER_NETWORK}' ❸
    network_cidr: '${NETWORK_CIDR}' ❹
EOF

```

- ❶ **allowed\_external\_cidr** is the CIDR range that can access the cluster API and SSH to the bootstrap host. For an internal cluster, set this value to **\${NETWORK\_CIDR}**.
- ❷ **infra\_id** is the **INFRA\_ID** infrastructure name from the extraction step.
- ❸ **cluster\_network** is the **selfLink** URL to the cluster network.
- ❹ **network\_cidr** is the CIDR of the VPC network, for example **10.0.0.0/16**.

3. Create the deployment by using the **gcloud** CLI:

```

$ gcloud deployment-manager deployments create ${INFRA_ID}-firewall --config
03_firewall.yaml

```

### 7.10.12.1. Deployment Manager template for firewall rules

You can use the following Deployment Manager template to deploy the firewall rules that you need for your OpenShift Container Platform cluster:

#### Example 7.5. 03\_firewall.py Deployment Manager template

```

def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-bootstrap-in-ssh',
        'type': 'compute.v1.firewall',
        'properties': {
            'network': context.properties['cluster_network'],
            'allowed': [{
                'IPProtocol': 'tcp',
                'ports': ['22']
            }],
            'sourceRanges': [context.properties['allowed_external_cidr']],
            'targetTags': [context.properties['infra_id'] + '-bootstrap']
        }
    ], {
        'name': context.properties['infra_id'] + '-api',
        'type': 'compute.v1.firewall',
        'properties': {
            'network': context.properties['cluster_network'],
            'allowed': [{
                'IPProtocol': 'tcp',
                'ports': ['6443']
            }],
            'sourceRanges': [context.properties['allowed_external_cidr']],

```

```

        'targetTags': [context.properties['infra_id'] + '-master']
      }
    }, {
      'name': context.properties['infra_id'] + '-health-checks',
      'type': 'compute.v1.firewall',
      'properties': {
        'network': context.properties['cluster_network'],
        'allowed': [{
          'IPProtocol': 'tcp',
          'ports': ['6080', '6443', '22624']
        }],
        'sourceRanges': ['35.191.0.0/16', '130.211.0.0/22', '209.85.152.0/22', '209.85.204.0/22'],
        'targetTags': [context.properties['infra_id'] + '-master']
      }
    }, {
      'name': context.properties['infra_id'] + '-etcd',
      'type': 'compute.v1.firewall',
      'properties': {
        'network': context.properties['cluster_network'],
        'allowed': [{
          'IPProtocol': 'tcp',
          'ports': ['2379-2380']
        }],
        'sourceTags': [context.properties['infra_id'] + '-master'],
        'targetTags': [context.properties['infra_id'] + '-master']
      }
    }, {
      'name': context.properties['infra_id'] + '-control-plane',
      'type': 'compute.v1.firewall',
      'properties': {
        'network': context.properties['cluster_network'],
        'allowed': [{
          'IPProtocol': 'tcp',
          'ports': ['10257']
        }],
        'sourceTags': [
          context.properties['infra_id'] + '-master',
          context.properties['infra_id'] + '-worker'
        ],
        'targetTags': [context.properties['infra_id'] + '-master']
      }
    }, {
      'name': context.properties['infra_id'] + '-internal-network',
      'type': 'compute.v1.firewall',
      'properties': {
        'network': context.properties['cluster_network'],
        'allowed': [{
          'IPProtocol': 'icmp'
        }],
        'sourceTags': [
          context.properties['infra_id'] + '-master',
          context.properties['infra_id'] + '-worker'
        ],
        'targetTags': [context.properties['infra_id'] + '-master']
      }
    }
  ],
  'sourceTags': [
    context.properties['infra_id'] + '-master',
    context.properties['infra_id'] + '-worker'
  ],
  'targetTags': [context.properties['infra_id'] + '-master']
}

```

```

        'ports': ['22']
      }},
      'sourceRanges': [context.properties['network_cidr']],
      'targetTags': [
        context.properties['infra_id'] + '-master',
        context.properties['infra_id'] + '-worker'
      ]
    }
  }, {
    'name': context.properties['infra_id'] + '-internal-cluster',
    'type': 'compute.v1.firewall',
    'properties': {
      'network': context.properties['cluster_network'],
      'allowed': [{
        'IPProtocol': 'udp',
        'ports': ['4789', '6081']
      }, {
        'IPProtocol': 'udp',
        'ports': ['500', '4500']
      }, {
        'IPProtocol': 'esp',
      }, {
        'IPProtocol': 'tcp',
        'ports': ['9000-9999']
      }, {
        'IPProtocol': 'udp',
        'ports': ['9000-9999']
      }, {
        'IPProtocol': 'tcp',
        'ports': ['10250']
      }, {
        'IPProtocol': 'tcp',
        'ports': ['30000-32767']
      }, {
        'IPProtocol': 'udp',
        'ports': ['30000-32767']
      }
    ],
    'sourceTags': [
      context.properties['infra_id'] + '-master',
      context.properties['infra_id'] + '-worker'
    ],
    'targetTags': [
      context.properties['infra_id'] + '-master',
      context.properties['infra_id'] + '-worker'
    ]
  }
}
]]

return {'resources': resources}

```

### 7.10.13. Creating IAM roles in GCP

You must create IAM roles in Google Cloud Platform (GCP) for your OpenShift Container Platform cluster to use. One way to create these components is to modify the provided Deployment Manager template.



## NOTE

If you do not use the provided Deployment Manager template to create your GCP infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

## Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.

## Procedure

1. Copy the template from the **Deployment Manager template for IAM roles** section of this topic and save it as **03\_iam.py** on your computer. This template describes the IAM roles that your cluster requires.
2. Create a **03\_iam.yaml** resource definition file:

```
$ cat <<EOF >03_iam.yaml
imports:
- path: 03_iam.py
resources:
- name: cluster-iam
  type: 03_iam.py
  properties:
    infra_id: '${INFRA_ID}' 1
EOF
```

- 1 **infra\_id** is the **INFRA\_ID** infrastructure name from the extraction step.

3. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-iam --config 03_iam.yaml
```

4. Export the variable for the master service account:

```
$ export MASTER_SERVICE_ACCOUNT=$(gcloud iam service-accounts list --filter
"email~^${INFRA_ID}-m@${PROJECT_NAME}." --format json | jq -r '[0].email')
```

5. Export the variable for the worker service account:

```
$ export WORKER_SERVICE_ACCOUNT=$(gcloud iam service-accounts list --filter
"email~^${INFRA_ID}-w@${PROJECT_NAME}." --format json | jq -r '[0].email')
```

- Export the variable for the subnet that hosts the compute machines:

```
$ export COMPUTE_SUBNET=$(gcloud compute networks subnets describe ${INFRA_ID}-worker-subnet --region=${REGION} --format json | jq -r .selfLink)
```

- The templates do not create the policy bindings due to limitations of Deployment Manager, so you must create them manually:

```
$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${MASTER_SERVICE_ACCOUNT}" --role "roles/compute.instanceAdmin"
$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${MASTER_SERVICE_ACCOUNT}" --role "roles/compute.networkAdmin"
$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${MASTER_SERVICE_ACCOUNT}" --role "roles/compute.securityAdmin"
$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${MASTER_SERVICE_ACCOUNT}" --role "roles/iam.serviceAccountUser"
$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${MASTER_SERVICE_ACCOUNT}" --role "roles/storage.admin"

$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${WORKER_SERVICE_ACCOUNT}" --role "roles/compute.viewer"
$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${WORKER_SERVICE_ACCOUNT}" --role "roles/storage.admin"
```

- Create a service account key and store it locally for later use:

```
$ gcloud iam service-accounts keys create service-account-key.json --iam-
account=${MASTER_SERVICE_ACCOUNT}
```

### 7.10.13.1. Deployment Manager template for IAM roles

You can use the following Deployment Manager template to deploy the IAM roles that you need for your OpenShift Container Platform cluster:

#### Example 7.6. 03\_iam.py Deployment Manager template

```
def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-master-node-sa',
        'type': 'iam.v1.serviceAccount',
        'properties': {
            'accountId': context.properties['infra_id'] + '-m',
            'displayName': context.properties['infra_id'] + '-master-node'
        }
    }, {
        'name': context.properties['infra_id'] + '-worker-node-sa',
        'type': 'iam.v1.serviceAccount',
        'properties': {
            'accountId': context.properties['infra_id'] + '-w',
            'displayName': context.properties['infra_id'] + '-worker-node'
        }
    }
```

```

}}
return {'resources': resources}

```

### 7.10.14. Creating the RHCOS cluster image for the GCP infrastructure

You must use a valid Red Hat Enterprise Linux CoreOS (RHCOS) image for Google Cloud Platform (GCP) for your OpenShift Container Platform nodes.

#### Procedure

1. Obtain the RHCOS image from the [RHCOS image mirror](#) page.



#### IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download an image with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image version that matches your OpenShift Container Platform version if it is available.

The file name contains the OpenShift Container Platform version number in the format **rhcos-  
<version>-<arch>-gcp.<arch>.tar.gz**.

2. Create the Google storage bucket:

```
$ gsutil mb gs://<bucket_name>
```

3. Upload the RHCOS image to the Google storage bucket:

```
$ gsutil cp <downloaded_image_file_path>/rhcos-<version>-x86_64-gcp.x86_64.tar.gz
gs://<bucket_name>
```

4. Export the uploaded RHCOS image location as a variable:

```
$ export IMAGE_SOURCE=gs://<bucket_name>/rhcos-<version>-x86_64-gcp.x86_64.tar.gz
```

5. Create the cluster image:

```
$ gcloud compute images create "${INFRA_ID}-rhcos-image" \
--source-uri="${IMAGE_SOURCE}"
```

### 7.10.15. Creating the bootstrap machine in GCP

You must create the bootstrap machine in Google Cloud Platform (GCP) to use during OpenShift Container Platform cluster initialization. One way to create this machine is to modify the provided Deployment Manager template.





## NOTE

If you do not use the provided Deployment Manager template to create your bootstrap machine, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

## Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.
- Create and configure networking and load balancers in GCP.
- Create control plane and compute roles.
- Ensure pyOpenSSL is installed.

## Procedure

1. Copy the template from the **Deployment Manager template for the bootstrap machine** section of this topic and save it as **04\_bootstrap.py** on your computer. This template describes the bootstrap machine that your cluster requires.
2. Export the location of the Red Hat Enterprise Linux CoreOS (RHCOS) image that the installation program requires:

```
$ export CLUSTER_IMAGE=(`gcloud compute images describe ${INFRA_ID}-rhcos-image --
format json | jq -r .selfLink`)
```

3. Create a bucket and upload the **bootstrap.ign** file:

```
$ gsutil mb gs://${INFRA_ID}-bootstrap-ignition
$ gsutil cp <installation_directory>/bootstrap.ign gs://${INFRA_ID}-bootstrap-ignition/
```

4. Create a signed URL for the bootstrap instance to use to access the Ignition config. Export the URL from the output as a variable:

```
$ export BOOTSTRAP_IGN=`gsutil signurl -d 1h service-account-key.json gs://${INFRA_ID}-
bootstrap-ignition/bootstrap.ign | grep "^gs:" | awk '{print $5}'`
```

5. Create a **04\_bootstrap.yaml** resource definition file:

```
$ cat <<EOF >04_bootstrap.yaml
imports:
- path: 04_bootstrap.py

resources:
- name: cluster-bootstrap
  type: 04_bootstrap.py
  properties:
    infra_id: '${INFRA_ID}' 1
```

```

region: '${REGION}' 2
zone: '${ZONE_0}' 3

cluster_network: '${CLUSTER_NETWORK}' 4
control_subnet: '${CONTROL_SUBNET}' 5
image: '${CLUSTER_IMAGE}' 6
machine_type: 'n1-standard-4' 7
root_volume_size: '128' 8

bootstrap_ign: '${BOOTSTRAP_IGN}' 9
EOF

```

- 1 **infra\_id** is the **INFRA\_ID** infrastructure name from the extraction step.
- 2 **region** is the region to deploy the cluster into, for example **us-central1**.
- 3 **zone** is the zone to deploy the bootstrap instance into, for example **us-central1-b**.
- 4 **cluster\_network** is the **selfLink** URL to the cluster network.
- 5 **control\_subnet** is the **selfLink** URL to the control subnet.
- 6 **image** is the **selfLink** URL to the RHCOS image.
- 7 **machine\_type** is the machine type of the instance, for example **n1-standard-4**.
- 8 **root\_volume\_size** is the boot disk size for the bootstrap machine.
- 9 **bootstrap\_ign** is the URL output when creating a signed URL.

6. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-bootstrap --config
04_bootstrap.yaml
```

7. The templates do not manage load balancer membership due to limitations of Deployment Manager, so you must add the bootstrap machine manually.

- a. Add the bootstrap instance to the internal load balancer instance group:

```
$ gcloud compute instance-groups unmanaged add-instances \
  ${INFRA_ID}-bootstrap-instance-group --zone=${ZONE_0} --instances=${INFRA_ID}-
  bootstrap
```

- b. Add the bootstrap instance group to the internal load balancer backend service:

```
$ gcloud compute backend-services add-backend \
  ${INFRA_ID}-api-internal-backend-service --region=${REGION} --instance-
  group=${INFRA_ID}-bootstrap-instance-group --instance-group-zone=${ZONE_0}
```

### 7.10.15.1. Deployment Manager template for the bootstrap machine

You can use the following Deployment Manager template to deploy the bootstrap machine that you need for your OpenShift Container Platform cluster:

### Example 7.7. 04\_bootstrap.py Deployment Manager template

```
def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-bootstrap-public-ip',
        'type': 'compute.v1.address',
        'properties': {
            'region': context.properties['region']
        }
    }, {
        'name': context.properties['infra_id'] + '-bootstrap',
        'type': 'compute.v1.instance',
        'properties': {
            'disks': [{
                'autoDelete': True,
                'boot': True,
                'initializeParams': {
                    'diskSizeGb': context.properties['root_volume_size'],
                    'sourceImage': context.properties['image']
                }
            }],
            'machineType': 'zones/' + context.properties['zone'] + '/machineTypes/' +
context.properties['machine_type'],
            'metadata': {
                'items': [{
                    'key': 'user-data',
                    'value': '{"ignition":{"config":{"replace":{"source":"' + context.properties['bootstrap_ign']
+ '"},"version":"3.1.0"}}}',
                }],
            },
            'networkInterfaces': [{
                'subnetwork': context.properties['control_subnet'],
                'accessConfigs': [{
                    'natIP': '$(ref.' + context.properties['infra_id'] + '-bootstrap-public-ip.address)'
                }],
            }],
            'tags': {
                'items': [
                    context.properties['infra_id'] + '-master',
                    context.properties['infra_id'] + '-bootstrap'
                ]
            },
            'zone': context.properties['zone']
        }
    }, {
        'name': context.properties['infra_id'] + '-bootstrap-instance-group',
        'type': 'compute.v1.instanceGroup',
        'properties': {
            'namedPorts': [
                {
                    'name': 'ignition',
                    'port': 22623
                }
            ]
        }
    }]
```

```

    }, {
      'name': 'https',
      'port': 6443
    }
  ],
  'network': context.properties['cluster_network'],
  'zone': context.properties['zone']
}
}}

return {'resources': resources}

```

## 7.10.16. Creating the control plane machines in GCP

You must create the control plane machines in Google Cloud Platform (GCP) for your cluster to use. One way to create these machines is to modify the provided Deployment Manager template.



### NOTE

If you do not use the provided Deployment Manager template to create your control plane machines, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

### Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.
- Create and configure networking and load balancers in GCP.
- Create control plane and compute roles.
- Create the bootstrap machine.

### Procedure

1. Copy the template from the **Deployment Manager template for control plane machines** section of this topic and save it as **05\_control\_plane.py** on your computer. This template describes the control plane machines that your cluster requires.
2. Export the following variable required by the resource definition:

```
$ export MASTER_IGNITION=`cat <installation_directory>/master.ign`
```

3. Create a **05\_control\_plane.yaml** resource definition file:

```
$ cat <<EOF >05_control_plane.yaml
imports:
- path: 05_control_plane.py
```

```

resources:
- name: cluster-control-plane
  type: 05_control_plane.py
  properties:
    infra_id: '${INFRA_ID}' 1
    zones: 2
    - '${ZONE_0}'
    - '${ZONE_1}'
    - '${ZONE_2}'

    control_subnet: '${CONTROL_SUBNET}' 3
    image: '${CLUSTER_IMAGE}' 4
    machine_type: 'n1-standard-4' 5
    root_volume_size: '128'
    service_account_email: '${MASTER_SERVICE_ACCOUNT}' 6

    ignition: '${MASTER_IGNITION}' 7
EOF

```

- 1 **infra\_id** is the **INFRA\_ID** infrastructure name from the extraction step.
- 2 **zones** are the zones to deploy the control plane instances into, for example **us-central1-a**, **us-central1-b**, and **us-central1-c**.
- 3 **control\_subnet** is the **selfLink** URL to the control subnet.
- 4 **image** is the **selfLink** URL to the RHCOS image.
- 5 **machine\_type** is the machine type of the instance, for example **n1-standard-4**.
- 6 **service\_account\_email** is the email address for the master service account that you created.
- 7 **ignition** is the contents of the **master.ign** file.

4. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-control-plane --config
05_control_plane.yaml
```

5. The templates do not manage load balancer membership due to limitations of Deployment Manager, so you must add the control plane machines manually.

- Run the following commands to add the control plane machines to the appropriate instance groups:

```
$ gcloud compute instance-groups unmanaged add-instances ${INFRA_ID}-master-
${ZONE_0}-instance-group --zone=${ZONE_0} --instances=${INFRA_ID}-master-0
$ gcloud compute instance-groups unmanaged add-instances ${INFRA_ID}-master-
${ZONE_1}-instance-group --zone=${ZONE_1} --instances=${INFRA_ID}-master-1
$ gcloud compute instance-groups unmanaged add-instances ${INFRA_ID}-master-
${ZONE_2}-instance-group --zone=${ZONE_2} --instances=${INFRA_ID}-master-2
```

- For an external cluster, you must also run the following commands to add the control plane machines to the target pools:

```
$ gcloud compute target-pools add-instances ${INFRA_ID}-api-target-pool --instances-zone="${ZONE_0}" --instances=${INFRA_ID}-master-0
$ gcloud compute target-pools add-instances ${INFRA_ID}-api-target-pool --instances-zone="${ZONE_1}" --instances=${INFRA_ID}-master-1
$ gcloud compute target-pools add-instances ${INFRA_ID}-api-target-pool --instances-zone="${ZONE_2}" --instances=${INFRA_ID}-master-2
```

### 7.10.16.1. Deployment Manager template for control plane machines

You can use the following Deployment Manager template to deploy the control plane machines that you need for your OpenShift Container Platform cluster:

#### Example 7.8. 05\_control\_plane.py Deployment Manager template

```
def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-master-0',
        'type': 'compute.v1.instance',
        'properties': {
            'disks': [{
                'autoDelete': True,
                'boot': True,
                'initializeParams': {
                    'diskSizeGb': context.properties['root_volume_size'],
                    'diskType': 'zones/' + context.properties['zones'][0] + '/diskTypes/pd-ssd',
                    'sourceImage': context.properties['image']
                }
            }],
            'machineType': 'zones/' + context.properties['zones'][0] + '/machineTypes/' +
context.properties['machine_type'],
            'metadata': {
                'items': [{
                    'key': 'user-data',
                    'value': context.properties['ignition']
                }]
            },
            'networkInterfaces': [{
                'subnetwork': context.properties['control_subnet']
            }],
            'serviceAccounts': [{
                'email': context.properties['service_account_email'],
                'scopes': ['https://www.googleapis.com/auth/cloud-platform']
            }],
            'tags': {
                'items': [
                    context.properties['infra_id'] + '-master',
                ]
            },
            'zone': context.properties['zones'][0]
        }
    ], {
```

```

'name': context.properties['infra_id'] + '-master-1',
'type': 'compute.v1.instance',
'properties': {
  'disks': [{
    'autoDelete': True,
    'boot': True,
    'initializeParams': {
      'diskSizeGb': context.properties['root_volume_size'],
      'diskType': 'zones/' + context.properties['zones'][1] + '/diskTypes/pd-ssd',
      'sourceImage': context.properties['image']
    }
  }],
  'machineType': 'zones/' + context.properties['zones'][1] + '/machineTypes/' +
context.properties['machine_type'],
'metadata': {
  'items': [{
    'key': 'user-data',
    'value': context.properties['ignition']
  }]
},
'networkInterfaces': [{
  'subnetwork': context.properties['control_subnet']
}],
'serviceAccounts': [{
  'email': context.properties['service_account_email'],
  'scopes': ['https://www.googleapis.com/auth/cloud-platform']
}],
'tags': {
  'items': [
    context.properties['infra_id'] + '-master',
  ]
},
'zone': context.properties['zones'][1]
}
}, {
'name': context.properties['infra_id'] + '-master-2',
'type': 'compute.v1.instance',
'properties': {
  'disks': [{
    'autoDelete': True,
    'boot': True,
    'initializeParams': {
      'diskSizeGb': context.properties['root_volume_size'],
      'diskType': 'zones/' + context.properties['zones'][2] + '/diskTypes/pd-ssd',
      'sourceImage': context.properties['image']
    }
  }],
  'machineType': 'zones/' + context.properties['zones'][2] + '/machineTypes/' +
context.properties['machine_type'],
'metadata': {
  'items': [{
    'key': 'user-data',
    'value': context.properties['ignition']
  }]
},
'networkInterfaces': [{

```

```

        'subnetwork': context.properties['control_subnet']
    }},
    'serviceAccounts': [{
        'email': context.properties['service_account_email'],
        'scopes': ['https://www.googleapis.com/auth/cloud-platform']
    }},
    'tags': {
        'items': [
            context.properties['infra_id'] + '-master',
        ]
    },
    'zone': context.properties['zones'][2]
}
]]

return {'resources': resources}

```

### 7.10.17. Wait for bootstrap completion and remove bootstrap resources in GCP

After you create all of the required infrastructure in Google Cloud Platform (GCP), wait for the bootstrap process to complete on the machines that you provisioned by using the Ignition config files that you generated with the installation program.

#### Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.
- Create and configure networking and load balancers in GCP.
- Create control plane and compute roles.
- Create the bootstrap machine.
- Create the control plane machines.

#### Procedure

1. Change to the directory that contains the installation program and run the following command:

```

$ ./openshift-install wait-for bootstrap-complete --dir <installation_directory> \ 1
--log-level info 2

```

**1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

**2** To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

If the command exits without a **FATAL** warning, your production control plane has initialized.



2. Delete the bootstrap resources:

```
$ gcloud compute backend-services remove-backend ${INFRA_ID}-api-internal-backend-
service --region=${REGION} --instance-group=${INFRA_ID}-bootstrap-instance-group --
instance-group-zone=${ZONE_0}
$ gsutil rm gs://${INFRA_ID}-bootstrap-ignition/bootstrap.ign
$ gsutil rb gs://${INFRA_ID}-bootstrap-ignition
$ gcloud deployment-manager deployments delete ${INFRA_ID}-bootstrap
```

### 7.10.18. Creating additional worker machines in GCP

You can create worker machines in Google Cloud Platform (GCP) for your cluster to use by launching individual instances discretely or by automated processes outside the cluster, such as auto scaling groups. You can also take advantage of the built-in cluster scaling mechanisms and the machine API in OpenShift Container Platform.

In this example, you manually launch one instance by using the Deployment Manager template. Additional instances can be launched by including additional resources of type **06\_worker.py** in the file.



#### NOTE

If you do not use the provided Deployment Manager template to create your worker machines, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

#### Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.
- Create and configure networking and load balancers in GCP.
- Create control plane and compute roles.
- Create the bootstrap machine.
- Create the control plane machines.

#### Procedure

1. Copy the template from the **Deployment Manager template for worker machines** section of this topic and save it as **06\_worker.py** on your computer. This template describes the worker machines that your cluster requires.
2. Export the variables that the resource definition uses.
  - a. Export the subnet that hosts the compute machines:

```
$ export COMPUTE_SUBNET=$(gcloud compute networks subnets describe
${INFRA_ID}-worker-subnet --region=${REGION} --format json | jq -r .selfLink`)
```

- b. Export the email address for your service account:

```
$ export WORKER_SERVICE_ACCOUNT=$(gcloud iam service-accounts list --filter
"email~^${INFRA_ID}-w@${PROJECT_NAME}." --format json | jq -r '.[0].email')
```

- c. Export the location of the compute machine Ignition config file:

```
$ export WORKER_IGNITION=`cat <installation_directory>/worker.ign`
```

3. Create a **06\_worker.yaml** resource definition file:

```
$ cat <<EOF >06_worker.yaml
imports:
- path: 06_worker.py

resources:
- name: 'worker-0' 1
  type: 06_worker.py
  properties:
    infra_id: '${INFRA_ID}' 2
    zone: '${ZONE_0}' 3
    compute_subnet: '${COMPUTE_SUBNET}' 4
    image: '${CLUSTER_IMAGE}' 5
    machine_type: 'n1-standard-4' 6
    root_volume_size: '128'
    service_account_email: '${WORKER_SERVICE_ACCOUNT}' 7
    ignition: '${WORKER_IGNITION}' 8
- name: 'worker-1'
  type: 06_worker.py
  properties:
    infra_id: '${INFRA_ID}' 9
    zone: '${ZONE_1}' 10
    compute_subnet: '${COMPUTE_SUBNET}' 11
    image: '${CLUSTER_IMAGE}' 12
    machine_type: 'n1-standard-4' 13
    root_volume_size: '128'
    service_account_email: '${WORKER_SERVICE_ACCOUNT}' 14
    ignition: '${WORKER_IGNITION}' 15
EOF
```

- 1 **name** is the name of the worker machine, for example **worker-0**.
- 2 9 **infra\_id** is the **INFRA\_ID** infrastructure name from the extraction step.
- 3 10 **zone** is the zone to deploy the worker machine into, for example **us-central1-a**.
- 4 11 **compute\_subnet** is the **selfLink** URL to the compute subnet.
- 5 12 **image** is the **selfLink** URL to the RHCOS image. <sup>1</sup>
- 6 13 **machine\_type** is the machine type of the instance, for example **n1-standard-4**.
- 7 14

`service_account_email` is the email address for the worker service account that you created.

**8 15** `ignition` is the contents of the `worker.ign` file.

4. Optional: If you want to launch additional instances, include additional resources of type `06_worker.py` in your `06_worker.yaml` resource definition file.
5. Create the deployment by using the `gcloud` CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-worker --config
06_worker.yaml
```

1. To use a GCP Marketplace image, specify the offer to use:
  - OpenShift Container Platform: <https://www.googleapis.com/compute/v1/projects/redhat-marketplace-public/global/images/redhat-coreos-ocp-48-x86-64-202210040145>
  - OpenShift Platform Plus: <https://www.googleapis.com/compute/v1/projects/redhat-marketplace-public/global/images/redhat-coreos-opp-48-x86-64-202206140145>
  - OpenShift Kubernetes Engine: <https://www.googleapis.com/compute/v1/projects/redhat-marketplace-public/global/images/redhat-coreos-oke-48-x86-64-202206140145>

### 7.10.18.1. Deployment Manager template for worker machines

You can use the following Deployment Manager template to deploy the worker machines that you need for your OpenShift Container Platform cluster:

#### Example 7.9. `06_worker.py` Deployment Manager template

```
def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-' + context.env['name'],
        'type': 'compute.v1.instance',
        'properties': {
            'disks': [{
                'autoDelete': True,
                'boot': True,
                'initializeParams': {
                    'diskSizeGb': context.properties['root_volume_size'],
                    'sourceImage': context.properties['image']
                }
            }],
            'machineType': 'zones/' + context.properties['zone'] + '/machineTypes/' +
context.properties['machine_type'],
            'metadata': {
                'items': [{
                    'key': 'user-data',
                    'value': context.properties['ignition']
                }]
            }
        },
    ]
```

```

'networkInterfaces': [{
  'subnetwork': context.properties['compute_subnet']
}],
'serviceAccounts': [{
  'email': context.properties['service_account_email'],
  'scopes': ['https://www.googleapis.com/auth/cloud-platform']
}],
'tags': {
  'items': [
    context.properties['infra_id'] + '-worker',
  ]
},
'zone': context.properties['zone']
}
}]

return {'resources': resources}

```

### 7.10.19. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



#### IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

#### Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

```
$ tar xvf <file>
```

5. Place the **oc** binary in a directory that is on your **PATH**.  
To check your **PATH**, execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

## Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

## Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your **PATH**.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### 7.10.20. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

## Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

## Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

### Example output

```
system:admin
```

## 7.10.21. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

## Prerequisites

- You added machines to your cluster.

## Procedure

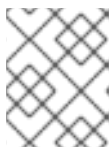
1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

### Example output

```
NAME      STATUS    ROLES    AGE   VERSION
master-0  Ready    master   63m   v1.22.1
master-1  Ready    master   63m   v1.22.1
master-2  Ready    master   64m   v1.22.1
```

The output lists all of the machines that you created.



### NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

- Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

### Example output

```
NAME          AGE   REQUESTOR                                     CONDITION
csr-8b2br    15m   system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper Pending
csr-8vnps    15m   system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper Pending
...
```

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

- If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:



#### NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.



#### NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{\n"}\n{{end}}\n' | xargs --no-run-if-empty oc adm certificate approve
```

**NOTE**

Some Operators might not become available until some CSRs are approved.

- Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

**Example output**

```
NAME      AGE   REQUESTOR                                     CONDITION
csr-bfd72 5m26s system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv 5m26s system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

- If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{\n"}\n{{end}}\n' | xargs oc adm certificate approve
```

- After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

**Example output**

```
NAME      STATUS  ROLES  AGE  VERSION
master-0  Ready   master 73m  v1.22.1
master-1  Ready   master 73m  v1.22.1
master-2  Ready   master 74m  v1.22.1
worker-0  Ready   worker 11m  v1.22.1
worker-1  Ready   worker 11m  v1.22.1
```



**NOTE**

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

**Additional information**

- For more information on CSRs, see [Certificate Signing Requests](#).

**7.10.22. Optional: Adding the ingress DNS records**

If you removed the DNS zone configuration when creating Kubernetes manifests and generating Ignition configs, you must manually create DNS records that point at the ingress load balancer. You can create either a wildcard **\*.apps.{baseDomain}**. or specific records. You can use A, CNAME, and other records per your requirements.

**Prerequisites**

- Configure a GCP account.
- Remove the DNS Zone configuration when creating Kubernetes manifests and generating Ignition configs.
- Create and configure a VPC and associated subnets in GCP.
- Create and configure networking and load balancers in GCP.
- Create control plane and compute roles.
- Create the bootstrap machine.
- Create the control plane machines.
- Create the worker machines.

**Procedure**

1. Wait for the Ingress router to create a load balancer and populate the **EXTERNAL-IP** field:

```
$ oc -n openshift-ingress get service router-default
```

**Example output**

NAME	TYPE	CLUSTER-IP	EXTERNAL-IP	PORT(S)	AGE
router-default	LoadBalancer	172.30.18.154	35.233.157.184	80:32288/TCP,443:31215/TCP	98

2. Add the A record to your zones:

- To use A records:
  - i. Export the variable for the router IP address:

```
$ export ROUTER_IP=`oc -n openshift-ingress get service router-default --no-headers | awk '{print $4}'`
```

- ii. Add the A record to the private zones:

```
$ if [ -f transaction.yaml ]; then rm transaction.yaml; fi
$ gcloud dns record-sets transaction start --zone ${INFRA_ID}-private-zone
$ gcloud dns record-sets transaction add ${ROUTER_IP} --name
\*.apps.${CLUSTER_NAME}.${BASE_DOMAIN}. --ttl 300 --type A --zone
${INFRA_ID}-private-zone
$ gcloud dns record-sets transaction execute --zone ${INFRA_ID}-private-zone
```

- iii. For an external cluster, also add the A record to the public zones:

```
$ if [ -f transaction.yaml ]; then rm transaction.yaml; fi
$ gcloud dns record-sets transaction start --zone ${BASE_DOMAIN_ZONE_NAME}
$ gcloud dns record-sets transaction add ${ROUTER_IP} --name
\*.apps.${CLUSTER_NAME}.${BASE_DOMAIN}. --ttl 300 --type A --zone
${BASE_DOMAIN_ZONE_NAME}
$ gcloud dns record-sets transaction execute --zone
${BASE_DOMAIN_ZONE_NAME}
```

- To add explicit domains instead of using a wildcard, create entries for each of the cluster's current routes:

```
$ oc get --all-namespaces -o jsonpath='{range .items[*]}{range .status.ingress[*]}{.host}
{"\n"}{end}{end}' routes
```

### Example output

```
oauth-openshift.apps.your.cluster.domain.example.com
console-openshift-console.apps.your.cluster.domain.example.com
downloads-openshift-console.apps.your.cluster.domain.example.com
alertmanager-main-openshift-monitoring.apps.your.cluster.domain.example.com
grafana-openshift-monitoring.apps.your.cluster.domain.example.com
prometheus-k8s-openshift-monitoring.apps.your.cluster.domain.example.com
```

## 7.10.23. Completing a GCP installation on user-provisioned infrastructure

After you start the OpenShift Container Platform installation on Google Cloud Platform (GCP) user-provisioned infrastructure, you can monitor the cluster events until the cluster is ready.

### Prerequisites

- Deploy the bootstrap machine for an OpenShift Container Platform cluster on user-provisioned GCP infrastructure.
- Install the **oc** CLI and log in.

### Procedure

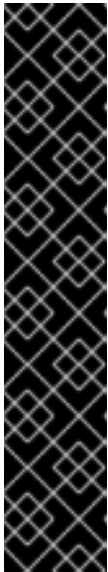
1. Complete the cluster installation:

```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

### Example output

INFO Waiting up to 30m0s for the cluster to initialize...

- 1 For `<installation_directory>`, specify the path to the directory that you stored the installation files in.



### IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Observe the running state of your cluster.

- a. Run the following command to view the current cluster version and status:

```
$ oc get clusterversion
```

#### Example output

```
NAME      VERSION AVAILABLE PROGRESSING SINCE STATUS
version   False    True    24m    Working towards 4.5.4: 99% complete
```

- b. Run the following command to view the Operators managed on the control plane by the Cluster Version Operator (CVO):

```
$ oc get clusteroperators
```

#### Example output

```
NAME                               VERSION AVAILABLE PROGRESSING DEGRADED
SINCE
authentication                     4.5.4 True    False    False    7m56s
cloud-credential                   4.5.4 True    False    False    31m
cluster-autoscaler                 4.5.4 True    False    False    16m
console                             4.5.4 True    False    False    10m
csi-snapshot-controller             4.5.4 True    False    False    16m
dns                                 4.5.4 True    False    False    22m
etcd                                 4.5.4 False   False    False    25s
image-registry                     4.5.4 True    False    False    16m
ingress                             4.5.4 True    False    False    16m
insights                           4.5.4 True    False    False    17m
```

kube-apiserver	4.5.4	True	False	False	19m
kube-controller-manager	4.5.4	True	False	False	20m
kube-scheduler	4.5.4	True	False	False	20m
kube-storage-version-migrator	4.5.4	True	False	False	16m
machine-api	4.5.4	True	False	False	22m
machine-config	4.5.4	True	False	False	22m
marketplace	4.5.4	True	False	False	16m
monitoring	4.5.4	True	False	False	10m
network	4.5.4	True	False	False	23m
node-tuning	4.5.4	True	False	False	23m
openshift-apiserver	4.5.4	True	False	False	17m
openshift-controller-manager	4.5.4	True	False	False	15m
openshift-samples	4.5.4	True	False	False	16m
operator-lifecycle-manager	4.5.4	True	False	False	22m
operator-lifecycle-manager-catalog	4.5.4	True	False	False	22m
operator-lifecycle-manager-packageserver	4.5.4	True	False	False	18m
service-ca	4.5.4	True	False	False	23m
service-catalog-apiserver	4.5.4	True	False	False	23m
service-catalog-controller-manager	4.5.4	True	False	False	23m
storage	4.5.4	True	False	False	17m

- c. Run the following command to view your cluster pods:

```
$ oc get pods --all-namespaces
```

### Example output

```

NAMESPACE                               NAME
READY  STATUS  RESTARTS  AGE
kube-system                               etcd-member-ip-10-0-3-111.us-east-
2.compute.internal                       1/1    Running  0    35m
kube-system                               etcd-member-ip-10-0-3-239.us-east-
2.compute.internal                       1/1    Running  0    37m
kube-system                               etcd-member-ip-10-0-3-24.us-east-
2.compute.internal                       1/1    Running  0    35m
openshift-apiserver-operator             openshift-apiserver-operator-6d6674f4f4-
h7t2t                                   1/1    Running  1    37m
openshift-apiserver                      apiserver-fm48r
1/1    Running  0    30m
openshift-apiserver                      apiserver-fxkvv
1/1    Running  0    29m
openshift-apiserver                      apiserver-q85nm
1/1    Running  0    29m
...
openshift-service-ca-operator            openshift-service-ca-operator-66ff6dc6cd-
9r257                                   1/1    Running  0    37m
openshift-service-ca                    apiservice-cabundle-injector-695b6bcbc-cl5hm
1/1    Running  0    35m
openshift-service-ca                    configmap-cabundle-injector-8498544d7-
25qn6                                   1/1    Running  0    35m
openshift-service-ca                    service-serving-cert-signer-6445fc9c6-wqdqn
1/1    Running  0    35m
openshift-service-catalog-apiserver-operator  openshift-service-catalog-apiserver-

```

```
operator-549f44668b-b5q2w    1/1    Running    0    32m
openshift-service-catalog-controller-manager-operator    openshift-service-catalog-
controller-manager-operator-b78cr2lnm    1/1    Running    0    31m
```

When the current cluster version is **AVAILABLE**, the installation is complete.

### 7.10.24. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

#### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

### 7.10.25. Next steps

- [Customize your cluster](#).
- If necessary, you can [opt out of remote health reporting](#).
- [Configure Global Access for an Ingress Controller on GCP](#).

## 7.11. INSTALLING A CLUSTER INTO A SHARED VPC ON GCP USING DEPLOYMENT MANAGER TEMPLATES

In OpenShift Container Platform version 4.9, you can install a cluster into a shared Virtual Private Cloud (VPC) on Google Cloud Platform (GCP) that uses infrastructure that you provide. In this context, a cluster installed into a shared VPC is a cluster that is configured to use a VPC from a project different from where the cluster is being deployed.

A shared VPC enables an organization to connect resources from multiple projects to a common VPC network. You can communicate within the organization securely and efficiently by using internal IPs from that network. For more information about shared VPC, see [Shared VPC overview](#) in the GCP documentation.

The steps for performing a user-provided infrastructure installation into a shared VPC are outlined here. Several [Deployment Manager](#) templates are provided to assist in completing these steps or to help model your own. You are also free to create the required resources through other methods.



#### IMPORTANT

The steps for performing a user-provisioned infrastructure installation are provided as an example only. Installing a cluster with infrastructure you provide requires knowledge of the cloud provider and the installation process of OpenShift Container Platform. Several Deployment Manager templates are provided to assist in completing these steps or to help model your own. You are also free to create the required resources through other methods; the templates are just an example.

### 7.11.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update processes](#).
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- If you use a firewall and plan to use the Telemetry service, you [configured the firewall to allow the sites](#) that your cluster requires access to.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can [manually create and maintain IAM credentials](#).



#### NOTE

Be sure to also review this site list if you are configuring a proxy.

### 7.11.2. Certificate signing requests management

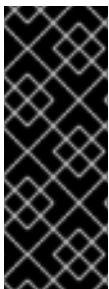
Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

### 7.11.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



#### IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

### 7.11.4. Configuring the GCP project that hosts your cluster

Before you can install OpenShift Container Platform, you must configure a Google Cloud Platform (GCP) project to host it.

#### 7.11.4.1. Creating a GCP project

To install OpenShift Container Platform, you must create a project in your Google Cloud Platform (GCP) account to host the cluster.

##### Procedure

- Create a project to host your OpenShift Container Platform cluster. See [Creating and Managing Projects](#) in the GCP documentation.



#### IMPORTANT

Your GCP project must use the Premium Network Service Tier if you are using installer-provisioned infrastructure. The Standard Network Service Tier is not supported for clusters installed using the installation program. The installation program configures internal load balancing for the **api-int.<cluster\_name>.<base\_domain>** URL; the Premium Tier is required for internal load balancing.

#### 7.11.4.2. Enabling API services in GCP

Your Google Cloud Platform (GCP) project requires access to several API services to complete OpenShift Container Platform installation.

##### Prerequisites

- You created a project to host your cluster.

##### Procedure

- Enable the following required API services in the project that hosts your cluster. See [Enabling services](#) in the GCP documentation.

**Table 7.43. Required API services**

API service	Console service name
Cloud Deployment Manager V2 API	<b>deploymentmanager.googleapis.com</b>
Compute Engine API	<b>compute.googleapis.com</b>
Google Cloud APIs	<b>cloudapis.googleapis.com</b>
Cloud Resource Manager API	<b>cloudresourcemanager.googleapis.com</b>
Google DNS API	<b>dns.googleapis.com</b>
IAM Service Account Credentials API	<b>iamcredentials.googleapis.com</b>

API service	Console service name
Identity and Access Management (IAM) API	<b>iam.googleapis.com</b>
Service Management API	<b>servicemanagement.googleapis.com</b>
Service Usage API	<b>serviceusage.googleapis.com</b>
Google Cloud Storage JSON API	<b>storage-api.googleapis.com</b>
Cloud Storage	<b>storage-component.googleapis.com</b>

### 7.11.4.3. GCP account limits

The OpenShift Container Platform cluster uses a number of Google Cloud Platform (GCP) components, but the default [Quotas](#) do not affect your ability to install a default OpenShift Container Platform cluster.

A default cluster, which contains three compute and three control plane machines, uses the following resources. Note that some resources are required only during the bootstrap process and are removed after the cluster deploys.

**Table 7.44. GCP resources used in a default cluster**

Service	Component	Location	Total resources required	Resources removed after bootstrap
Service account	IAM	Global	5	0
Firewall rules	Networking	Global	11	1
Forwarding rules	Compute	Global	2	0
Health checks	Compute	Global	2	0
Images	Compute	Global	1	0
Networks	Networking	Global	1	0
Routers	Networking	Global	1	0
Routes	Networking	Global	2	0
Subnetworks	Compute	Global	2	0
Target pools	Networking	Global	2	0





## NOTE

If any of the quotas are insufficient during installation, the installation program displays an error that states both which quota was exceeded and the region.

Be sure to consider your actual cluster size, planned cluster growth, and any usage from other clusters that are associated with your account. The CPU, static IP addresses, and persistent disk SSD (storage) quotas are the ones that are most likely to be insufficient.

If you plan to deploy your cluster in one of the following regions, you will exceed the maximum storage quota and are likely to exceed the CPU quota limit:

- **asia-east2**
- **asia-northeast2**
- **asia-south1**
- **australia-southeast1**
- **europa-north1**
- **europa-west2**
- **europa-west3**
- **europa-west6**
- **northamerica-northeast1**
- **southamerica-east1**
- **us-west2**

You can increase resource quotas from the [GCP console](#), but you might need to file a support ticket. Be sure to plan your cluster size early so that you can allow time to resolve the support ticket before you install your OpenShift Container Platform cluster.

### 7.11.4.4. Creating a service account in GCP

OpenShift Container Platform requires a Google Cloud Platform (GCP) service account that provides authentication and authorization to access data in the Google APIs. If you do not have an existing IAM service account that contains the required roles in your project, you must create one.

#### Prerequisites

- You created a project to host your cluster.

#### Procedure

1. Create a service account in the project that you use to host your OpenShift Container Platform cluster. See [Creating a service account](#) in the GCP documentation.
2. Grant the service account the appropriate permissions. You can either grant the individual permissions that follow or assign the **Owner** role to it. See [Granting roles to a service account for specific resources](#).

**NOTE**

While making the service account an owner of the project is the easiest way to gain the required permissions, it means that service account has complete control over the project. You must determine if the risk that comes from offering that power is acceptable.

3. Create the service account key in JSON format. See [Creating service account keys](#) in the GCP documentation.  
The service account key is required to create a cluster.

**7.11.4.4.1. Required GCP permissions**

When you attach the **Owner** role to the service account that you create, you grant that service account all permissions, including those that are required to install OpenShift Container Platform. To deploy an OpenShift Container Platform cluster, the service account requires the following permissions. If you deploy your cluster into an existing VPC, the service account does not require certain networking permissions, which are noted in the following lists:

**Required roles for the installation program**

- Compute Admin
- Security Admin
- Service Account Admin
- Service Account User
- Storage Admin

**Required roles for creating network resources during installation**

- DNS Administrator

**Required roles for user-provisioned GCP infrastructure**

- Deployment Manager Editor
- Service Account Key Admin

**Optional roles**

For the cluster to create new limited credentials for its Operators, add the following role:

- Service Account Key Admin

The roles are applied to the service accounts that the control plane and compute machines use:

**Table 7.45. GCP service account permissions**

Account	Roles
Control Plane	<b>roles/compute.instanceAdmin</b>

Account	Roles
	<b>roles/compute.networkAdmin</b>
	<b>roles/compute.securityAdmin</b>
	<b>roles/storage.admin</b>
	<b>roles/iam.serviceAccountUser</b>
Compute	<b>roles/compute.viewer</b>
	<b>roles/storage.admin</b>

#### 7.11.4.5. Supported GCP regions

You can deploy an OpenShift Container Platform cluster to the following Google Cloud Platform (GCP) regions:

- **asia-east1** (Changhua County, Taiwan)
- **asia-east2** (Hong Kong)
- **asia-northeast1** (Tokyo, Japan)
- **asia-northeast2** (Osaka, Japan)
- **asia-northeast3** (Seoul, South Korea)
- **asia-south1** (Mumbai, India)
- **asia-southeast1** (Jurong West, Singapore)
- **asia-southeast2** (Jakarta, Indonesia)
- **australia-southeast1** (Sydney, Australia)
- **europa-central2** (Warsaw, Poland)
- **europa-north1** (Hamina, Finland)
- **europa-west1** (St. Ghislain, Belgium)
- **europa-west2** (London, England, UK)
- **europa-west3** (Frankfurt, Germany)
- **europa-west4** (Eemshaven, Netherlands)
- **europa-west6** (Zürich, Switzerland)
- **northamerica-northeast1** (Montréal, Québec, Canada)

- **southamerica-east1** (São Paulo, Brazil)
- **us-central1** (Council Bluffs, Iowa, USA)
- **us-east1** (Moncks Corner, South Carolina, USA)
- **us-east4** (Ashburn, Northern Virginia, USA)
- **us-west1** (The Dalles, Oregon, USA)
- **us-west2** (Los Angeles, California, USA)
- **us-west3** (Salt Lake City, Utah, USA)
- **us-west4** (Las Vegas, Nevada, USA)

#### 7.11.4.6. Installing and configuring CLI tools for GCP

To install OpenShift Container Platform on Google Cloud Platform (GCP) using user-provisioned infrastructure, you must install and configure the CLI tools for GCP.

##### Prerequisites

- You created a project to host your cluster.
- You created a service account and granted it the required permissions.

##### Procedure

1. Install the following binaries in **\$PATH**:
  - **gcloud**
  - **gsutil**

See [Install the latest Cloud SDK version](#) in the GCP documentation.

2. Authenticate using the **gcloud** tool with your configured service account.  
See [Authorizing with a service account](#) in the GCP documentation.

#### 7.11.5. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

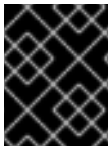
This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

##### 7.11.5.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

**Table 7.46. Minimum required hosts**

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.



### IMPORTANT

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 7.9, or RHEL 8.4.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See [Red Hat Enterprise Linux technology capabilities and limits](#) .

#### 7.11.5.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

**Table 7.47. Minimum resource requirements**

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 7.9, or RHEL 8.4 [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio:  $(\text{threads per core} \times \text{cores}) \times \text{sockets} = \text{vCPUs}$ .
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms

p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.

3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.

### 7.11.5.3. Using custom machine types

Using a custom machine type to install a OpenShift Container Platform cluster is supported.

Consider the following when using a custom machine type:

- Similar to predefined instance types, custom machine types must meet the minimum resource requirements for control plane and compute machines. For more information, see "Minimum resource requirements for cluster installation".
- The name of the custom machine type must adhere to the following syntax:  
**custom-<number\_of\_cpus>-<amount\_of\_memory\_in\_mb>**

For example, **custom-6-20480**.

### 7.11.6. Configuring the GCP project that hosts your shared VPC network

If you use a shared Virtual Private Cloud (VPC) to host your OpenShift Container Platform cluster in Google Cloud Platform (GCP), you must configure the project that hosts it.



#### NOTE

If you already have a project that hosts the shared VPC network, review this section to ensure that the project meets all of the requirements to install an OpenShift Container Platform cluster.

#### Procedure

1. Create a project to host the shared VPC for your OpenShift Container Platform cluster. See [Creating and Managing Projects](#) in the GCP documentation.
2. Create a service account in the project that hosts your shared VPC. See [Creating a service account](#) in the GCP documentation.
3. Grant the service account the appropriate permissions. You can either grant the individual permissions that follow or assign the **Owner** role to it. See [Granting roles to a service account for specific resources](#).



## NOTE

While making the service account an owner of the project is the easiest way to gain the required permissions, it means that service account has complete control over the project. You must determine if the risk that comes from offering that power is acceptable.

The service account for the project that hosts the shared VPC network requires the following roles:

- Compute Network User
- Compute Security Admin
- Deployment Manager Editor
- DNS Administrator
- Security Admin
- Network Management Admin

### 7.11.6.1. Configuring DNS for GCP

To install OpenShift Container Platform, the Google Cloud Platform (GCP) account you use must have a dedicated public hosted zone in the project that hosts the shared VPC that you install the cluster into. This zone must be authoritative for the domain. The DNS service provides cluster DNS resolution and name lookup for external connections to the cluster.

#### Procedure

1. Identify your domain, or subdomain, and registrar. You can transfer an existing domain and registrar or obtain a new one through GCP or another source.



## NOTE

If you purchase a new domain, it can take time for the relevant DNS changes to propagate. For more information about purchasing domains through Google, see [Google Domains](#).

2. Create a public hosted zone for your domain or subdomain in your GCP project. See [Creating public zones](#) in the GCP documentation. Use an appropriate root domain, such as **openshiftcorp.com**, or subdomain, such as **clusters.openshiftcorp.com**.
3. Extract the new authoritative name servers from the hosted zone records. See [Look up your Cloud DNS name servers](#) in the GCP documentation. You typically have four name servers.
4. Update the registrar records for the name servers that your domain uses. For example, if you registered your domain to Google Domains, see the following topic in the Google Domains Help: [How to switch to custom name servers](#).
5. If you migrated your root domain to Google Cloud DNS, migrate your DNS records. See [Migrating to Cloud DNS](#) in the GCP documentation.

6. If you use a subdomain, follow your company's procedures to add its delegation records to the parent domain. This process might include a request to your company's IT department or the division that controls the root domain and DNS services for your company.

### 7.11.6.2. Creating a VPC in GCP

You must create a VPC in Google Cloud Platform (GCP) for your OpenShift Container Platform cluster to use. You can customize the VPC to meet your requirements. One way to create the VPC is to modify the provided Deployment Manager template.



#### NOTE

If you do not use the provided Deployment Manager template to create your GCP infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

#### Prerequisites

- Configure a GCP account.

#### Procedure

1. Copy the template from the **Deployment Manager template for the VPC** section of this topic and save it as **01\_vpc.py** on your computer. This template describes the VPC that your cluster requires.
2. Export the following variables required by the resource definition:

- a. Export the control plane CIDR:

```
$ export MASTER_SUBNET_CIDR='10.0.0.0/17'
```

- b. Export the compute CIDR:

```
$ export WORKER_SUBNET_CIDR='10.0.128.0/17'
```

- c. Export the region to deploy the VPC network and cluster to:

```
$ export REGION='<region>'
```

3. Export the variable for the ID of the project that hosts the shared VPC:

```
$ export HOST_PROJECT=<host_project>
```

4. Export the variable for the email of the service account that belongs to host project:

```
$ export HOST_PROJECT_ACCOUNT=<host_service_account_email>
```

5. Create a **01\_vpc.yaml** resource definition file:

```
$ cat <<EOF >01_vpc.yaml
imports:
```



```

- path: 01_vpc.py

resources:
- name: cluster-vpc
  type: 01_vpc.py
  properties:
    infra_id: '<prefix>' ❶
    region: '${REGION}' ❷
    master_subnet_cidr: '${MASTER_SUBNET_CIDR}' ❸
    worker_subnet_cidr: '${WORKER_SUBNET_CIDR}' ❹
EOF

```

- ❶ **infra\_id** is the prefix of the network name.
- ❷ **region** is the region to deploy the cluster into, for example **us-central1**.
- ❸ **master\_subnet\_cidr** is the CIDR for the master subnet, for example **10.0.0.0/17**.
- ❹ **worker\_subnet\_cidr** is the CIDR for the worker subnet, for example **10.0.128.0/17**.

6. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create <vpc_deployment_name> --config
01_vpc.yaml --project ${HOST_PROJECT} --account ${HOST_PROJECT_ACCOUNT} ❶
```

- ❶ For **<vpc\_deployment\_name>**, specify the name of the VPC to deploy.

7. Export the VPC variable that other components require:

a. Export the name of the host project network:

```
$ export HOST_PROJECT_NETWORK=<vpc_network>
```

b. Export the name of the host project control plane subnet:

```
$ export HOST_PROJECT_CONTROL_SUBNET=<control_plane_subnet>
```

c. Export the name of the host project compute subnet:

```
$ export HOST_PROJECT_COMPUTE_SUBNET=<compute_subnet>
```

8. Set up the shared VPC. See [Setting up Shared VPC](#) in the GCP documentation.

#### 7.11.6.2.1. Deployment Manager template for the VPC

You can use the following Deployment Manager template to deploy the VPC that you need for your OpenShift Container Platform cluster:

##### Example 7.10. 01\_vpc.py Deployment Manager template

```
def GenerateConfig(context):
```

```

resources = [{
  'name': context.properties['infra_id'] + '-network',
  'type': 'compute.v1.network',
  'properties': {
    'region': context.properties['region'],
    'autoCreateSubnetworks': False
  }
}, {
  'name': context.properties['infra_id'] + '-master-subnet',
  'type': 'compute.v1.subnetwork',
  'properties': {
    'region': context.properties['region'],
    'network': '$(ref.' + context.properties['infra_id'] + '-network.selfLink)',
    'ipCidrRange': context.properties['master_subnet_cidr']
  }
}, {
  'name': context.properties['infra_id'] + '-worker-subnet',
  'type': 'compute.v1.subnetwork',
  'properties': {
    'region': context.properties['region'],
    'network': '$(ref.' + context.properties['infra_id'] + '-network.selfLink)',
    'ipCidrRange': context.properties['worker_subnet_cidr']
  }
}, {
  'name': context.properties['infra_id'] + '-router',
  'type': 'compute.v1.router',
  'properties': {
    'region': context.properties['region'],
    'network': '$(ref.' + context.properties['infra_id'] + '-network.selfLink)',
    'nats': [{
      'name': context.properties['infra_id'] + '-nat-master',
      'natIpAllocateOption': 'AUTO_ONLY',
      'minPortsPerVm': 7168,
      'sourceSubnetworkIpRangesToNat': 'LIST_OF_SUBNETWORKS',
      'subnetworks': [{
        'name': '$(ref.' + context.properties['infra_id'] + '-master-subnet.selfLink)',
        'sourceIpRangesToNat': ['ALL_IP_RANGES']
      }]
    }]
  }
}, {
  'name': context.properties['infra_id'] + '-nat-worker',
  'natIpAllocateOption': 'AUTO_ONLY',
  'minPortsPerVm': 512,
  'sourceSubnetworkIpRangesToNat': 'LIST_OF_SUBNETWORKS',
  'subnetworks': [{
    'name': '$(ref.' + context.properties['infra_id'] + '-worker-subnet.selfLink)',
    'sourceIpRangesToNat': ['ALL_IP_RANGES']
  }]
}]
}
]

return {'resources': resources}

```

### 7.11.7. Creating the installation files for GCP

To install OpenShift Container Platform on Google Cloud Platform (GCP) using user-provisioned infrastructure, you must generate the files that the installation program needs to deploy your cluster and modify them so that the cluster creates only the machines that it will use. You generate and customize the **install-config.yaml** file, Kubernetes manifests, and Ignition config files. You also have the option to first set up a separate **var** partition during the preparation phases of installation.

### 7.11.7.1. Manually creating the installation configuration file

For user-provisioned installations of OpenShift Container Platform, you manually generate your installation configuration file.

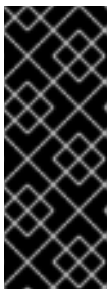
#### Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

#### Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```



#### IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation\_directory>**.



#### NOTE

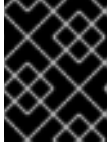
You must name this configuration file **install-config.yaml**.



#### NOTE

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation\_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

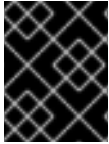
3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

**IMPORTANT**

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

**7.11.7.2. Sample customized install-config.yaml file for GCP**

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

**IMPORTANT**

This sample YAML file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program and modify it.

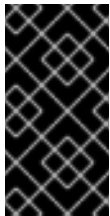
```

apiVersion: v1
baseDomain: example.com 1
controlPlane: 2
  hyperthreading: Enabled 3 4
  name: master
  platform:
    gcp:
      type: n2-standard-4
      zones:
        - us-central1-a
        - us-central1-c
  replicas: 3
compute: 5
- hyperthreading: Enabled 6
  name: worker
  platform:
    gcp:
      type: n2-standard-4
      zones:
        - us-central1-a
        - us-central1-c
  replicas: 0
metadata:
  name: test-cluster
networking:
  clusterNetwork:
    - cidr: 10.128.0.0/14
      hostPrefix: 23
  machineNetwork:
    - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
    - 172.30.0.0/16
platform:
  gcp:
    projectID: openshift-production 7
    region: us-central1 8
pullSecret: '{"auths": ...}'

```

```
fips: false 9
sshKey: ssh-ed25519 AAAA... 10
publish: Internal 11
```

- 1** Specify the public DNS on the host project.
- 2** **5** If you do not provide these parameters and values, the installation program provides the default value.
- 3** **6** The **controlPlane** section is a single mapping, but the compute section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. Although both sections currently define a single machine pool, it is possible that future versions of OpenShift Container Platform will support defining multiple compute pools during installation. Only one control plane pool is used.
- 4** Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.



### IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Use larger machine types, such as **n1-standard-8**, for your machines if you disable simultaneous multithreading.

- 7** Specify the main project where the VM instances reside.
- 8** Specify the region that your VPC network is in.
- 9** Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.



### IMPORTANT

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

- 10** You can optionally provide the **sshKey** value that you use to access the machines in your cluster.



### NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

- 11** How to publish the user-facing endpoints of your cluster. Set **publish** to **Internal** to deploy a private cluster, which cannot be accessed from the internet. The default value is **External**. To use a shared VPC in a cluster that uses infrastructure that you provision, you must set **publish** to

**Internal.** The installation program will no longer be able to access the public DNS zone for the base domain in the host project.

### 7.11.7.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

#### Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



#### NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

#### Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
  additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
  ...
```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations.

- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide



#### NOTE

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



#### NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

#### 7.11.7.4. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.



#### IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

#### Prerequisites

- You obtained the OpenShift Container Platform installation program.
- You created the **install-config.yaml** installation configuration file.

#### Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

- 1 For **<installation\_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

2. Remove the Kubernetes manifest files that define the control plane machines:

```
$ rm -f <installation_directory>/openshift/99_openshift-cluster-api_master-machines-*.yaml
```

By removing these files, you prevent the cluster from automatically generating control plane machines.

3. Remove the Kubernetes manifest files that define the worker machines:

```
$ rm -f <installation_directory>/openshift/99_openshift-cluster-api_worker-machineset-*.yaml
```

Because you create and manage the worker machines yourself, you do not need to initialize these machines.

4. Check that the **mastersSchedulable** parameter in the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:

- a. Open the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** file.
- b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.
- c. Save and exit the file.

5. Remove the **privateZone** sections from the **<installation\_directory>/manifests/cluster-dns-02-config.yml** DNS configuration file:

```
apiVersion: config.openshift.io/v1
kind: DNS
metadata:
  creationTimestamp: null
  name: cluster
spec:
  baseDomain: example.openshift.com
  privateZone: 1
  id: mycluster-100419-private-zone
status: {}
```

- 1 Remove this section completely.

6. Configure the cloud provider for your VPC.

- a. Open the **<installation\_directory>/manifests/cloud-provider-config.yaml** file.
- b. Add the **network-project-id** parameter and set its value to the ID of project that hosts the shared VPC network.



- c. Add the **network-name** parameter and set its value to the name of the shared VPC network that hosts the OpenShift Container Platform cluster.
- d. Replace the value of the **subnet-name** parameter with the value of the shared VPC subnet that hosts your compute machines.

The contents of the `<installation_directory>/manifests/cloud-provider-config.yaml` resemble the following example:

```
config: |+
  [global]
  project-id      = example-project
  regional       = true
  multizone      = true
  node-tags      = opensh-ptzxx-master
  node-tags      = opensh-ptzxx-worker
  node-instance-prefix = opensh-ptzxx
  external-instance-groups-prefix = opensh-ptzxx
  network-project-id = example-shared-vpc
  network-name    = example-network
  subnet-name     = example-worker-subnet
```

7. If you deploy a cluster that is not on a private network, open the `<installation_directory>/manifests/cluster-ingress-default-ingresscontroller.yaml` file and replace the value of the **scope** parameter with **External**. The contents of the file resemble the following example:

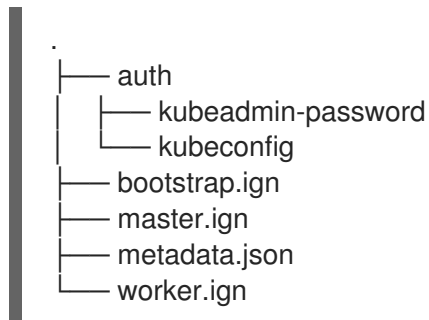
```
apiVersion: operator.openshift.io/v1
kind: IngressController
metadata:
  creationTimestamp: null
  name: default
  namespace: openshift-ingress-operator
spec:
  endpointPublishingStrategy:
    loadBalancer:
      scope: External
      type: LoadBalancerService
status:
  availableReplicas: 0
  domain: ""
  selector: ""
```

8. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

- 1** For `<installation_directory>`, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the `./<installation_directory>/auth` directory:



## 7.11.8. Exporting common variables

### 7.11.8.1. Extracting the infrastructure name

The Ignition config files contain a unique cluster identifier that you can use to uniquely identify your cluster in Google Cloud Platform (GCP). The infrastructure name is also used to locate the appropriate GCP resources during an OpenShift Container Platform installation. The provided Deployment Manager templates contain references to this infrastructure name, so you must extract it.

#### Prerequisites

- You obtained the OpenShift Container Platform installation program and the pull secret for your cluster.
- You generated the Ignition config files for your cluster.
- You installed the **jq** package.

#### Procedure

- To extract and view the infrastructure name from the Ignition config file metadata, run the following command:

```
$ jq -r .infraID <installation_directory>/metadata.json 1
```

- 1 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

#### Example output

```
openshift-vw9j6 1
```

- 1 The output of this command is your cluster name and a random string.

### 7.11.8.2. Exporting common variables for Deployment Manager templates

You must export a common set of variables that are used with the provided Deployment Manager templates used to assist in completing a user-provided infrastructure install on Google Cloud Platform (GCP).



## NOTE

Specific Deployment Manager templates can also require additional exported variables, which are detailed in their related procedures.

### Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Generate the Ignition config files for your cluster.
- Install the **jq** package.

### Procedure

1. Export the following common variables to be used by the provided Deployment Manager templates:

```
$ export BASE_DOMAIN='<base_domain>' 1
$ export BASE_DOMAIN_ZONE_NAME='<base_domain_zone_name>' 2
$ export NETWORK_CIDR='10.0.0.0/16'

$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 3
$ export CLUSTER_NAME=`jq -r .clusterName <installation_directory>/metadata.json`
$ export INFRA_ID=`jq -r .infraID <installation_directory>/metadata.json`
$ export PROJECT_NAME=`jq -r .gcp.projectID <installation_directory>/metadata.json`
```

- 1 2 Supply the values for the host project.

- 3 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

## 7.11.9. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

### 7.11.9.1. Setting the cluster node hostnames through DHCP

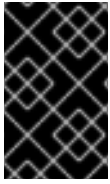
On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

### 7.11.9.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.



### IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

**Table 7.48. Ports used for all-machine to all-machine communications**

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	<b>1936</b>	Metrics
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> and the Cluster Version Operator on port <b>9099</b> .
	<b>10250-10259</b>	The default ports that Kubernetes reserves
	<b>10256</b>	openshift-sdn
UDP	<b>4789</b>	VXLAN and Geneve
	<b>6081</b>	VXLAN and Geneve
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> .
	<b>500</b>	IPsec IKE packets
	<b>4500</b>	IPsec NAT-T packets
TCP/UDP	<b>30000-32767</b>	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

**Table 7.49. Ports used for all-machine to control plane communications**

Protocol	Port	Description
TCP	<b>6443</b>	Kubernetes API

**Table 7.50. Ports used for control plane machine to control plane machine communications**

Protocol	Port	Description
TCP	<b>2379-2380</b>	etcd server and peer ports

### 7.11.10. Creating load balancers in GCP

You must configure load balancers in Google Cloud Platform (GCP) for your OpenShift Container Platform cluster to use. One way to create these components is to modify the provided Deployment Manager template.



#### NOTE

If you do not use the provided Deployment Manager template to create your GCP infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

#### Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.

#### Procedure

1. Copy the template from the **Deployment Manager template for the internal load balancer** section of this topic and save it as **02\_lb\_int.py** on your computer. This template describes the internal load balancing objects that your cluster requires.
2. For an external cluster, also copy the template from the **Deployment Manager template for the external load balancer** section of this topic and save it as **02\_lb\_ext.py** on your computer. This template describes the external load balancing objects that your cluster requires.
3. Export the variables that the deployment template uses:
  - a. Export the cluster network location:

```
$ export CLUSTER_NETWORK=(`gcloud compute networks describe
${HOST_PROJECT_NETWORK} --project ${HOST_PROJECT} --account
${HOST_PROJECT_ACCOUNT} --format json | jq -r .selfLink`)
```

- b. Export the control plane subnet location:

```
$ export CONTROL_SUBNET=(`gcloud compute networks subnets describe
${HOST_PROJECT_CONTROL_SUBNET} --region=${REGION} --project
${HOST_PROJECT} --account ${HOST_PROJECT_ACCOUNT} --format json | jq -r
.selfLink`)
```

- c. Export the three zones that the cluster uses:

```
$ export ZONE_0=(`gcloud compute regions describe ${REGION} --format=json | jq -r
.zones[0] | cut -d "/" -f9`)
```

```
$ export ZONE_1=(`gcloud compute regions describe ${REGION} --format=json | jq -r
.zones[1] | cut -d "/" -f9`)
```

```
$ export ZONE_2=(`gcloud compute regions describe ${REGION} --format=json | jq -r
.zones[2] | cut -d "/" -f9`)
```

4. Create a **02\_infra.yaml** resource definition file:

```
$ cat <<EOF >02_infra.yaml
imports:
- path: 02_lb_ext.py
- path: 02_lb_int.py 1
resources:
- name: cluster-lb-ext 2
  type: 02_lb_ext.py
  properties:
    infra_id: '${INFRA_ID}' 3
    region: '${REGION}' 4
- name: cluster-lb-int
  type: 02_lb_int.py
  properties:
    cluster_network: '${CLUSTER_NETWORK}'
    control_subnet: '${CONTROL_SUBNET}' 5
    infra_id: '${INFRA_ID}'
    region: '${REGION}'
    zones: 6
    - '${ZONE_0}'
    - '${ZONE_1}'
    - '${ZONE_2}'
EOF
```

1 2 Required only when deploying an external cluster.

3 **infra\_id** is the **INFRA\_ID** infrastructure name from the extraction step.

4 **region** is the region to deploy the cluster into, for example **us-central1**.

5 **control\_subnet** is the URI to the control subnet.

6 **zones** are the zones to deploy the control plane instances into, like **us-east1-b**, **us-east1-c**, and **us-east1-d**.

5. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-infra --config 02_infra.yaml
```

6. Export the cluster IP address:

```
$ export CLUSTER_IP=(`gcloud compute addresses describe ${INFRA_ID}-cluster-ip --
region=${REGION} --format json | jq -r .address`)
```

7. For an external cluster, also export the cluster public IP address:

```
$ export CLUSTER_PUBLIC_IP=(`gcloud compute addresses describe ${INFRA_ID}-cluster-
public-ip --region=${REGION} --format json | jq -r .address`)
```

### 7.11.10.1. Deployment Manager template for the external load balancer

You can use the following Deployment Manager template to deploy the external load balancer that you need for your OpenShift Container Platform cluster:

#### Example 7.11. 02\_lb\_ext.py Deployment Manager template

```
def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-cluster-public-ip',
        'type': 'compute.v1.address',
        'properties': {
            'region': context.properties['region']
        }
    }, {
        # Refer to docs/dev/kube-apiserver-health-check.md on how to correctly setup health check
        # probe for kube-apiserver
        'name': context.properties['infra_id'] + '-api-http-health-check',
        'type': 'compute.v1.httpHealthCheck',
        'properties': {
            'port': 6080,
            'requestPath': '/readyz'
        }
    }, {
        'name': context.properties['infra_id'] + '-api-target-pool',
        'type': 'compute.v1.targetPool',
        'properties': {
            'region': context.properties['region'],
            'healthChecks': ['$$(ref.' + context.properties['infra_id'] + '-api-http-health-check.selfLink)'],
            'instances': []
        }
    }, {
        'name': context.properties['infra_id'] + '-api-forwarding-rule',
        'type': 'compute.v1.forwardingRule',
        'properties': {
            'region': context.properties['region'],
            'IPAddress': '$(ref.' + context.properties['infra_id'] + '-cluster-public-ip.selfLink)',
            'target': '$(ref.' + context.properties['infra_id'] + '-api-target-pool.selfLink)',
            'portRange': '6443'
        }
    }
    ]

    return {'resources': resources}
```

### 7.11.10.2. Deployment Manager template for the internal load balancer

You can use the following Deployment Manager template to deploy the internal load balancer that you need for your OpenShift Container Platform cluster:

#### Example 7.12. 02\_lb\_int.py Deployment Manager template

```
def GenerateConfig(context):

    backends = []
    for zone in context.properties['zones']:
        backends.append({
            'group': '${ref.' + context.properties['infra_id'] + '-master-' + zone + '-instance-group' +
            '.selfLink}'
        })

    resources = [{
        'name': context.properties['infra_id'] + '-cluster-ip',
        'type': 'compute.v1.address',
        'properties': {
            'addressType': 'INTERNAL',
            'region': context.properties['region'],
            'subnetwork': context.properties['control_subnet']
        }
    }, {
        # Refer to docs/dev/kube-apiserver-health-check.md on how to correctly setup health check
        # probe for kube-apiserver
        'name': context.properties['infra_id'] + '-api-internal-health-check',
        'type': 'compute.v1.healthCheck',
        'properties': {
            'httpsHealthCheck': {
                'port': 6443,
                'requestPath': '/readyz'
            },
            'type': "HTTPS"
        }
    }, {
        'name': context.properties['infra_id'] + '-api-internal-backend-service',
        'type': 'compute.v1.regionBackendService',
        'properties': {
            'backends': backends,
            'healthChecks': ['${ref.' + context.properties['infra_id'] + '-api-internal-health-
            check.selfLink}'],
            'loadBalancingScheme': 'INTERNAL',
            'region': context.properties['region'],
            'protocol': 'TCP',
            'timeoutSec': 120
        }
    }, {
        'name': context.properties['infra_id'] + '-api-internal-forwarding-rule',
        'type': 'compute.v1.forwardingRule',
        'properties': {
            'backendService': '${ref.' + context.properties['infra_id'] + '-api-internal-backend-
            service.selfLink}',
            'IPAddress': '${ref.' + context.properties['infra_id'] + '-cluster-ip.selfLink}',
            'loadBalancingScheme': 'INTERNAL',
```



```

        'ports': ['6443', '22623'],
        'region': context.properties['region'],
        'subnetwork': context.properties['control_subnet']
    }
}]]

for zone in context.properties['zones']:
    resources.append({
        'name': context.properties['infra_id'] + '-master-' + zone + '-instance-group',
        'type': 'compute.v1.instanceGroup',
        'properties': {
            'namedPorts': [
                {
                    'name': 'ignition',
                    'port': 22623
                }, {
                    'name': 'https',
                    'port': 6443
                }
            ],
            'network': context.properties['cluster_network'],
            'zone': zone
        }
    })

return {'resources': resources}

```

You will need this template in addition to the **02\_lb\_ext.py** template when you create an external cluster.

### 7.11.11. Creating a private DNS zone in GCP

You must configure a private DNS zone in Google Cloud Platform (GCP) for your OpenShift Container Platform cluster to use. One way to create this component is to modify the provided Deployment Manager template.



#### NOTE

If you do not use the provided Deployment Manager template to create your GCP infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

#### Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.

#### Procedure

1. Copy the template from the **Deployment Manager template for the private DNS** section of this topic and save it as **02\_dns.py** on your computer. This template describes the private DNS objects that your cluster requires.
2. Create a **02\_dns.yaml** resource definition file:

```
$ cat <<EOF >02_dns.yaml
imports:
- path: 02_dns.py

resources:
- name: cluster-dns
  type: 02_dns.py
  properties:
    infra_id: '${INFRA_ID}' ❶
    cluster_domain: '${CLUSTER_NAME}.${BASE_DOMAIN}' ❷
    cluster_network: '${CLUSTER_NETWORK}' ❸
EOF
```

- ❶ **infra\_id** is the **INFRA\_ID** infrastructure name from the extraction step.
- ❷ **cluster\_domain** is the domain for the cluster, for example **openshift.example.com**.
- ❸ **cluster\_network** is the **selfLink** URL to the cluster network.

3. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-dns --config 02_dns.yaml --
project ${HOST_PROJECT} --account ${HOST_PROJECT_ACCOUNT}
```

4. The templates do not create DNS entries due to limitations of Deployment Manager, so you must create them manually:
  - a. Add the internal DNS entries:

```
$ if [ -f transaction.yaml ]; then rm transaction.yaml; fi
$ gcloud dns record-sets transaction start --zone ${INFRA_ID}-private-zone --project
${HOST_PROJECT} --account ${HOST_PROJECT_ACCOUNT}
$ gcloud dns record-sets transaction add ${CLUSTER_IP} --name
api.${CLUSTER_NAME}.${BASE_DOMAIN}. --ttl 60 --type A --zone ${INFRA_ID}-
private-zone --project ${HOST_PROJECT} --account ${HOST_PROJECT_ACCOUNT}
$ gcloud dns record-sets transaction add ${CLUSTER_IP} --name api-
int.${CLUSTER_NAME}.${BASE_DOMAIN}. --ttl 60 --type A --zone ${INFRA_ID}-
private-zone --project ${HOST_PROJECT} --account ${HOST_PROJECT_ACCOUNT}
$ gcloud dns record-sets transaction execute --zone ${INFRA_ID}-private-zone --project
${HOST_PROJECT} --account ${HOST_PROJECT_ACCOUNT}
```

- b. For an external cluster, also add the external DNS entries:

```
$ if [ -f transaction.yaml ]; then rm transaction.yaml; fi
$ gcloud --account=${HOST_PROJECT_ACCOUNT} --project=${HOST_PROJECT} dns
record-sets transaction start --zone ${BASE_DOMAIN_ZONE_NAME}
$ gcloud --account=${HOST_PROJECT_ACCOUNT} --project=${HOST_PROJECT} dns
record-sets transaction add ${CLUSTER_PUBLIC_IP} --name
```

```
api.${CLUSTER_NAME}.${BASE_DOMAIN}. --ttl 60 --type A --zone
${BASE_DOMAIN_ZONE_NAME}
$ gcloud --account=${HOST_PROJECT_ACCOUNT} --project=${HOST_PROJECT} dns
record-sets transaction execute --zone ${BASE_DOMAIN_ZONE_NAME}
```

### 7.11.11.1. Deployment Manager template for the private DNS

You can use the following Deployment Manager template to deploy the private DNS that you need for your OpenShift Container Platform cluster:

#### Example 7.13. `02_dns.py` Deployment Manager template

```
def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-private-zone',
        'type': 'dns.v1.managedZone',
        'properties': {
            'description': '',
            'dnsName': context.properties['cluster_domain'] + '.',
            'visibility': 'private',
            'privateVisibilityConfig': {
                'networks': [{
                    'networkUrl': context.properties['cluster_network']
                }]
            }
        }
    }]

    return {'resources': resources}
```

### 7.11.12. Creating firewall rules in GCP

You must create firewall rules in Google Cloud Platform (GCP) for your OpenShift Container Platform cluster to use. One way to create these components is to modify the provided Deployment Manager template.



#### NOTE

If you do not use the provided Deployment Manager template to create your GCP infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

#### Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.

## Procedure

1. Copy the template from the **Deployment Manager template for firewall rules** section of this topic and save it as **03\_firewall.py** on your computer. This template describes the security groups that your cluster requires.
2. Create a **03\_firewall.yaml** resource definition file:

```
$ cat <<EOF >03_firewall.yaml
imports:
- path: 03_firewall.py

resources:
- name: cluster-firewall
  type: 03_firewall.py
  properties:
    allowed_external_cidr: '0.0.0.0/0' 1
    infra_id: '${INFRA_ID}' 2
    cluster_network: '${CLUSTER_NETWORK}' 3
    network_cidr: '${NETWORK_CIDR}' 4
EOF
```

- 1** **allowed\_external\_cidr** is the CIDR range that can access the cluster API and SSH to the bootstrap host. For an internal cluster, set this value to **\${NETWORK\_CIDR}**.
- 2** **infra\_id** is the **INFRA\_ID** infrastructure name from the extraction step.
- 3** **cluster\_network** is the **selfLink** URL to the cluster network.
- 4** **network\_cidr** is the CIDR of the VPC network, for example **10.0.0.0/16**.

3. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-firewall --config
03_firewall.yaml --project ${HOST_PROJECT} --account ${HOST_PROJECT_ACCOUNT}
```

### 7.11.12.1. Deployment Manager template for firewall rules

You can use the following Deployment Manager template to deploy the firewall rules that you need for your OpenShift Container Platform cluster:

#### Example 7.14. 03\_firewall.py Deployment Manager template

```
def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-bootstrap-in-ssh',
        'type': 'compute.v1.firewall',
        'properties': {
            'network': context.properties['cluster_network'],
            'allowed': [{
                'IPProtocol': 'tcp',
                'ports': ['22']
            }],
        }
    ]
```

```

    'sourceRanges': [context.properties['allowed_external_cidr']],
    'targetTags': [context.properties['infra_id'] + '-bootstrap']
  }
}, {
  'name': context.properties['infra_id'] + '-api',
  'type': 'compute.v1.firewall',
  'properties': {
    'network': context.properties['cluster_network'],
    'allowed': [{
      'IPProtocol': 'tcp',
      'ports': ['6443']
    }],
    'sourceRanges': [context.properties['allowed_external_cidr']],
    'targetTags': [context.properties['infra_id'] + '-master']
  }
}, {
  'name': context.properties['infra_id'] + '-health-checks',
  'type': 'compute.v1.firewall',
  'properties': {
    'network': context.properties['cluster_network'],
    'allowed': [{
      'IPProtocol': 'tcp',
      'ports': ['6080', '6443', '22624']
    }],
    'sourceRanges': ['35.191.0.0/16', '130.211.0.0/22', '209.85.152.0/22', '209.85.204.0/22'],
    'targetTags': [context.properties['infra_id'] + '-master']
  }
}, {
  'name': context.properties['infra_id'] + '-etcd',
  'type': 'compute.v1.firewall',
  'properties': {
    'network': context.properties['cluster_network'],
    'allowed': [{
      'IPProtocol': 'tcp',
      'ports': ['2379-2380']
    }],
    'sourceTags': [context.properties['infra_id'] + '-master'],
    'targetTags': [context.properties['infra_id'] + '-master']
  }
}, {
  'name': context.properties['infra_id'] + '-control-plane',
  'type': 'compute.v1.firewall',
  'properties': {
    'network': context.properties['cluster_network'],
    'allowed': [{
      'IPProtocol': 'tcp',
      'ports': ['10257']
    }],
    {
      'IPProtocol': 'tcp',
      'ports': ['10259']
    },
    {
      'IPProtocol': 'tcp',
      'ports': ['22623']
    }
  ],
  'sourceTags': [
    context.properties['infra_id'] + '-master',

```

```

        context.properties['infra_id'] + '-worker'
    ],
    'targetTags': [context.properties['infra_id'] + '-master']
  }
}, {
  'name': context.properties['infra_id'] + '-internal-network',
  'type': 'compute.v1.firewall',
  'properties': {
    'network': context.properties['cluster_network'],
    'allowed': [{
      'IPProtocol': 'icmp'
    }, {
      'IPProtocol': 'tcp',
      'ports': ['22']
    }],
    'sourceRanges': [context.properties['network_cidr']],
    'targetTags': [
      context.properties['infra_id'] + '-master',
      context.properties['infra_id'] + '-worker'
    ]
  }
}, {
  'name': context.properties['infra_id'] + '-internal-cluster',
  'type': 'compute.v1.firewall',
  'properties': {
    'network': context.properties['cluster_network'],
    'allowed': [{
      'IPProtocol': 'udp',
      'ports': ['4789', '6081']
    }, {
      'IPProtocol': 'udp',
      'ports': ['500', '4500']
    }, {
      'IPProtocol': 'esp',
    }, {
      'IPProtocol': 'tcp',
      'ports': ['9000-9999']
    }, {
      'IPProtocol': 'udp',
      'ports': ['9000-9999']
    }, {
      'IPProtocol': 'tcp',
      'ports': ['10250']
    }, {
      'IPProtocol': 'tcp',
      'ports': ['30000-32767']
    }, {
      'IPProtocol': 'udp',
      'ports': ['30000-32767']
    }],
    'sourceTags': [
      context.properties['infra_id'] + '-master',
      context.properties['infra_id'] + '-worker'
    ],
    'targetTags': [
      context.properties['infra_id'] + '-master',

```

```

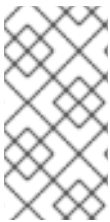
        context.properties['infra_id'] + '-worker'
    ]
}
}}

return {'resources': resources}

```

### 7.11.13. Creating IAM roles in GCP

You must create IAM roles in Google Cloud Platform (GCP) for your OpenShift Container Platform cluster to use. One way to create these components is to modify the provided Deployment Manager template.



#### NOTE

If you do not use the provided Deployment Manager template to create your GCP infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

#### Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.

#### Procedure

1. Copy the template from the **Deployment Manager template for IAM roles** section of this topic and save it as **03\_iam.py** on your computer. This template describes the IAM roles that your cluster requires.
2. Create a **03\_iam.yaml** resource definition file:

```

$ cat <<EOF >03_iam.yaml
imports:
- path: 03_iam.py
resources:
- name: cluster-iam
  type: 03_iam.py
  properties:
    infra_id: '${INFRA_ID}' 1
EOF

```

- 1** **infra\_id** is the **INFRA\_ID** infrastructure name from the extraction step.

3. Create the deployment by using the **gcloud** CLI:

```

$ gcloud deployment-manager deployments create ${INFRA_ID}-iam --config 03_iam.yaml

```

4. Export the variable for the master service account:

```
$ export MASTER_SERVICE_ACCOUNT=$(gcloud iam service-accounts list --filter "email~^${INFRA_ID}-m@${PROJECT_NAME}." --format json | jq -r '[0].email')
```

5. Export the variable for the worker service account:

```
$ export WORKER_SERVICE_ACCOUNT=$(gcloud iam service-accounts list --filter "email~^${INFRA_ID}-w@${PROJECT_NAME}." --format json | jq -r '[0].email')
```

6. Assign the permissions that the installation program requires to the service accounts for the subnets that host the control plane and compute subnets:

- a. Grant the **networkViewer** role of the project that hosts your shared VPC to the master service account:

```
$ gcloud --account=${HOST_PROJECT_ACCOUNT} --project=${HOST_PROJECT} projects add-iam-policy-binding ${HOST_PROJECT} --member "serviceAccount:${MASTER_SERVICE_ACCOUNT}" --role "roles/compute.networkViewer"
```

- b. Grant the **networkUser** role to the master service account for the control plane subnet:

```
$ gcloud --account=${HOST_PROJECT_ACCOUNT} --project=${HOST_PROJECT} compute networks subnets add-iam-policy-binding "${HOST_PROJECT_CONTROL_SUBNET}" --member "serviceAccount:${MASTER_SERVICE_ACCOUNT}" --role "roles/compute.networkUser" --region ${REGION}
```

- c. Grant the **networkUser** role to the worker service account for the control plane subnet:

```
$ gcloud --account=${HOST_PROJECT_ACCOUNT} --project=${HOST_PROJECT} compute networks subnets add-iam-policy-binding "${HOST_PROJECT_CONTROL_SUBNET}" --member "serviceAccount:${WORKER_SERVICE_ACCOUNT}" --role "roles/compute.networkUser" --region ${REGION}
```

- d. Grant the **networkUser** role to the master service account for the compute subnet:

```
$ gcloud --account=${HOST_PROJECT_ACCOUNT} --project=${HOST_PROJECT} compute networks subnets add-iam-policy-binding "${HOST_PROJECT_COMPUTE_SUBNET}" --member "serviceAccount:${MASTER_SERVICE_ACCOUNT}" --role "roles/compute.networkUser" --region ${REGION}
```

- e. Grant the **networkUser** role to the worker service account for the compute subnet:

```
$ gcloud --account=${HOST_PROJECT_ACCOUNT} --project=${HOST_PROJECT} compute networks subnets add-iam-policy-binding "${HOST_PROJECT_COMPUTE_SUBNET}" --member "serviceAccount:${WORKER_SERVICE_ACCOUNT}" --role "roles/compute.networkUser" --region ${REGION}
```



- The templates do not create the policy bindings due to limitations of Deployment Manager, so you must create them manually:

```
$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${MASTER_SERVICE_ACCOUNT}" --role "roles/compute.instanceAdmin"
$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${MASTER_SERVICE_ACCOUNT}" --role "roles/compute.networkAdmin"
$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${MASTER_SERVICE_ACCOUNT}" --role "roles/compute.securityAdmin"
$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${MASTER_SERVICE_ACCOUNT}" --role "roles/iam.serviceAccountUser"
$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${MASTER_SERVICE_ACCOUNT}" --role "roles/storage.admin"

$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${WORKER_SERVICE_ACCOUNT}" --role "roles/compute.viewer"
$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${WORKER_SERVICE_ACCOUNT}" --role "roles/storage.admin"
```

- Create a service account key and store it locally for later use:

```
$ gcloud iam service-accounts keys create service-account-key.json --iam-
account=${MASTER_SERVICE_ACCOUNT}
```

### 7.11.13.1. Deployment Manager template for IAM roles

You can use the following Deployment Manager template to deploy the IAM roles that you need for your OpenShift Container Platform cluster:

#### Example 7.15. `03_iam.py` Deployment Manager template

```
def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-master-node-sa',
        'type': 'iam.v1.serviceAccount',
        'properties': {
            'accountId': context.properties['infra_id'] + '-m',
            'displayName': context.properties['infra_id'] + '-master-node'
        }
    }, {
        'name': context.properties['infra_id'] + '-worker-node-sa',
        'type': 'iam.v1.serviceAccount',
        'properties': {
            'accountId': context.properties['infra_id'] + '-w',
            'displayName': context.properties['infra_id'] + '-worker-node'
        }
    }
    ]

    return {'resources': resources}
```

### 7.11.14. Creating the RHCOS cluster image for the GCP infrastructure

You must use a valid Red Hat Enterprise Linux CoreOS (RHCOS) image for Google Cloud Platform (GCP) for your OpenShift Container Platform nodes.

## Procedure

1. Obtain the RHCOS image from the [RHCOS image mirror](#) page.



### IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download an image with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image version that matches your OpenShift Container Platform version if it is available.

The file name contains the OpenShift Container Platform version number in the format **rhcos-  
<version>-<arch>-gcp.<arch>.tar.gz**.

2. Create the Google storage bucket:

```
$ gsutil mb gs://<bucket_name>
```

3. Upload the RHCOS image to the Google storage bucket:

```
$ gsutil cp <downloaded_image_file_path>/rhcos-<version>-x86_64-gcp.x86_64.tar.gz  
gs://<bucket_name>
```

4. Export the uploaded RHCOS image location as a variable:

```
$ export IMAGE_SOURCE=gs://<bucket_name>/rhcos-<version>-x86_64-gcp.x86_64.tar.gz
```

5. Create the cluster image:

```
$ gcloud compute images create "${INFRA_ID}-rhcos-image" \  
--source-uri="${IMAGE_SOURCE}"
```

## 7.11.15. Creating the bootstrap machine in GCP

You must create the bootstrap machine in Google Cloud Platform (GCP) to use during OpenShift Container Platform cluster initialization. One way to create this machine is to modify the provided Deployment Manager template.



### NOTE

If you do not use the provided Deployment Manager template to create your bootstrap machine, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

## Prerequisites

- Configure a GCP account.

- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.
- Create and configure networking and load balancers in GCP.
- Create control plane and compute roles.
- Ensure pyOpenSSL is installed.

## Procedure

1. Copy the template from the **Deployment Manager template for the bootstrap machine** section of this topic and save it as **04\_bootstrap.py** on your computer. This template describes the bootstrap machine that your cluster requires.
2. Export the location of the Red Hat Enterprise Linux CoreOS (RHCOS) image that the installation program requires:

```
$ export CLUSTER_IMAGE=(`gcloud compute images describe ${INFRA_ID}-rhcos-image --
format json | jq -r .selfLink`)
```

3. Create a bucket and upload the **bootstrap.ign** file:

```
$ gsutil mb gs://${INFRA_ID}-bootstrap-ignition
$ gsutil cp <installation_directory>/bootstrap.ign gs://${INFRA_ID}-bootstrap-ignition/
```

4. Create a signed URL for the bootstrap instance to use to access the Ignition config. Export the URL from the output as a variable:

```
$ export BOOTSTRAP_IGN=`gsutil signurl -d 1h service-account-key.json gs://${INFRA_ID}-
bootstrap-ignition/bootstrap.ign | grep "^gs:" | awk '{print $5}'`
```

5. Create a **04\_bootstrap.yaml** resource definition file:

```
$ cat <<EOF >04_bootstrap.yaml
imports:
- path: 04_bootstrap.py

resources:
- name: cluster-bootstrap
  type: 04_bootstrap.py
  properties:
    infra_id: '${INFRA_ID}' 1
    region: '${REGION}' 2
    zone: '${ZONE_0}' 3

    cluster_network: '${CLUSTER_NETWORK}' 4
    control_subnet: '${CONTROL_SUBNET}' 5
    image: '${CLUSTER_IMAGE}' 6
    machine_type: 'n1-standard-4' 7
    root_volume_size: '128' 8
```

```
bootstrap_ign: '${BOOTSTRAP_IGN}' 9
EOF
```

- 1 **infra\_id** is the **INFRA\_ID** infrastructure name from the extraction step.
- 2 **region** is the region to deploy the cluster into, for example **us-central1**.
- 3 **zone** is the zone to deploy the bootstrap instance into, for example **us-central1-b**.
- 4 **cluster\_network** is the **selfLink** URL to the cluster network.
- 5 **control\_subnet** is the **selfLink** URL to the control subnet.
- 6 **image** is the **selfLink** URL to the RHCOS image.
- 7 **machine\_type** is the machine type of the instance, for example **n1-standard-4**.
- 8 **root\_volume\_size** is the boot disk size for the bootstrap machine.
- 9 **bootstrap\_ign** is the URL output when creating a signed URL.

6. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-bootstrap --config
04_bootstrap.yaml
```

7. Add the bootstrap instance to the internal load balancer instance group:

```
$ gcloud compute instance-groups unmanaged add-instances ${INFRA_ID}-bootstrap-
instance-group --zone=${ZONE_0} --instances=${INFRA_ID}-bootstrap
```

8. Add the bootstrap instance group to the internal load balancer backend service:

```
$ gcloud compute backend-services add-backend ${INFRA_ID}-api-internal-backend-service
--region=${REGION} --instance-group=${INFRA_ID}-bootstrap-instance-group --instance-
group-zone=${ZONE_0}
```

### 7.11.15.1. Deployment Manager template for the bootstrap machine

You can use the following Deployment Manager template to deploy the bootstrap machine that you need for your OpenShift Container Platform cluster:

#### Example 7.16. 04\_bootstrap.py Deployment Manager template

```
def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-bootstrap-public-ip',
        'type': 'compute.v1.address',
        'properties': {
            'region': context.properties['region']
        }
    }, {
```

```

'name': context.properties['infra_id'] + '-bootstrap',
'type': 'compute.v1.instance',
'properties': {
  'disks': [{
    'autoDelete': True,
    'boot': True,
    'initializeParams': {
      'diskSizeGb': context.properties['root_volume_size'],
      'sourceImage': context.properties['image']
    }
  }],
  'machineType': 'zones/' + context.properties['zone'] + '/machineTypes/' +
context.properties['machine_type'],
  'metadata': {
    'items': [{
      'key': 'user-data',
      'value': '{"ignition":{"config":{"replace":{"source":"" + context.properties['bootstrap_ign']
+ ""},"version":"3.1.0"}}',
    }],
  },
  'networkInterfaces': [{
    'subnetwork': context.properties['control_subnet'],
    'accessConfigs': [{
      'natIP': '${ref.' + context.properties['infra_id'] + '-bootstrap-public-ip.address}'
    }],
  }],
  'tags': {
    'items': [
      context.properties['infra_id'] + '-master',
      context.properties['infra_id'] + '-bootstrap'
    ]
  },
  'zone': context.properties['zone']
}
}, {
'name': context.properties['infra_id'] + '-bootstrap-instance-group',
'type': 'compute.v1.instanceGroup',
'properties': {
  'namedPorts': [
    {
      'name': 'ignition',
      'port': 22623
    }, {
      'name': 'https',
      'port': 6443
    }
  ],
  'network': context.properties['cluster_network'],
  'zone': context.properties['zone']
}
]]

return {'resources': resources}

```

## 7.11.16. Creating the control plane machines in GCP

You must create the control plane machines in Google Cloud Platform (GCP) for your cluster to use. One way to create these machines is to modify the provided Deployment Manager template.



### NOTE

If you do not use the provided Deployment Manager template to create your control plane machines, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

### Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.
- Create and configure networking and load balancers in GCP.
- Create control plane and compute roles.
- Create the bootstrap machine.

### Procedure

1. Copy the template from the **Deployment Manager template for control plane machines** section of this topic and save it as **05\_control\_plane.py** on your computer. This template describes the control plane machines that your cluster requires.
2. Export the following variable required by the resource definition:

```
$ export MASTER_IGNITION=`cat <installation_directory>/master.ign`
```

3. Create a **05\_control\_plane.yaml** resource definition file:

```
$ cat <<EOF >05_control_plane.yaml
imports:
- path: 05_control_plane.py

resources:
- name: cluster-control-plane
  type: 05_control_plane.py
  properties:
    infra_id: '${INFRA_ID}' 1
    zones: 2
    - '${ZONE_0}'
    - '${ZONE_1}'
    - '${ZONE_2}'

    control_subnet: '${CONTROL_SUBNET}' 3
    image: '${CLUSTER_IMAGE}' 4
    machine_type: 'n1-standard-4' 5
```

```

root_volume_size: '128'
service_account_email: '${MASTER_SERVICE_ACCOUNT}' ❹

ignition: '${MASTER_IGNITION}' ❺
EOF

```

- ❶ **infra\_id** is the **INFRA\_ID** infrastructure name from the extraction step.
- ❷ **zones** are the zones to deploy the control plane instances into, for example **us-central1-a**, **us-central1-b**, and **us-central1-c**.
- ❸ **control\_subnet** is the **selfLink** URL to the control subnet.
- ❹ **image** is the **selfLink** URL to the RHCOS image.
- ❺ **machine\_type** is the machine type of the instance, for example **n1-standard-4**.
- ❻ **service\_account\_email** is the email address for the master service account that you created.
- ❼ **ignition** is the contents of the **master.ign** file.

4. Create the deployment by using the **gcloud** CLI:

```

$ gcloud deployment-manager deployments create ${INFRA_ID}-control-plane --config
05_control_plane.yaml

```

5. The templates do not manage load balancer membership due to limitations of Deployment Manager, so you must add the control plane machines manually.

- Run the following commands to add the control plane machines to the appropriate instance groups:

```

$ gcloud compute instance-groups unmanaged add-instances ${INFRA_ID}-master-
${ZONE_0}-instance-group --zone=${ZONE_0} --instances=${INFRA_ID}-master-0
$ gcloud compute instance-groups unmanaged add-instances ${INFRA_ID}-master-
${ZONE_1}-instance-group --zone=${ZONE_1} --instances=${INFRA_ID}-master-1
$ gcloud compute instance-groups unmanaged add-instances ${INFRA_ID}-master-
${ZONE_2}-instance-group --zone=${ZONE_2} --instances=${INFRA_ID}-master-2

```

- For an external cluster, you must also run the following commands to add the control plane machines to the target pools:

```

$ gcloud compute target-pools add-instances ${INFRA_ID}-api-target-pool --instances-
zone="${ZONE_0}" --instances=${INFRA_ID}-master-0
$ gcloud compute target-pools add-instances ${INFRA_ID}-api-target-pool --instances-
zone="${ZONE_1}" --instances=${INFRA_ID}-master-1
$ gcloud compute target-pools add-instances ${INFRA_ID}-api-target-pool --instances-
zone="${ZONE_2}" --instances=${INFRA_ID}-master-2

```

### 7.11.16.1. Deployment Manager template for control plane machines

You can use the following Deployment Manager template to deploy the control plane machines that you need for your OpenShift Container Platform cluster:

## Example 7.17. 05\_control\_plane.py Deployment Manager template

```

def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-master-0',
        'type': 'compute.v1.instance',
        'properties': {
            'disks': [{
                'autoDelete': True,
                'boot': True,
                'initializeParams': {
                    'diskSizeGb': context.properties['root_volume_size'],
                    'diskType': 'zones/' + context.properties['zones'][0] + '/diskTypes/pd-ssd',
                    'sourceImage': context.properties['image']
                }
            }],
            'machineType': 'zones/' + context.properties['zones'][0] + '/machineTypes/' +
context.properties['machine_type'],
            'metadata': {
                'items': [{
                    'key': 'user-data',
                    'value': context.properties['ignition']
                }]
            },
            'networkInterfaces': [{
                'subnetwork': context.properties['control_subnet']
            }],
            'serviceAccounts': [{
                'email': context.properties['service_account_email'],
                'scopes': ['https://www.googleapis.com/auth/cloud-platform']
            }],
            'tags': {
                'items': [
                    context.properties['infra_id'] + '-master',
                ]
            },
            'zone': context.properties['zones'][0]
        }
    ], {
        'name': context.properties['infra_id'] + '-master-1',
        'type': 'compute.v1.instance',
        'properties': {
            'disks': [{
                'autoDelete': True,
                'boot': True,
                'initializeParams': {
                    'diskSizeGb': context.properties['root_volume_size'],
                    'diskType': 'zones/' + context.properties['zones'][1] + '/diskTypes/pd-ssd',
                    'sourceImage': context.properties['image']
                }
            }],
            'machineType': 'zones/' + context.properties['zones'][1] + '/machineTypes/' +
context.properties['machine_type'],
            'metadata': {
                'items': [{

```



```

        'key': 'user-data',
        'value': context.properties['ignition']
    }}
},
'networkInterfaces': [{
    'subnetwork': context.properties['control_subnet']
}],
'serviceAccounts': [{
    'email': context.properties['service_account_email'],
    'scopes': ['https://www.googleapis.com/auth/cloud-platform']
}],
'tags': {
    'items': [
        context.properties['infra_id'] + '-master',
    ]
},
'zone': context.properties['zones'][1]
}
}, {
    'name': context.properties['infra_id'] + '-master-2',
    'type': 'compute.v1.instance',
    'properties': {
        'disks': [{
            'autoDelete': True,
            'boot': True,
            'initializeParams': {
                'diskSizeGb': context.properties['root_volume_size'],
                'diskType': 'zones/' + context.properties['zones'][2] + '/diskTypes/pd-ssd',
                'sourceImage': context.properties['image']
            }
        }
    ],
    'machineType': 'zones/' + context.properties['zones'][2] + '/machineTypes/' +
context.properties['machine_type'],
    'metadata': {
        'items': [{
            'key': 'user-data',
            'value': context.properties['ignition']
        }
    ]
},
'networkInterfaces': [{
    'subnetwork': context.properties['control_subnet']
}],
'serviceAccounts': [{
    'email': context.properties['service_account_email'],
    'scopes': ['https://www.googleapis.com/auth/cloud-platform']
}],
'tags': {
    'items': [
        context.properties['infra_id'] + '-master',
    ]
},
'zone': context.properties['zones'][2]
}
}
}
}
return {'resources': resources}

```

### 7.11.17. Wait for bootstrap completion and remove bootstrap resources in GCP

After you create all of the required infrastructure in Google Cloud Platform (GCP), wait for the bootstrap process to complete on the machines that you provisioned by using the Ignition config files that you generated with the installation program.

#### Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.
- Create and configure networking and load balancers in GCP.
- Create control plane and compute roles.
- Create the bootstrap machine.
- Create the control plane machines.

#### Procedure

1. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install wait-for bootstrap-complete --dir <installation_directory> \ 1
--log-level info 2
```

**1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

**2** To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

If the command exits without a **FATAL** warning, your production control plane has initialized.

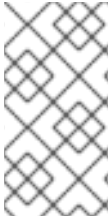
2. Delete the bootstrap resources:

```
$ gcloud compute backend-services remove-backend ${INFRA_ID}-api-internal-backend-
service --region=${REGION} --instance-group=${INFRA_ID}-bootstrap-instance-group --
instance-group-zone=${ZONE_0}
$ gsutil rm gs://${INFRA_ID}-bootstrap-ignition/bootstrap.ign
$ gsutil rb gs://${INFRA_ID}-bootstrap-ignition
$ gcloud deployment-manager deployments delete ${INFRA_ID}-bootstrap
```

### 7.11.18. Creating additional worker machines in GCP

You can create worker machines in Google Cloud Platform (GCP) for your cluster to use by launching individual instances discretely or by automated processes outside the cluster, such as auto scaling groups. You can also take advantage of the built-in cluster scaling mechanisms and the machine API in OpenShift Container Platform.

In this example, you manually launch one instance by using the Deployment Manager template. Additional instances can be launched by including additional resources of type **06\_worker.py** in the file.



## NOTE

If you do not use the provided Deployment Manager template to create your worker machines, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

## Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.
- Create and configure networking and load balancers in GCP.
- Create control plane and compute roles.
- Create the bootstrap machine.
- Create the control plane machines.

## Procedure

1. Copy the template from the **Deployment Manager template for worker machines** section of this topic and save it as **06\_worker.py** on your computer. This template describes the worker machines that your cluster requires.
2. Export the variables that the resource definition uses.

- a. Export the subnet that hosts the compute machines:

```
$ export COMPUTE_SUBNET=$(gcloud compute networks subnets describe
${HOST_PROJECT_COMPUTE_SUBNET} --region=${REGION} --project
${HOST_PROJECT} --account ${HOST_PROJECT_ACCOUNT} --format json | jq -r
.selfLink`)
```

- b. Export the email address for your service account:

```
$ export WORKER_SERVICE_ACCOUNT=$(gcloud iam service-accounts list --filter
"email~^${INFRA_ID}-w@${PROJECT_NAME}." --format json | jq -r '[0].email')
```

- c. Export the location of the compute machine Ignition config file:

```
$ export WORKER_IGNITION=`cat <installation_directory>/worker.ign`
```

3. Create a **06\_worker.yaml** resource definition file:

```
$ cat <<EOF >06_worker.yaml
imports:
- path: 06_worker.py
```

```

resources:
- name: 'worker-0' 1
  type: 06_worker.py
  properties:
    infra_id: '${INFRA_ID}' 2
    zone: '${ZONE_0}' 3
    compute_subnet: '${COMPUTE_SUBNET}' 4
    image: '${CLUSTER_IMAGE}' 5
    machine_type: 'n1-standard-4' 6
    root_volume_size: '128'
    service_account_email: '${WORKER_SERVICE_ACCOUNT}' 7
    ignition: '${WORKER_IGNITION}' 8
- name: 'worker-1'
  type: 06_worker.py
  properties:
    infra_id: '${INFRA_ID}' 9
    zone: '${ZONE_1}' 10
    compute_subnet: '${COMPUTE_SUBNET}' 11
    image: '${CLUSTER_IMAGE}' 12
    machine_type: 'n1-standard-4' 13
    root_volume_size: '128'
    service_account_email: '${WORKER_SERVICE_ACCOUNT}' 14
    ignition: '${WORKER_IGNITION}' 15
EOF

```

- 1 **name** is the name of the worker machine, for example **worker-0**.
- 2 9 **infra\_id** is the **INFRA\_ID** infrastructure name from the extraction step.
- 3 10 **zone** is the zone to deploy the worker machine into, for example **us-central1-a**.
- 4 11 **compute\_subnet** is the **selfLink** URL to the compute subnet.
- 5 12 **image** is the **selfLink** URL to the RHCOS image. <sup>1</sup>
- 6 13 **machine\_type** is the machine type of the instance, for example **n1-standard-4**.
- 7 14 **service\_account\_email** is the email address for the worker service account that you created.
- 8 15 **ignition** is the contents of the **worker.ign** file.

4. Optional: If you want to launch additional instances, include additional resources of type **06\_worker.py** in your **06\_worker.yaml** resource definition file.
5. Create the deployment by using the **gcloud** CLI:

```

$ gcloud deployment-manager deployments create ${INFRA_ID}-worker --config
06_worker.yaml

```

1. To use a GCP Marketplace image, specify the offer to use:

- OpenShift Container Platform:  
<https://www.googleapis.com/compute/v1/projects/redhat-marketplace-public/global/images/redhat-coreos-ocp-48-x86-64-202210040145>
- OpenShift Platform Plus: <https://www.googleapis.com/compute/v1/projects/redhat-marketplace-public/global/images/redhat-coreos-opp-48-x86-64-202206140145>
- OpenShift Kubernetes Engine:  
<https://www.googleapis.com/compute/v1/projects/redhat-marketplace-public/global/images/redhat-coreos-oke-48-x86-64-202206140145>

### 7.11.18.1. Deployment Manager template for worker machines

You can use the following Deployment Manager template to deploy the worker machines that you need for your OpenShift Container Platform cluster:

#### Example 7.18. 06\_worker.py Deployment Manager template

```
def GenerateConfig(context):
    resources = [{
        'name': context.properties['infra_id'] + '-' + context.env['name'],
        'type': 'compute.v1.instance',
        'properties': {
            'disks': [{
                'autoDelete': True,
                'boot': True,
                'initializeParams': {
                    'diskSizeGb': context.properties['root_volume_size'],
                    'sourceImage': context.properties['image']
                }
            }],
            'machineType': 'zones/' + context.properties['zone'] + '/machineTypes/' +
context.properties['machine_type'],
            'metadata': {
                'items': [{
                    'key': 'user-data',
                    'value': context.properties['ignition']
                }]
            },
            'networkInterfaces': [{
                'subnetwork': context.properties['compute_subnet']
            }],
            'serviceAccounts': [{
                'email': context.properties['service_account_email'],
                'scopes': ['https://www.googleapis.com/auth/cloud-platform']
            }],
            'tags': {
                'items': [
                    context.properties['infra_id'] + '-worker',
                ]
            },
            'zone': context.properties['zone']
        }
    ]
```

```

}}
return {'resources': resources}

```

### 7.11.19. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



#### IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

#### Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

##### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

```
$ tar xvf <file>
```

5. Place the **oc** binary in a directory that is on your **PATH**. To check your **PATH**, execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

#### Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

##### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.

5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

### Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### 7.11.20. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

#### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

#### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

- Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

### Example output

```
system:admin
```

## 7.11.21. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

### Prerequisites

- You added machines to your cluster.

### Procedure

- Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

### Example output

```
NAME      STATUS   ROLES    AGE   VERSION
master-0  Ready   master   63m   v1.22.1
master-1  Ready   master   63m   v1.22.1
master-2  Ready   master   64m   v1.22.1
```

The output lists all of the machines that you created.



### NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

- Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

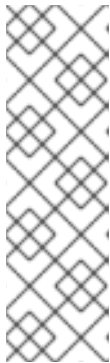
### Example output

```
NAME      AGE   REQUESTOR                                     CONDITION
csr-8b2br  15m   system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper  Pending
csr-8vnps  15m   system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper  Pending
...
```



In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

3. If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:



#### NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.



#### NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrap** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{"\n"}\n{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```



#### NOTE

Some Operators might not become available until some CSRs are approved.

4. Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

#### Example output

```

NAME      AGE   REQUESTOR                                     CONDITION
csr-bfd72 5m26s system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv 5m26s system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...

```

5. If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

**1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{\n"}\n{{end}}' | xargs oc adm certificate approve
```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

### Example output

```

NAME      STATUS   ROLES    AGE   VERSION
master-0  Ready   master   73m   v1.22.1
master-1  Ready   master   73m   v1.22.1
master-2  Ready   master   74m   v1.22.1
worker-0  Ready   worker   11m   v1.22.1
worker-1  Ready   worker   11m   v1.22.1

```



### NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

### Additional information

- For more information on CSRs, see [Certificate Signing Requests](#).

## 7.11.22. Adding the ingress DNS records

DNS zone configuration is removed when creating Kubernetes manifests and generating Ignition configs. You must manually create DNS records that point at the ingress load balancer. You can create either a wildcard **\*.apps.{baseDomain}**. or specific records. You can use A, CNAME, and other records per your requirements.

### Prerequisites

- Configure a GCP account.
- Remove the DNS Zone configuration when creating Kubernetes manifests and generating Ignition configs.
- Create and configure a VPC and associated subnets in GCP.
- Create and configure networking and load balancers in GCP.
- Create control plane and compute roles.
- Create the bootstrap machine.
- Create the control plane machines.
- Create the worker machines.

## Procedure

1. Wait for the Ingress router to create a load balancer and populate the **EXTERNAL-IP** field:

```
$ oc -n openshift-ingress get service router-default
```

### Example output

```
NAME          TYPE          CLUSTER-IP   EXTERNAL-IP   PORT(S)          AGE
router-default LoadBalancer  172.30.18.154 35.233.157.184 80:32288/TCP,443:31215/TCP 98
```

2. Add the A record to your zones:

- To use A records:
  - i. Export the variable for the router IP address:

```
$ export ROUTER_IP=`oc -n openshift-ingress get service router-default --no-headers | awk '{print $4}'`
```

- ii. Add the A record to the private zones:

```
$ if [ -f transaction.yaml ]; then rm transaction.yaml; fi
$ gcloud dns record-sets transaction start --zone ${INFRA_ID}-private-zone --project
${HOST_PROJECT} --account ${HOST_PROJECT_ACCOUNT}
$ gcloud dns record-sets transaction add ${ROUTER_IP} --name
\*.apps.${CLUSTER_NAME}.${BASE_DOMAIN}. --ttl 300 --type A --zone
${INFRA_ID}-private-zone --project ${HOST_PROJECT} --account
${HOST_PROJECT_ACCOUNT}
$ gcloud dns record-sets transaction execute --zone ${INFRA_ID}-private-zone --
project ${HOST_PROJECT} --account ${HOST_PROJECT_ACCOUNT}
```

- iii. For an external cluster, also add the A record to the public zones:

```
$ if [ -f transaction.yaml ]; then rm transaction.yaml; fi
$ gcloud dns record-sets transaction start --zone ${BASE_DOMAIN_ZONE_NAME} -
-project ${HOST_PROJECT} --account ${HOST_PROJECT_ACCOUNT}
```

```
$ gcloud dns record-sets transaction add ${ROUTER_IP} --name
\*.apps.${CLUSTER_NAME}.${BASE_DOMAIN}. --ttl 300 --type A --zone
${BASE_DOMAIN_ZONE_NAME} --project ${HOST_PROJECT} --account
${HOST_PROJECT_ACCOUNT}
$ gcloud dns record-sets transaction execute --zone
${BASE_DOMAIN_ZONE_NAME} --project ${HOST_PROJECT} --account
${HOST_PROJECT_ACCOUNT}
```

- To add explicit domains instead of using a wildcard, create entries for each of the cluster's current routes:

```
$ oc get --all-namespaces -o jsonpath='{range .items[*]}{range .status.ingress[*]}{.host}
{"\n"}{end}{end}' routes
```

### Example output

```
oauth-openshift.apps.your.cluster.domain.example.com
console-openshift-console.apps.your.cluster.domain.example.com
downloads-openshift-console.apps.your.cluster.domain.example.com
alertmanager-main-openshift-monitoring.apps.your.cluster.domain.example.com
grafana-openshift-monitoring.apps.your.cluster.domain.example.com
prometheus-k8s-openshift-monitoring.apps.your.cluster.domain.example.com
```

## 7.11.23. Adding ingress firewall rules

The cluster requires several firewall rules. If you do not use a shared VPC, these rules are created by the ingress controller via the GCP cloud provider. When you use a shared VPC, you can either create cluster-wide firewall rules for all services now or create each rule based on events, when the cluster requests access. By creating each rule when the cluster requests access, you know exactly which firewall rules are required. By creating cluster-wide firewall rules, you can apply the same rule set across multiple clusters.

If you choose to create each rule based on events, you must create firewall rules after you provision the cluster and during the life of the cluster when the console notifies you that rules are missing. Events that are similar to the following event are displayed, and you must add the firewall rules that are required:

```
$ oc get events -n openshift-ingress --field-selector="reason=LoadBalancerManualChange"
```

### Example output

```
Firewall change required by security admin: `gcloud compute firewall-rules create k8s-fw-
a26e631036a3f46cba28f8df67266d55 --network example-network --description "
{"kubernetes.io/service-name":"openshift-ingress/router-default", "kubernetes.io/service-
ip":"35.237.236.234"}" --allow tcp:443,tcp:80 --source-ranges 0.0.0.0/0 --target-tags exampl-fqzq7-
master,exampl-fqzq7-worker --project example-project`
```

If you encounter issues when creating these rule-based events, you can configure the cluster-wide firewall rules while your cluster is running.

### 7.11.23.1. Creating cluster-wide firewall rules for a shared VPC in GCP

You can create cluster-wide firewall rules to allow the access that the OpenShift Container Platform cluster requires.



## WARNING

If you do not choose to create firewall rules based on cluster events, you must create cluster-wide firewall rules.

### Prerequisites

- You exported the variables that the Deployment Manager templates require to deploy your cluster.
- You created the networking and load balancing components in GCP that your cluster requires.

### Procedure

1. Add a single firewall rule to allow the Google Cloud Engine health checks to access all of the services. This rule enables the ingress load balancers to determine the health status of their instances.

```
$ gcloud compute firewall-rules create --allow='tcp:30000-32767,udp:30000-32767' --
network="${CLUSTER_NETWORK}" --source-
ranges='130.211.0.0/22,35.191.0.0/16,209.85.152.0/22,209.85.204.0/22' --target-
tags="${INFRA_ID}-master,${INFRA_ID}-worker" ${INFRA_ID}-ingress-hc --
account=${HOST_PROJECT_ACCOUNT} --project=${HOST_PROJECT}
```

2. Add a single firewall rule to allow access to all cluster services:

- For an external cluster:

```
$ gcloud compute firewall-rules create --allow='tcp:80,tcp:443' --
network="${CLUSTER_NETWORK}" --source-ranges="0.0.0.0/0" --target-
tags="${INFRA_ID}-master,${INFRA_ID}-worker" ${INFRA_ID}-ingress --
account=${HOST_PROJECT_ACCOUNT} --project=${HOST_PROJECT}
```

- For a private cluster:

```
$ gcloud compute firewall-rules create --allow='tcp:80,tcp:443' --
network="${CLUSTER_NETWORK}" --source-ranges=${NETWORK_CIDR} --target-
tags="${INFRA_ID}-master,${INFRA_ID}-worker" ${INFRA_ID}-ingress --
account=${HOST_PROJECT_ACCOUNT} --project=${HOST_PROJECT}
```

Because this rule only allows traffic on TCP ports **80** and **443**, ensure that you add all the ports that your services use.

### 7.11.24. Completing a GCP installation on user-provisioned infrastructure

After you start the OpenShift Container Platform installation on Google Cloud Platform (GCP) user-provisioned infrastructure, you can monitor the cluster events until the cluster is ready.

### Prerequisites

- Deploy the bootstrap machine for an OpenShift Container Platform cluster on user-provisioned GCP infrastructure.
- Install the **oc** CLI and log in.

## Procedure

1. Complete the cluster installation:

```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

### Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.



### IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Observe the running state of your cluster.

- a. Run the following command to view the current cluster version and status:

```
$ oc get clusterversion
```

### Example output

```
NAME      VERSION  AVAILABLE  PROGRESSING  SINCE   STATUS
version   False    True        24m         Working towards 4.5.4: 99% complete
```

- b. Run the following command to view the Operators managed on the control plane by the Cluster Version Operator (CVO):

```
$ oc get clusteroperators
```

### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
authentication	4.5.4	True	False	False	7m56s
cloud-credential	4.5.4	True	False	False	31m
cluster-autoscaler	4.5.4	True	False	False	16m
console	4.5.4	True	False	False	10m
csi-snapshot-controller	4.5.4	True	False	False	16m
dns	4.5.4	True	False	False	22m
etcd	4.5.4	False	False	False	25s
image-registry	4.5.4	True	False	False	16m
ingress	4.5.4	True	False	False	16m
insights	4.5.4	True	False	False	17m
kube-apiserver	4.5.4	True	False	False	19m
kube-controller-manager	4.5.4	True	False	False	20m
kube-scheduler	4.5.4	True	False	False	20m
kube-storage-version-migrator	4.5.4	True	False	False	16m
machine-api	4.5.4	True	False	False	22m
machine-config	4.5.4	True	False	False	22m
marketplace	4.5.4	True	False	False	16m
monitoring	4.5.4	True	False	False	10m
network	4.5.4	True	False	False	23m
node-tuning	4.5.4	True	False	False	23m
openshift-apiserver	4.5.4	True	False	False	17m
openshift-controller-manager	4.5.4	True	False	False	15m
openshift-samples	4.5.4	True	False	False	16m
operator-lifecycle-manager	4.5.4	True	False	False	22m
operator-lifecycle-manager-catalog	4.5.4	True	False	False	22m
operator-lifecycle-manager-packageserver	4.5.4	True	False	False	18m
service-ca	4.5.4	True	False	False	23m
service-catalog-apiserver	4.5.4	True	False	False	23m
service-catalog-controller-manager	4.5.4	True	False	False	23m
storage	4.5.4	True	False	False	17m

- c. Run the following command to view your cluster pods:

```
$ oc get pods --all-namespaces
```

### Example output

NAMESPACE	NAME	READY	STATUS	RESTARTS	AGE
kube-system	etcd-member-ip-10-0-3-111.us-east-2.compute.internal	1/1	Running	0	35m
kube-system	etcd-member-ip-10-0-3-239.us-east-2.compute.internal	1/1	Running	0	37m
kube-system	etcd-member-ip-10-0-3-24.us-east-2.compute.internal	1/1	Running	0	35m
openshift-apiserver-operator	openshift-apiserver-operator-6d6674f4f4-h7t2t	1/1	Running	1	37m
openshift-apiserver	apiserver-fm48r	1/1	Running	0	30m
openshift-apiserver	apiserver-fxkvv	1/1	Running	0	29m
openshift-apiserver	apiserver-q85nm	1/1	Running	0	29m

```

...
openshift-service-ca-operator          openshift-service-ca-operator-66ff6dc6cd-
9r257          1/1    Running    0    37m
openshift-service-ca                  apiservice-cabundle-injector-695b6bcbc-cl5hm
1/1    Running    0    35m
openshift-service-ca                  configmap-cabundle-injector-8498544d7-
25qn6          1/1    Running    0    35m
openshift-service-ca                  service-serving-cert-signer-6445fc9c6-wqdqn
1/1    Running    0    35m
openshift-service-catalog-apiserver-operator  openshift-service-catalog-apiserver-
operator-549f44668b-b5q2w  1/1    Running    0    32m
openshift-service-catalog-controller-manager-operator  openshift-service-catalog-
controller-manager-operator-b78cr2lnm  1/1    Running    0    31m

```

When the current cluster version is **AVAILABLE**, the installation is complete.

### 7.11.25. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

#### Additional resources

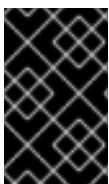
- See [About remote health monitoring](#) for more information about the Telemetry service

### 7.11.26. Next steps

- [Customize your cluster](#).
- If necessary, you can [opt out of remote health reporting](#).

## 7.12. INSTALLING A CLUSTER ON GCP IN A RESTRICTED NETWORK WITH USER-PROVISIONED INFRASTRUCTURE

In OpenShift Container Platform version 4.9, you can install a cluster on Google Cloud Platform (GCP) that uses infrastructure that you provide and an internal mirror of the installation release content.

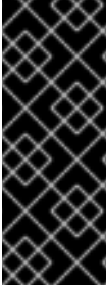


### IMPORTANT

While you can install an OpenShift Container Platform cluster by using mirrored installation release content, your cluster still requires internet access to use the GCP APIs.

The steps for performing a user-provided infrastructure install are outlined here. Several [Deployment Manager](#) templates are provided to assist in completing these steps or to help model your own. You are also free to create the required resources through other methods.





## IMPORTANT

The steps for performing a user-provisioned infrastructure installation are provided as an example only. Installing a cluster with infrastructure you provide requires knowledge of the cloud provider and the installation process of OpenShift Container Platform. Several Deployment Manager templates are provided to assist in completing these steps or to help model your own. You are also free to create the required resources through other methods; the templates are just an example.

### 7.12.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You [created a registry on your mirror host](#) and obtained the **imageContentSources** data for your version of OpenShift Container Platform.



## IMPORTANT

Because the installation media is on the mirror host, you can use that computer to complete all installation steps.

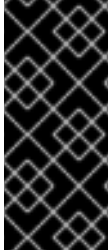
- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to. While you might need to grant access to more sites, you must grant access to **\*.googleapis.com** and **accounts.google.com**.
- If the cloud identity and access management (IAM) APIs are not accessible in your environment, or if you do not want to store an administrator-level credential secret in the **kube-system** namespace, you can [manually create and maintain IAM credentials](#).

### 7.12.2. About installations in restricted networks

In OpenShift Container Platform 4.9, you can perform an installation that does not require an active connection to the internet to obtain software components. Restricted network installations can be completed using installer-provisioned infrastructure or user-provisioned infrastructure, depending on the cloud platform to which you are installing the cluster.

If you choose to perform a restricted network installation on a cloud platform, you still require access to its cloud APIs. Some cloud functions, like Amazon Web Service's Route 53 DNS and IAM services, require internet access. Depending on your network, you might require less internet access for an installation on bare metal hardware or on VMware vSphere.

To complete a restricted network installation, you must create a registry that mirrors the contents of the OpenShift Container Platform registry and contains the installation media. You can create this registry on a mirror host, which can access both the internet and your closed network, or by using other methods that meet your restrictions.



## IMPORTANT

Because of the complexity of the configuration for user-provisioned installations, consider completing a standard user-provisioned infrastructure installation before you attempt a restricted network installation using user-provisioned infrastructure. Completing this test installation might make it easier to isolate and troubleshoot any issues that might arise during your installation in a restricted network.

### 7.12.2.1. Additional limits

Clusters in restricted networks have the following additional limitations and restrictions:

- The **ClusterVersion** status includes an **Unable to retrieve available updates** error.
- By default, you cannot use the contents of the Developer Catalog because you cannot access the required image stream tags.

### 7.12.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to obtain the images that are necessary to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



## IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

### 7.12.4. Configuring your GCP project

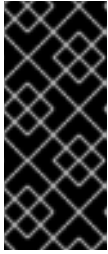
Before you can install OpenShift Container Platform, you must configure a Google Cloud Platform (GCP) project to host it.

#### 7.12.4.1. Creating a GCP project

To install OpenShift Container Platform, you must create a project in your Google Cloud Platform (GCP) account to host the cluster.

#### Procedure

- Create a project to host your OpenShift Container Platform cluster. See [Creating and Managing Projects](#) in the GCP documentation.



## IMPORTANT

Your GCP project must use the Premium Network Service Tier if you are using installer-provisioned infrastructure. The Standard Network Service Tier is not supported for clusters installed using the installation program. The installation program configures internal load balancing for the **api-int.<cluster\_name>.<base\_domain>** URL; the Premium Tier is required for internal load balancing.

### 7.12.4.2. Enabling API services in GCP

Your Google Cloud Platform (GCP) project requires access to several API services to complete OpenShift Container Platform installation.

#### Prerequisites

- You created a project to host your cluster.

#### Procedure

- Enable the following required API services in the project that hosts your cluster. See [Enabling services](#) in the GCP documentation.

**Table 7.51. Required API services**

API service	Console service name
Compute Engine API	<b>compute.googleapis.com</b>
Google Cloud APIs	<b>cloudapis.googleapis.com</b>
Cloud Resource Manager API	<b>cloudresourcemanager.googleapis.com</b>
Google DNS API	<b>dns.googleapis.com</b>
IAM Service Account Credentials API	<b>iamcredentials.googleapis.com</b>
Identity and Access Management (IAM) API	<b>iam.googleapis.com</b>
Service Management API	<b>servicemanagement.googleapis.com</b>
Service Usage API	<b>serviceusage.googleapis.com</b>
Google Cloud Storage JSON API	<b>storage-api.googleapis.com</b>
Cloud Storage	<b>storage-component.googleapis.com</b>

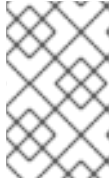
### 7.12.4.3. Configuring DNS for GCP

To install OpenShift Container Platform, the Google Cloud Platform (GCP) account you use must have a dedicated public hosted zone in the same project that you host the OpenShift Container Platform

cluster. This zone must be authoritative for the domain. The DNS service provides cluster DNS resolution and name lookup for external connections to the cluster.

## Procedure

1. Identify your domain, or subdomain, and registrar. You can transfer an existing domain and registrar or obtain a new one through GCP or another source.



### NOTE

If you purchase a new domain, it can take time for the relevant DNS changes to propagate. For more information about purchasing domains through Google, see [Google Domains](#).

2. Create a public hosted zone for your domain or subdomain in your GCP project. See [Creating public zones](#) in the GCP documentation. Use an appropriate root domain, such as **openshiftcorp.com**, or subdomain, such as **clusters.openshiftcorp.com**.
3. Extract the new authoritative name servers from the hosted zone records. See [Look up your Cloud DNS name servers](#) in the GCP documentation. You typically have four name servers.
4. Update the registrar records for the name servers that your domain uses. For example, if you registered your domain to Google Domains, see the following topic in the Google Domains Help: [How to switch to custom name servers](#).
5. If you migrated your root domain to Google Cloud DNS, migrate your DNS records. See [Migrating to Cloud DNS](#) in the GCP documentation.
6. If you use a subdomain, follow your company's procedures to add its delegation records to the parent domain. This process might include a request to your company's IT department or the division that controls the root domain and DNS services for your company.

### 7.12.4.4. GCP account limits

The OpenShift Container Platform cluster uses a number of Google Cloud Platform (GCP) components, but the default [Quotas](#) do not affect your ability to install a default OpenShift Container Platform cluster.

A default cluster, which contains three compute and three control plane machines, uses the following resources. Note that some resources are required only during the bootstrap process and are removed after the cluster deploys.

**Table 7.52. GCP resources used in a default cluster**

Service	Component	Location	Total resources required	Resources removed after bootstrap
Service account	IAM	Global	5	0
Firewall rules	Networking	Global	11	1

Service	Component	Location	Total resources required	Resources removed after bootstrap
Forwarding rules	Compute	Global	2	0
Health checks	Compute	Global	2	0
Images	Compute	Global	1	0
Networks	Networking	Global	1	0
Routers	Networking	Global	1	0
Routes	Networking	Global	2	0
Subnetworks	Compute	Global	2	0
Target pools	Networking	Global	2	0



## NOTE

If any of the quotas are insufficient during installation, the installation program displays an error that states both which quota was exceeded and the region.

Be sure to consider your actual cluster size, planned cluster growth, and any usage from other clusters that are associated with your account. The CPU, static IP addresses, and persistent disk SSD (storage) quotas are the ones that are most likely to be insufficient.

If you plan to deploy your cluster in one of the following regions, you will exceed the maximum storage quota and are likely to exceed the CPU quota limit:

- **asia-east2**
- **asia-northeast2**
- **asia-south1**
- **australia-southeast1**
- **europa-north1**
- **europa-west2**
- **europa-west3**
- **europa-west6**
- **northamerica-northeast1**
- **southamerica-east1**

- **us-west2**

You can increase resource quotas from the [GCP console](#), but you might need to file a support ticket. Be sure to plan your cluster size early so that you can allow time to resolve the support ticket before you install your OpenShift Container Platform cluster.

#### 7.12.4.5. Creating a service account in GCP

OpenShift Container Platform requires a Google Cloud Platform (GCP) service account that provides authentication and authorization to access data in the Google APIs. If you do not have an existing IAM service account that contains the required roles in your project, you must create one.

##### Prerequisites

- You created a project to host your cluster.

##### Procedure

1. Create a service account in the project that you use to host your OpenShift Container Platform cluster. See [Creating a service account](#) in the GCP documentation.
2. Grant the service account the appropriate permissions. You can either grant the individual permissions that follow or assign the **Owner** role to it. See [Granting roles to a service account for specific resources](#).



##### NOTE

While making the service account an owner of the project is the easiest way to gain the required permissions, it means that service account has complete control over the project. You must determine if the risk that comes from offering that power is acceptable.

3. Create the service account key in JSON format. See [Creating service account keys](#) in the GCP documentation.  
The service account key is required to create a cluster.

##### 7.12.4.5.1. Required GCP permissions

When you attach the **Owner** role to the service account that you create, you grant that service account all permissions, including those that are required to install OpenShift Container Platform. To deploy an OpenShift Container Platform cluster, the service account requires the following permissions. If you deploy your cluster into an existing VPC, the service account does not require certain networking permissions, which are noted in the following lists:

##### Required roles for the installation program

- Compute Admin
- Security Admin
- Service Account Admin
- Service Account User
- Storage Admin

### Required roles for creating network resources during installation

- DNS Administrator

### Required roles for user-provisioned GCP infrastructure

- Deployment Manager Editor
- Service Account Key Admin

### Optional roles

For the cluster to create new limited credentials for its Operators, add the following role:

- Service Account Key Admin

The roles are applied to the service accounts that the control plane and compute machines use:

**Table 7.53. GCP service account permissions**

Account	Roles
Control Plane	<b>roles/compute.instanceAdmin</b>
	<b>roles/compute.networkAdmin</b>
	<b>roles/compute.securityAdmin</b>
	<b>roles/storage.admin</b>
	<b>roles/iam.serviceAccountUser</b>
Compute	<b>roles/compute.viewer</b>
	<b>roles/storage.admin</b>

#### 7.12.4.6. Supported GCP regions

You can deploy an OpenShift Container Platform cluster to the following Google Cloud Platform (GCP) regions:

- **asia-east1** (Changhua County, Taiwan)
- **asia-east2** (Hong Kong)
- **asia-northeast1** (Tokyo, Japan)
- **asia-northeast2** (Osaka, Japan)
- **asia-northeast3** (Seoul, South Korea)
- **asia-south1** (Mumbai, India)
- **asia-southeast1** (Jurong West, Singapore)

- **asia-southeast2** (Jakarta, Indonesia)
- **australia-southeast1** (Sydney, Australia)
- **europa-central2** (Warsaw, Poland)
- **europa-north1** (Hamina, Finland)
- **europa-west1** (St. Ghislain, Belgium)
- **europa-west2** (London, England, UK)
- **europa-west3** (Frankfurt, Germany)
- **europa-west4** (Eemshaven, Netherlands)
- **europa-west6** (Zürich, Switzerland)
- **northamerica-northeast1** (Montréal, Québec, Canada)
- **southamerica-east1** (São Paulo, Brazil)
- **us-central1** (Council Bluffs, Iowa, USA)
- **us-east1** (Moncks Corner, South Carolina, USA)
- **us-east4** (Ashburn, Northern Virginia, USA)
- **us-west1** (The Dalles, Oregon, USA)
- **us-west2** (Los Angeles, California, USA)
- **us-west3** (Salt Lake City, Utah, USA)
- **us-west4** (Las Vegas, Nevada, USA)

#### 7.12.4.7. Installing and configuring CLI tools for GCP

To install OpenShift Container Platform on Google Cloud Platform (GCP) using user-provisioned infrastructure, you must install and configure the CLI tools for GCP.

##### Prerequisites

- You created a project to host your cluster.
- You created a service account and granted it the required permissions.

##### Procedure

1. Install the following binaries in **\$PATH**:
  - **gcloud**
  - **gsutil**

See [Install the latest Cloud SDK version](#) in the GCP documentation.



2. Authenticate using the **gcloud** tool with your configured service account.  
See [Authorizing with a service account](#) in the GCP documentation.

## 7.12.5. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

### 7.12.5.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

**Table 7.54. Minimum required hosts**

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.



#### IMPORTANT

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 7.9, or RHEL 8.4.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See [Red Hat Enterprise Linux technology capabilities and limits](#).

### 7.12.5.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

**Table 7.55. Minimum resource requirements**

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
---------	------------------	----------	-------------	---------	----------

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 7.9, or RHEL 8.4 [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.

### 7.12.5.3. Using custom machine types

Using a custom machine type to install a OpenShift Container Platform cluster is supported.

Consider the following when using a custom machine type:

- Similar to predefined instance types, custom machine types must meet the minimum resource requirements for control plane and compute machines. For more information, see "Minimum resource requirements for cluster installation".
- The name of the custom machine type must adhere to the following syntax:  
**custom-`<number_of_cpus>`-`<amount_of_memory_in_mb>`**

For example, **custom-6-20480**.

### 7.12.6. Creating the installation files for GCP

To install OpenShift Container Platform on Google Cloud Platform (GCP) using user-provisioned infrastructure, you must generate the files that the installation program needs to deploy your cluster and modify them so that the cluster creates only the machines that it will use. You generate and customize the **install-config.yaml** file, Kubernetes manifests, and Ignition config files. You also have the option to first set up a separate **var** partition during the preparation phases of installation.

#### 7.12.6.1. Optional: Creating a separate /var partition

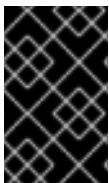
It is recommended that disk partitioning for OpenShift Container Platform be left to the installer. However, there are cases where you might want to create separate partitions in a part of the filesystem that you expect to grow.

OpenShift Container Platform supports the addition of a single partition to attach storage to either the **/var** partition or a subdirectory of **/var**. For example:

- **/var/lib/containers**: Holds container-related content that can grow as more images and containers are added to a system.
- **/var/lib/etcd**: Holds data that you might want to keep separate for purposes such as performance optimization of etcd storage.
- **/var**: Holds data that you might want to keep separate for purposes such as auditing.

Storing the contents of a **/var** directory separately makes it easier to grow storage for those areas as needed and reinstall OpenShift Container Platform at a later date and keep that data intact. With this method, you will not have to pull all your containers again, nor will you have to copy massive log files when you update systems.

Because **/var** must be in place before a fresh installation of Red Hat Enterprise Linux CoreOS (RHCOS), the following procedure sets up the separate **/var** partition by creating a machine config manifest that is inserted during the **openshift-install** preparation phases of an OpenShift Container Platform installation.



## IMPORTANT

If you follow the steps to create a separate **/var** partition in this procedure, it is not necessary to create the Kubernetes manifest and Ignition config files again as described later in this section.

## Procedure

1. Create a directory to hold the OpenShift Container Platform installation files:

```
$ mkdir $HOME/clusterconfig
```

2. Run **openshift-install** to create a set of files in the **manifest** and **openshift** subdirectories. Answer the system questions as you are prompted:

```
$ openshift-install create manifests --dir $HOME/clusterconfig
```

## Example output

```
? SSH Public Key ...
INFO Credentials loaded from the "myprofile" profile in file "/home/myuser/.aws/credentials"
INFO Consuming Install Config from target directory
INFO Manifests created in: $HOME/clusterconfig/manifests and
$HOME/clusterconfig/openshift
```

3. Optional: Confirm that the installation program created manifests in the **clusterconfig/openshift** directory:

```
$ ls $HOME/clusterconfig/openshift/
```

## Example output

```
99_kubeadmin-password-secret.yaml
99_openshift-cluster-api_master-machines-0.yaml
99_openshift-cluster-api_master-machines-1.yaml
99_openshift-cluster-api_master-machines-2.yaml
...
```

4. Create a Butane config that configures the additional partition. For example, name the file **\$HOME/clusterconfig/98-var-partition.bu**, change the disk device name to the name of the storage device on the **worker** systems, and set the storage size as appropriate. This example places the **/var** directory on a separate partition:

```
variant: openshift
version: 4.9.0
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 98-var-partition
storage:
  disks:
    - device: /dev/<device_name> 1
      partitions:
        - label: var
          start_mib: <partition_start_offset> 2
          size_mib: <partition_size> 3
      filesystems:
        - device: /dev/disk/by-partlabel/var
          path: /var
          format: xfs
          mount_options: [defaults, prjquota] 4
          with_mount_unit: true
```

- 1 The storage device name of the disk that you want to partition.
- 2 When adding a data partition to the boot disk, a minimum value of 25000 MiB (Mebibytes) is recommended. The root file system is automatically resized to fill all available space up to the specified offset. If no value is specified, or if the specified value is smaller than the recommended minimum, the resulting root file system will be too small, and future reinstalls of RHCOS might overwrite the beginning of the data partition.
- 3 The size of the data partition in mebibytes.
- 4 The **prjquota** mount option must be enabled for filesystems used for container storage.



### NOTE

When creating a separate **/var** partition, you cannot use different instance types for worker nodes, if the different instance types do not have the same device name.

5. Create a manifest from the Butane config and save it to the **clusterconfig/openshift** directory. For example, run the following command:

```
$ butane $HOME/clusterconfig/98-var-partition.bu -o $HOME/clusterconfig/openshift/98-var-partition.yaml
```

6. Run **openshift-install** again to create Ignition configs from a set of files in the **manifest** and **openshift** subdirectories:

```
$ openshift-install create ignition-configs --dir $HOME/clusterconfig
$ ls $HOME/clusterconfig/
auth bootstrap.ign master.ign metadata.json worker.ign
```

Now you can use the Ignition config files as input to the installation procedures to install Red Hat Enterprise Linux CoreOS (RHCOS) systems.

### 7.12.6.2. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Google Cloud Platform (GCP).

#### Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster. For a restricted network installation, these files are on your mirror host.
- Have the **imageContentSources** values that were generated during mirror registry creation.
- Obtain the contents of the certificate for your mirror registry.
- Obtain service principal permissions at the subscription level.

#### Procedure

1. Create the **install-config.yaml** file.
  - a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

- 1** For **<installation\_directory>**, specify the directory name to store the files that the installation program creates.



#### IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

- b. At the prompts, provide the configuration details for your cloud:



```
network: <existing_vpc>
controlPlaneSubnet: <control_plane_subnet>
computeSubnet: <compute_subnet>
```

For **platform.gcp.network**, specify the name for the existing Google VPC. For **platform.gcp.controlPlaneSubnet** and **platform.gcp.computeSubnet**, specify the existing subnets to deploy the control plane machines and compute machines, respectively.

- d. Add the image content resources, which look like this excerpt:

```
imageContentSources:
- mirrors:
  - <mirror_host_name>:5000/<repo_name>/release
    source: quay.io/openshift-release-dev/ocp-release
- mirrors:
  - <mirror_host_name>:5000/<repo_name>/release
    source: registry.redhat.io/ocp/release
```

To complete these values, use the **imageContentSources** that you recorded during mirror registry creation.

3. Make any other modifications to the **install-config.yaml** file that you require. You can find more information about the available parameters in the **Installation configuration parameters** section.
4. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



### IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

#### 7.12.6.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

#### Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



## NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

## Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
  additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
  ...
```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations.
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.



## NOTE

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.



The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



#### NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

#### 7.12.6.4. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.



#### IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

#### Prerequisites

- You obtained the OpenShift Container Platform installation program. For a restricted network installation, these files are on your mirror host.
- You created the **install-config.yaml** installation configuration file.

#### Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

- 1** For **<installation\_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

2. Remove the Kubernetes manifest files that define the control plane machines:

```
$ rm -f <installation_directory>/openshift/99_openshift-cluster-api_master-machines-*.yaml
```

-

By removing these files, you prevent the cluster from automatically generating control plane machines.

- Optional: If you do not want the cluster to provision compute machines, remove the Kubernetes manifest files that define the worker machines:

```
$ rm -f <installation_directory>/openshift/99_openshift-cluster-api_worker-machineset-*.yaml
```

Because you create and manage the worker machines yourself, you do not need to initialize these machines.

- Check that the **mastersSchedulable** parameter in the `<installation_directory>/manifests/cluster-scheduler-02-config.yml` Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:
  - Open the `<installation_directory>/manifests/cluster-scheduler-02-config.yml` file.
  - Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.
  - Save and exit the file.
- Optional: If you do not want [the Ingress Operator](#) to create DNS records on your behalf, remove the **privateZone** and **publicZone** sections from the `<installation_directory>/manifests/cluster-dns-02-config.yml` DNS configuration file:

```
apiVersion: config.openshift.io/v1
kind: DNS
metadata:
  creationTimestamp: null
  name: cluster
spec:
  baseDomain: example.openshift.com
  privateZone: 1
    id: mycluster-100419-private-zone
  publicZone: 2
    id: example.openshift.com
status: {}
```

1 2 Remove this section completely.

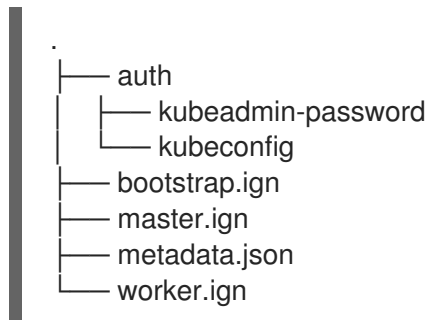
If you do so, you must add ingress DNS records manually in a later step.

- To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

1 For `<installation_directory>`, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the `./<installation_directory>/auth` directory:



## Additional resources

- [Optional: Adding the ingress DNS records](#)

## 7.12.7. Exporting common variables

### 7.12.7.1. Extracting the infrastructure name

The Ignition config files contain a unique cluster identifier that you can use to uniquely identify your cluster in Google Cloud Platform (GCP). The infrastructure name is also used to locate the appropriate GCP resources during an OpenShift Container Platform installation. The provided Deployment Manager templates contain references to this infrastructure name, so you must extract it.

#### Prerequisites

- You obtained the OpenShift Container Platform installation program and the pull secret for your cluster.
- You generated the Ignition config files for your cluster.
- You installed the **jq** package.

#### Procedure

- To extract and view the infrastructure name from the Ignition config file metadata, run the following command:

```
$ jq -r .infraID <installation_directory>/metadata.json 1
```

- 1 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

#### Example output

```
openshift-vw9j6 1
```

- 1 The output of this command is your cluster name and a random string.

### 7.12.7.2. Exporting common variables for Deployment Manager templates

You must export a common set of variables that are used with the provided Deployment Manager templates used to assist in completing a user-provided infrastructure install on Google Cloud Platform (GCP).



## NOTE

Specific Deployment Manager templates can also require additional exported variables, which are detailed in their related procedures.

## Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Generate the Ignition config files for your cluster.
- Install the **jq** package.

## Procedure

1. Export the following common variables to be used by the provided Deployment Manager templates:

```
$ export BASE_DOMAIN='<base_domain>'
$ export BASE_DOMAIN_ZONE_NAME='<base_domain_zone_name>'
$ export NETWORK_CIDR='10.0.0.0/16'
$ export MASTER_SUBNET_CIDR='10.0.0.0/17'
$ export WORKER_SUBNET_CIDR='10.0.128.0/17'

$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
$ export CLUSTER_NAME=`jq -r .clusterName <installation_directory>/metadata.json`
$ export INFRA_ID=`jq -r .infraID <installation_directory>/metadata.json`
$ export PROJECT_NAME=`jq -r .gcp.projectID <installation_directory>/metadata.json`
$ export REGION=`jq -r .gcp.region <installation_directory>/metadata.json`
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

## 7.12.8. Creating a VPC in GCP

You must create a VPC in Google Cloud Platform (GCP) for your OpenShift Container Platform cluster to use. You can customize the VPC to meet your requirements. One way to create the VPC is to modify the provided Deployment Manager template.



## NOTE

If you do not use the provided Deployment Manager template to create your GCP infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

## Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.

## Procedure

1. Copy the template from the **Deployment Manager template for the VPC** section of this topic and save it as **01\_vpc.py** on your computer. This template describes the VPC that your cluster requires.
2. Create a **01\_vpc.yaml** resource definition file:

```
$ cat <<EOF >01_vpc.yaml
imports:
- path: 01_vpc.py

resources:
- name: cluster-vpc
  type: 01_vpc.py
  properties:
    infra_id: '${INFRA_ID}' ❶
    region: '${REGION}' ❷
    master_subnet_cidr: '${MASTER_SUBNET_CIDR}' ❸
    worker_subnet_cidr: '${WORKER_SUBNET_CIDR}' ❹
EOF
```

- ❶ **infra\_id** is the **INFRA\_ID** infrastructure name from the extraction step.
- ❷ **region** is the region to deploy the cluster into, for example **us-central1**.
- ❸ **master\_subnet\_cidr** is the CIDR for the master subnet, for example **10.0.0.0/17**.
- ❹ **worker\_subnet\_cidr** is the CIDR for the worker subnet, for example **10.0.128.0/17**.

3. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-vpc --config 01_vpc.yaml
```

### 7.12.8.1. Deployment Manager template for the VPC

You can use the following Deployment Manager template to deploy the VPC that you need for your OpenShift Container Platform cluster:

#### Example 7.19. 01\_vpc.py Deployment Manager template

```
def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-network',
        'type': 'compute.v1.network',
        'properties': {
            'region': context.properties['region'],
            'autoCreateSubnetworks': False
```

```

    }
  }, {
    'name': context.properties['infra_id'] + '-master-subnet',
    'type': 'compute.v1.subnetwork',
    'properties': {
      'region': context.properties['region'],
      'network': '${ref.' + context.properties['infra_id'] + '-network.selfLink}',
      'ipCidrRange': context.properties['master_subnet_cidr']
    }
  }, {
    'name': context.properties['infra_id'] + '-worker-subnet',
    'type': 'compute.v1.subnetwork',
    'properties': {
      'region': context.properties['region'],
      'network': '${ref.' + context.properties['infra_id'] + '-network.selfLink}',
      'ipCidrRange': context.properties['worker_subnet_cidr']
    }
  }, {
    'name': context.properties['infra_id'] + '-router',
    'type': 'compute.v1.router',
    'properties': {
      'region': context.properties['region'],
      'network': '${ref.' + context.properties['infra_id'] + '-network.selfLink}',
      'nats': [{
        'name': context.properties['infra_id'] + '-nat-master',
        'natIpAllocateOption': 'AUTO_ONLY',
        'minPortsPerVm': 7168,
        'sourceSubnetworkIpRangesToNat': 'LIST_OF_SUBNETWORKS',
        'subnetworks': [{
          'name': '${ref.' + context.properties['infra_id'] + '-master-subnet.selfLink}',
          'sourceIpRangesToNat': ['ALL_IP_RANGES']
        }]
      }]
    }
  }, {
    'name': context.properties['infra_id'] + '-nat-worker',
    'natIpAllocateOption': 'AUTO_ONLY',
    'minPortsPerVm': 512,
    'sourceSubnetworkIpRangesToNat': 'LIST_OF_SUBNETWORKS',
    'subnetworks': [{
      'name': '${ref.' + context.properties['infra_id'] + '-worker-subnet.selfLink}',
      'sourceIpRangesToNat': ['ALL_IP_RANGES']
    }]
  }
}
]]
return {'resources': resources}

```

## 7.12.9. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

### 7.12.9.1. Setting the cluster node hostnames through DHCP

On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

### 7.12.9.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.

**Table 7.56. Ports used for all-machine to all-machine communications**

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	<b>1936</b>	Metrics
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> and the Cluster Version Operator on port <b>9099</b> .
	<b>10250-10259</b>	The default ports that Kubernetes reserves
	<b>10256</b>	openshift-sdn
UDP	<b>4789</b>	VXLAN and Geneve
	<b>6081</b>	VXLAN and Geneve
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> .
	<b>500</b>	IPsec IKE packets
	<b>4500</b>	IPsec NAT-T packets
TCP/UDP	<b>30000-32767</b>	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

**Table 7.57. Ports used for all-machine to control plane communications**

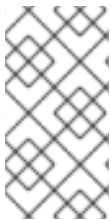
Protocol	Port	Description
TCP	<b>6443</b>	Kubernetes API

**Table 7.58. Ports used for control plane machine to control plane machine communications**

Protocol	Port	Description
TCP	<b>2379-2380</b>	etcd server and peer ports

### 7.12.10. Creating load balancers in GCP

You must configure load balancers in Google Cloud Platform (GCP) for your OpenShift Container Platform cluster to use. One way to create these components is to modify the provided Deployment Manager template.



#### NOTE

If you do not use the provided Deployment Manager template to create your GCP infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

#### Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.

#### Procedure

1. Copy the template from the **Deployment Manager template for the internal load balancer** section of this topic and save it as **02\_lb\_int.py** on your computer. This template describes the internal load balancing objects that your cluster requires.
2. For an external cluster, also copy the template from the **Deployment Manager template for the external load balancer** section of this topic and save it as **02\_lb\_ext.py** on your computer. This template describes the external load balancing objects that your cluster requires.
3. Export the variables that the deployment template uses:
  - a. Export the cluster network location:

```
$ export CLUSTER_NETWORK=(`gcloud compute networks describe ${INFRA_ID}-network --format json | jq -r .selfLink`)
```

- b. Export the control plane subnet location:

```
$ export CONTROL_SUBNET=(`gcloud compute networks subnets describe ${INFRA_ID}-master-subnet --region=${REGION} --format json | jq -r .selfLink`)
```



- c. Export the three zones that the cluster uses:

```
$ export ZONE_0=`gcloud compute regions describe ${REGION} --format=json | jq -r
.zones[0] | cut -d "/" -f9`
```

```
$ export ZONE_1=`gcloud compute regions describe ${REGION} --format=json | jq -r
.zones[1] | cut -d "/" -f9`
```

```
$ export ZONE_2=`gcloud compute regions describe ${REGION} --format=json | jq -r
.zones[2] | cut -d "/" -f9`
```

4. Create a **02\_infra.yaml** resource definition file:

```
$ cat <<EOF >02_infra.yaml
imports:
- path: 02_lb_ext.py
- path: 02_lb_int.py 1
resources:
- name: cluster-lb-ext 2
  type: 02_lb_ext.py
  properties:
    infra_id: '${INFRA_ID}' 3
    region: '${REGION}' 4
- name: cluster-lb-int
  type: 02_lb_int.py
  properties:
    cluster_network: '${CLUSTER_NETWORK}'
    control_subnet: '${CONTROL_SUBNET}' 5
    infra_id: '${INFRA_ID}'
    region: '${REGION}'
    zones: 6
    - '${ZONE_0}'
    - '${ZONE_1}'
    - '${ZONE_2}'
EOF
```

1 2 Required only when deploying an external cluster.

3 **infra\_id** is the **INFRA\_ID** infrastructure name from the extraction step.

4 **region** is the region to deploy the cluster into, for example **us-central1**.

5 **control\_subnet** is the URI to the control subnet.

6 **zones** are the zones to deploy the control plane instances into, like **us-east1-b**, **us-east1-c**, and **us-east1-d**.

5. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-infra --config 02_infra.yaml
```

6. Export the cluster IP address:

```
$ export CLUSTER_IP=(`gcloud compute addresses describe ${INFRA_ID}-cluster-ip --
region=${REGION} --format json | jq -r .address`)
```

- For an external cluster, also export the cluster public IP address:

```
$ export CLUSTER_PUBLIC_IP=(`gcloud compute addresses describe ${INFRA_ID}-cluster-
public-ip --region=${REGION} --format json | jq -r .address`)
```

### 7.12.10.1. Deployment Manager template for the external load balancer

You can use the following Deployment Manager template to deploy the external load balancer that you need for your OpenShift Container Platform cluster:

#### Example 7.20. `02_lb_ext.py` Deployment Manager template

```
def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-cluster-public-ip',
        'type': 'compute.v1.address',
        'properties': {
            'region': context.properties['region']
        }
    }, {
        # Refer to docs/dev/kube-apiserver-health-check.md on how to correctly setup health check
        # probe for kube-apiserver
        'name': context.properties['infra_id'] + '-api-http-health-check',
        'type': 'compute.v1.httpHealthCheck',
        'properties': {
            'port': 6080,
            'requestPath': '/readyz'
        }
    }, {
        'name': context.properties['infra_id'] + '-api-target-pool',
        'type': 'compute.v1.targetPool',
        'properties': {
            'region': context.properties['region'],
            'healthChecks': ['$$(ref.' + context.properties['infra_id'] + '-api-http-health-check.selfLink)'],
            'instances': []
        }
    }, {
        'name': context.properties['infra_id'] + '-api-forwarding-rule',
        'type': 'compute.v1.forwardingRule',
        'properties': {
            'region': context.properties['region'],
            'IPAddress': '$$(ref.' + context.properties['infra_id'] + '-cluster-public-ip.selfLink)',
            'target': '$$(ref.' + context.properties['infra_id'] + '-api-target-pool.selfLink)',
            'portRange': '6443'
        }
    }
    ]

    return {'resources': resources}
```

### 7.12.10.2. Deployment Manager template for the internal load balancer

You can use the following Deployment Manager template to deploy the internal load balancer that you need for your OpenShift Container Platform cluster:

#### Example 7.21. `02_lb_int.py` Deployment Manager template

```
def GenerateConfig(context):

    backends = []
    for zone in context.properties['zones']:
        backends.append({
            'group': '$(ref.' + context.properties['infra_id'] + '-master-' + zone + '-instance-group' +
            '.selfLink)'
        })

    resources = [{
        'name': context.properties['infra_id'] + '-cluster-ip',
        'type': 'compute.v1.address',
        'properties': {
            'addressType': 'INTERNAL',
            'region': context.properties['region'],
            'subnetwork': context.properties['control_subnet']
        }
    }, {
        # Refer to docs/dev/kube-apiserver-health-check.md on how to correctly setup health check
        # probe for kube-apiserver
        'name': context.properties['infra_id'] + '-api-internal-health-check',
        'type': 'compute.v1.healthCheck',
        'properties': {
            'httpsHealthCheck': {
                'port': 6443,
                'requestPath': '/readyz'
            },
            'type': "HTTPS"
        }
    }, {
        'name': context.properties['infra_id'] + '-api-internal-backend-service',
        'type': 'compute.v1.regionBackendService',
        'properties': {
            'backends': backends,
            'healthChecks': ['$(ref.' + context.properties['infra_id'] + '-api-internal-health-
            check.selfLink)'],
            'loadBalancingScheme': 'INTERNAL',
            'region': context.properties['region'],
            'protocol': 'TCP',
            'timeoutSec': 120
        }
    }, {
        'name': context.properties['infra_id'] + '-api-internal-forwarding-rule',
        'type': 'compute.v1.forwardingRule',
        'properties': {
            'backendService': '$(ref.' + context.properties['infra_id'] + '-api-internal-backend-
            service.selfLink)',
            'IPAddress': '$(ref.' + context.properties['infra_id'] + '-cluster-ip.selfLink)',
            'loadBalancingScheme': 'INTERNAL',
```

```

        'ports': ['6443', '22623'],
        'region': context.properties['region'],
        'subnetwork': context.properties['control_subnet']
    }
}]

for zone in context.properties['zones']:
    resources.append({
        'name': context.properties['infra_id'] + '-master-' + zone + '-instance-group',
        'type': 'compute.v1.instanceGroup',
        'properties': {
            'namedPorts': [
                {
                    'name': 'ignition',
                    'port': 22623
                }, {
                    'name': 'https',
                    'port': 6443
                }
            ],
            'network': context.properties['cluster_network'],
            'zone': zone
        }
    })

return {'resources': resources}

```

You will need this template in addition to the **02\_lb\_ext.py** template when you create an external cluster.

### 7.12.11. Creating a private DNS zone in GCP

You must configure a private DNS zone in Google Cloud Platform (GCP) for your OpenShift Container Platform cluster to use. One way to create this component is to modify the provided Deployment Manager template.



#### NOTE

If you do not use the provided Deployment Manager template to create your GCP infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

#### Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.

#### Procedure

1. Copy the template from the **Deployment Manager template for the private DNS** section of this topic and save it as **02\_dns.py** on your computer. This template describes the private DNS objects that your cluster requires.
2. Create a **02\_dns.yaml** resource definition file:

```
$ cat <<EOF >02_dns.yaml
imports:
- path: 02_dns.py

resources:
- name: cluster-dns
  type: 02_dns.py
  properties:
    infra_id: '${INFRA_ID}' 1
    cluster_domain: '${CLUSTER_NAME}.${BASE_DOMAIN}' 2
    cluster_network: '${CLUSTER_NETWORK}' 3
EOF
```

- 1** **infra\_id** is the **INFRA\_ID** infrastructure name from the extraction step.
- 2** **cluster\_domain** is the domain for the cluster, for example **openshift.example.com**.
- 3** **cluster\_network** is the **selfLink** URL to the cluster network.

3. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-dns --config 02_dns.yaml
```

4. The templates do not create DNS entries due to limitations of Deployment Manager, so you must create them manually:
  - a. Add the internal DNS entries:

```
$ if [ -f transaction.yaml ]; then rm transaction.yaml; fi
$ gcloud dns record-sets transaction start --zone ${INFRA_ID}-private-zone
$ gcloud dns record-sets transaction add ${CLUSTER_IP} --name
api.${CLUSTER_NAME}.${BASE_DOMAIN}. --ttl 60 --type A --zone ${INFRA_ID}-
private-zone
$ gcloud dns record-sets transaction add ${CLUSTER_IP} --name api-
int.${CLUSTER_NAME}.${BASE_DOMAIN}. --ttl 60 --type A --zone ${INFRA_ID}-
private-zone
$ gcloud dns record-sets transaction execute --zone ${INFRA_ID}-private-zone
```

- b. For an external cluster, also add the external DNS entries:

```
$ if [ -f transaction.yaml ]; then rm transaction.yaml; fi
$ gcloud dns record-sets transaction start --zone ${BASE_DOMAIN_ZONE_NAME}
$ gcloud dns record-sets transaction add ${CLUSTER_PUBLIC_IP} --name
api.${CLUSTER_NAME}.${BASE_DOMAIN}. --ttl 60 --type A --zone
${BASE_DOMAIN_ZONE_NAME}
$ gcloud dns record-sets transaction execute --zone ${BASE_DOMAIN_ZONE_NAME}
```

### 7.12.11.1. Deployment Manager template for the private DNS

You can use the following Deployment Manager template to deploy the private DNS that you need for your OpenShift Container Platform cluster:

#### Example 7.22. `02_dns.py` Deployment Manager template

```
def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-private-zone',
        'type': 'dns.v1.managedZone',
        'properties': {
            'description': "",
            'dnsName': context.properties['cluster_domain'] + '.',
            'visibility': 'private',
            'privateVisibilityConfig': {
                'networks': [{
                    'networkUrl': context.properties['cluster_network']
                }]
            }
        }
    }]

    return {'resources': resources}
```

### 7.12.12. Creating firewall rules in GCP

You must create firewall rules in Google Cloud Platform (GCP) for your OpenShift Container Platform cluster to use. One way to create these components is to modify the provided Deployment Manager template.



#### NOTE

If you do not use the provided Deployment Manager template to create your GCP infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

#### Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.

#### Procedure

1. Copy the template from the **Deployment Manager template for firewall rules** section of this topic and save it as `03_firewall.py` on your computer. This template describes the security groups that your cluster requires.

2. Create a **03\_firewall.yaml** resource definition file:

```
$ cat <<EOF >03_firewall.yaml
imports:
- path: 03_firewall.py

resources:
- name: cluster-firewall
  type: 03_firewall.py
  properties:
    allowed_external_cidr: '0.0.0.0/0' ❶
    infra_id: '${INFRA_ID}' ❷
    cluster_network: '${CLUSTER_NETWORK}' ❸
    network_cidr: '${NETWORK_CIDR}' ❹
EOF
```

- ❶ **allowed\_external\_cidr** is the CIDR range that can access the cluster API and SSH to the bootstrap host. For an internal cluster, set this value to **\${NETWORK\_CIDR}**.
- ❷ **infra\_id** is the **INFRA\_ID** infrastructure name from the extraction step.
- ❸ **cluster\_network** is the **selfLink** URL to the cluster network.
- ❹ **network\_cidr** is the CIDR of the VPC network, for example **10.0.0.0/16**.

3. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-firewall --config
03_firewall.yaml
```

### 7.12.12.1. Deployment Manager template for firewall rules

You can use the following Deployment Manager template to deploy the firewall rules that you need for your OpenShift Container Platform cluster:

#### Example 7.23. 03\_firewall.py Deployment Manager template

```
def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-bootstrap-in-ssh',
        'type': 'compute.v1.firewall',
        'properties': {
            'network': context.properties['cluster_network'],
            'allowed': [{
                'IPProtocol': 'tcp',
                'ports': ['22']
            }],
            'sourceRanges': [context.properties['allowed_external_cidr']],
            'targetTags': [context.properties['infra_id'] + '-bootstrap']
        }
    ], {
        'name': context.properties['infra_id'] + '-api',
```

```

    'type': 'compute.v1.firewall',
    'properties': {
      'network': context.properties[cluster_network],
      'allowed': [{
        'IPProtocol': 'tcp',
        'ports': ['6443']
      }],
      'sourceRanges': [context.properties[allowed_external_cidr]],
      'targetTags': [context.properties[infra_id] + '-master']
    }
  }, {
    'name': context.properties[infra_id] + '-health-checks',
    'type': 'compute.v1.firewall',
    'properties': {
      'network': context.properties[cluster_network],
      'allowed': [{
        'IPProtocol': 'tcp',
        'ports': ['6080', '6443', '22624']
      }],
      'sourceRanges': ['35.191.0.0/16', '130.211.0.0/22', '209.85.152.0/22', '209.85.204.0/22'],
      'targetTags': [context.properties[infra_id] + '-master']
    }
  }, {
    'name': context.properties[infra_id] + '-etcd',
    'type': 'compute.v1.firewall',
    'properties': {
      'network': context.properties[cluster_network],
      'allowed': [{
        'IPProtocol': 'tcp',
        'ports': ['2379-2380']
      }],
      'sourceTags': [context.properties[infra_id] + '-master'],
      'targetTags': [context.properties[infra_id] + '-master']
    }
  }, {
    'name': context.properties[infra_id] + '-control-plane',
    'type': 'compute.v1.firewall',
    'properties': {
      'network': context.properties[cluster_network],
      'allowed': [{
        'IPProtocol': 'tcp',
        'ports': ['10257']
      }],
      'sourceTags': [
        context.properties[infra_id] + '-master',
        context.properties[infra_id] + '-worker'
      ],
      'targetTags': [context.properties[infra_id] + '-master']
    }
  }, {

```



```

'name': context.properties['infra_id'] + '-internal-network',
'type': 'compute.v1.firewall',
'properties': {
  'network': context.properties['cluster_network'],
  'allowed': [{
    'IPProtocol': 'icmp'
  },{
    'IPProtocol': 'tcp',
    'ports': ['22']
  }],
  'sourceRanges': [context.properties['network_cidr']],
  'targetTags': [
    context.properties['infra_id'] + '-master',
    context.properties['infra_id'] + '-worker'
  ]
}
}, {
'name': context.properties['infra_id'] + '-internal-cluster',
'type': 'compute.v1.firewall',
'properties': {
  'network': context.properties['cluster_network'],
  'allowed': [{
    'IPProtocol': 'udp',
    'ports': ['4789', '6081']
  },{
    'IPProtocol': 'udp',
    'ports': ['500', '4500']
  },{
    'IPProtocol': 'esp',
  },{
    'IPProtocol': 'tcp',
    'ports': ['9000-9999']
  },{
    'IPProtocol': 'udp',
    'ports': ['9000-9999']
  },{
    'IPProtocol': 'tcp',
    'ports': ['10250']
  },{
    'IPProtocol': 'tcp',
    'ports': ['30000-32767']
  },{
    'IPProtocol': 'udp',
    'ports': ['30000-32767']
  }],
  'sourceTags': [
    context.properties['infra_id'] + '-master',
    context.properties['infra_id'] + '-worker'
  ],
  'targetTags': [
    context.properties['infra_id'] + '-master',
    context.properties['infra_id'] + '-worker'
  ]
}
}

```

```

}}
return {'resources': resources}

```

### 7.12.13. Creating IAM roles in GCP

You must create IAM roles in Google Cloud Platform (GCP) for your OpenShift Container Platform cluster to use. One way to create these components is to modify the provided Deployment Manager template.



#### NOTE

If you do not use the provided Deployment Manager template to create your GCP infrastructure, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

#### Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.

#### Procedure

1. Copy the template from the **Deployment Manager template for IAM roles** section of this topic and save it as **03\_iam.py** on your computer. This template describes the IAM roles that your cluster requires.
2. Create a **03\_iam.yaml** resource definition file:

```

$ cat <<EOF >03_iam.yaml
imports:
- path: 03_iam.py
resources:
- name: cluster-iam
  type: 03_iam.py
  properties:
    infra_id: '${INFRA_ID}' 1
EOF

```

- 1 **infra\_id** is the **INFRA\_ID** infrastructure name from the extraction step.

3. Create the deployment by using the **gcloud** CLI:

```

$ gcloud deployment-manager deployments create ${INFRA_ID}-iam --config 03_iam.yaml

```

4. Export the variable for the master service account:

```
$ export MASTER_SERVICE_ACCOUNT=$(gcloud iam service-accounts list --filter
"email~^${INFRA_ID}-m@${PROJECT_NAME}." --format json | jq -r '[0].email')
```

- Export the variable for the worker service account:

```
$ export WORKER_SERVICE_ACCOUNT=$(gcloud iam service-accounts list --filter
"email~^${INFRA_ID}-w@${PROJECT_NAME}." --format json | jq -r '[0].email')
```

- Export the variable for the subnet that hosts the compute machines:

```
$ export COMPUTE_SUBNET=$(gcloud compute networks subnets describe ${INFRA_ID}-
worker-subnet --region=${REGION} --format json | jq -r .selfLink)
```

- The templates do not create the policy bindings due to limitations of Deployment Manager, so you must create them manually:

```
$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${MASTER_SERVICE_ACCOUNT}" --role "roles/compute.instanceAdmin"
$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${MASTER_SERVICE_ACCOUNT}" --role "roles/compute.networkAdmin"
$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${MASTER_SERVICE_ACCOUNT}" --role "roles/compute.securityAdmin"
$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${MASTER_SERVICE_ACCOUNT}" --role "roles/iam.serviceAccountUser"
$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${MASTER_SERVICE_ACCOUNT}" --role "roles/storage.admin"

$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${WORKER_SERVICE_ACCOUNT}" --role "roles/compute.viewer"
$ gcloud projects add-iam-policy-binding ${PROJECT_NAME} --member
"serviceAccount:${WORKER_SERVICE_ACCOUNT}" --role "roles/storage.admin"
```

- Create a service account key and store it locally for later use:

```
$ gcloud iam service-accounts keys create service-account-key.json --iam-
account=${MASTER_SERVICE_ACCOUNT}
```

### 7.12.13.1. Deployment Manager template for IAM roles

You can use the following Deployment Manager template to deploy the IAM roles that you need for your OpenShift Container Platform cluster:

#### Example 7.24. 03\_iam.py Deployment Manager template

```
def GenerateConfig(context):
    resources = [{
        'name': context.properties['infra_id'] + '-master-node-sa',
        'type': 'iam.v1.serviceAccount',
        'properties': {
            'accountId': context.properties['infra_id'] + '-m',
            'displayName': context.properties['infra_id'] + '-master-node'
        }
    }]
```

```

    }, {
      'name': context.properties['infra_id'] + '-worker-node-sa',
      'type': 'iam.v1.serviceAccount',
      'properties': {
        'accountId': context.properties['infra_id'] + '-w',
        'displayName': context.properties['infra_id'] + '-worker-node'
      }
    }
  ]
}

return {'resources': resources}

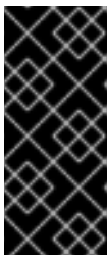
```

### 7.12.14. Creating the RHCOS cluster image for the GCP infrastructure

You must use a valid Red Hat Enterprise Linux CoreOS (RHCOS) image for Google Cloud Platform (GCP) for your OpenShift Container Platform nodes.

#### Procedure

1. Obtain the RHCOS image from the [RHCOS image mirror](#) page.



#### IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download an image with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image version that matches your OpenShift Container Platform version if it is available.

The file name contains the OpenShift Container Platform version number in the format **rhcos-  
<version>-<arch>-gcp.<arch>.tar.gz**.

2. Create the Google storage bucket:

```
$ gsutil mb gs://<bucket_name>
```

3. Upload the RHCOS image to the Google storage bucket:

```
$ gsutil cp <downloaded_image_file_path>/rhcos-<version>-x86_64-gcp.x86_64.tar.gz
gs://<bucket_name>
```

4. Export the uploaded RHCOS image location as a variable:

```
$ export IMAGE_SOURCE=gs://<bucket_name>/rhcos-<version>-x86_64-gcp.x86_64.tar.gz
```

5. Create the cluster image:

```
$ gcloud compute images create "${INFRA_ID}-rhcos-image" \
  --source-uri="${IMAGE_SOURCE}"
```

### 7.12.15. Creating the bootstrap machine in GCP

You must create the bootstrap machine in Google Cloud Platform (GCP) to use during OpenShift Container Platform cluster initialization. One way to create this machine is to modify the provided Deployment Manager template.



## NOTE

If you do not use the provided Deployment Manager template to create your bootstrap machine, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

## Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.
- Create and configure networking and load balancers in GCP.
- Create control plane and compute roles.
- Ensure pyOpenSSL is installed.

## Procedure

1. Copy the template from the **Deployment Manager template for the bootstrap machine** section of this topic and save it as **04\_bootstrap.py** on your computer. This template describes the bootstrap machine that your cluster requires.
2. Export the location of the Red Hat Enterprise Linux CoreOS (RHCOS) image that the installation program requires:

```
$ export CLUSTER_IMAGE=$(gcloud compute images describe ${INFRA_ID}-rhcos-image --
format json | jq -r .selfLink`)
```

3. Create a bucket and upload the **bootstrap.ign** file:

```
$ gsutil mb gs://${INFRA_ID}-bootstrap-ignition
$ gsutil cp <installation_directory>/bootstrap.ign gs://${INFRA_ID}-bootstrap-ignition/
```

4. Create a signed URL for the bootstrap instance to use to access the Ignition config. Export the URL from the output as a variable:

```
$ export BOOTSTRAP_IGN=`gsutil signurl -d 1h service-account-key.json gs://${INFRA_ID}-
bootstrap-ignition/bootstrap.ign | grep "^gs:" | awk '{print $5}`
```

5. Create a **04\_bootstrap.yaml** resource definition file:

```
$ cat <<EOF >04_bootstrap.yaml
imports:
- path: 04_bootstrap.py
```

```
resources:
- name: cluster-bootstrap
  type: 04_bootstrap.py
  properties:
    infra_id: '${INFRA_ID}' 1
    region: '${REGION}' 2
    zone: '${ZONE_0}' 3

    cluster_network: '${CLUSTER_NETWORK}' 4
    control_subnet: '${CONTROL_SUBNET}' 5
    image: '${CLUSTER_IMAGE}' 6
    machine_type: 'n1-standard-4' 7
    root_volume_size: '128' 8

    bootstrap_ign: '${BOOTSTRAP_IGN}' 9
EOF
```

- 1 **infra\_id** is the **INFRA\_ID** infrastructure name from the extraction step.
- 2 **region** is the region to deploy the cluster into, for example **us-central1**.
- 3 **zone** is the zone to deploy the bootstrap instance into, for example **us-central1-b**.
- 4 **cluster\_network** is the **selfLink** URL to the cluster network.
- 5 **control\_subnet** is the **selfLink** URL to the control subnet.
- 6 **image** is the **selfLink** URL to the RHCOS image.
- 7 **machine\_type** is the machine type of the instance, for example **n1-standard-4**.
- 8 **root\_volume\_size** is the boot disk size for the bootstrap machine.
- 9 **bootstrap\_ign** is the URL output when creating a signed URL.

6. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-bootstrap --config
04_bootstrap.yaml
```

7. The templates do not manage load balancer membership due to limitations of Deployment Manager, so you must add the bootstrap machine manually.

- a. Add the bootstrap instance to the internal load balancer instance group:

```
$ gcloud compute instance-groups unmanaged add-instances \
  ${INFRA_ID}-bootstrap-instance-group --zone=${ZONE_0} --instances=${INFRA_ID}-
  bootstrap
```

- b. Add the bootstrap instance group to the internal load balancer backend service:

```
$ gcloud compute backend-services add-backend \
  ${INFRA_ID}-api-internal-backend-service --region=${REGION} --instance-
  group=${INFRA_ID}-bootstrap-instance-group --instance-group-zone=${ZONE_0}
```

### 7.12.15.1. Deployment Manager template for the bootstrap machine

You can use the following Deployment Manager template to deploy the bootstrap machine that you need for your OpenShift Container Platform cluster:

#### Example 7.25. 04\_bootstrap.py Deployment Manager template

```
def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-bootstrap-public-ip',
        'type': 'compute.v1.address',
        'properties': {
            'region': context.properties['region']
        }
    }, {
        'name': context.properties['infra_id'] + '-bootstrap',
        'type': 'compute.v1.instance',
        'properties': {
            'disks': [{
                'autoDelete': True,
                'boot': True,
                'initializeParams': {
                    'diskSizeGb': context.properties['root_volume_size'],
                    'sourceImage': context.properties['image']
                }
            }],
            'machineType': 'zones/' + context.properties['zone'] + '/machineTypes/' +
context.properties['machine_type'],
            'metadata': {
                'items': [{
                    'key': 'user-data',
                    'value': '{"ignition":{"config":{"replace":{"source":"' + context.properties['bootstrap_ign']
+ '"},"version":"3.1.0"}}}',
                }],
            },
            'networkInterfaces': [{
                'subnetwork': context.properties['control_subnet'],
                'accessConfigs': [{
                    'natIP': '$(ref.' + context.properties['infra_id'] + '-bootstrap-public-ip.address)'
                }],
            }],
            'tags': {
                'items': [
                    context.properties['infra_id'] + '-master',
                    context.properties['infra_id'] + '-bootstrap'
                ]
            },
            'zone': context.properties['zone']
        }
    }, {
        'name': context.properties['infra_id'] + '-bootstrap-instance-group',
        'type': 'compute.v1.instanceGroup',
        'properties': {
```

```

    'namedPorts': [
      {
        'name': 'ignition',
        'port': 22623
      }, {
        'name': 'https',
        'port': 6443
      }
    ],
    'network': context.properties['cluster_network'],
    'zone': context.properties['zone']
  }
}
]]

return {'resources': resources}

```

### 7.12.16. Creating the control plane machines in GCP

You must create the control plane machines in Google Cloud Platform (GCP) for your cluster to use. One way to create these machines is to modify the provided Deployment Manager template.



#### NOTE

If you do not use the provided Deployment Manager template to create your control plane machines, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

#### Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.
- Create and configure networking and load balancers in GCP.
- Create control plane and compute roles.
- Create the bootstrap machine.

#### Procedure

1. Copy the template from the **Deployment Manager template for control plane machines** section of this topic and save it as **05\_control\_plane.py** on your computer. This template describes the control plane machines that your cluster requires.
2. Export the following variable required by the resource definition:

```
$ export MASTER_IGNITION=`cat <installation_directory>/master.ign`
```

3. Create a **05\_control\_plane.yaml** resource definition file:

-



```

$ cat <<EOF >05_control_plane.yaml
imports:
- path: 05_control_plane.py

resources:
- name: cluster-control-plane
  type: 05_control_plane.py
  properties:
    infra_id: '${INFRA_ID}' ❶
    zones: ❷
    - '${ZONE_0}'
    - '${ZONE_1}'
    - '${ZONE_2}'

    control_subnet: '${CONTROL_SUBNET}' ❸
    image: '${CLUSTER_IMAGE}' ❹
    machine_type: 'n1-standard-4' ❺
    root_volume_size: '128'
    service_account_email: '${MASTER_SERVICE_ACCOUNT}' ❻

    ignition: '${MASTER_IGNITION}' ❼
EOF

```

- ❶ **infra\_id** is the **INFRA\_ID** infrastructure name from the extraction step.
- ❷ **zones** are the zones to deploy the control plane instances into, for example **us-central1-a**, **us-central1-b**, and **us-central1-c**.
- ❸ **control\_subnet** is the **selfLink** URL to the control subnet.
- ❹ **image** is the **selfLink** URL to the RHCOS image.
- ❺ **machine\_type** is the machine type of the instance, for example **n1-standard-4**.
- ❻ **service\_account\_email** is the email address for the master service account that you created.
- ❼ **ignition** is the contents of the **master.ign** file.

4. Create the deployment by using the **gcloud** CLI:

```

$ gcloud deployment-manager deployments create ${INFRA_ID}-control-plane --config
05_control_plane.yaml

```

5. The templates do not manage load balancer membership due to limitations of Deployment Manager, so you must add the control plane machines manually.

- Run the following commands to add the control plane machines to the appropriate instance groups:

```

$ gcloud compute instance-groups unmanaged add-instances ${INFRA_ID}-master-
${ZONE_0}-instance-group --zone=${ZONE_0} --instances=${INFRA_ID}-master-0
$ gcloud compute instance-groups unmanaged add-instances ${INFRA_ID}-master-

```

```

    ${ZONE_1}-instance-group --zone=${ZONE_1} --instances=${INFRA_ID}-master-1
    $ gcloud compute instance-groups unmanaged add-instances ${INFRA_ID}-master-
    ${ZONE_2}-instance-group --zone=${ZONE_2} --instances=${INFRA_ID}-master-2

```

- For an external cluster, you must also run the following commands to add the control plane machines to the target pools:

```

    $ gcloud compute target-pools add-instances ${INFRA_ID}-api-target-pool --instances-
    zone="${ZONE_0}" --instances=${INFRA_ID}-master-0
    $ gcloud compute target-pools add-instances ${INFRA_ID}-api-target-pool --instances-
    zone="${ZONE_1}" --instances=${INFRA_ID}-master-1
    $ gcloud compute target-pools add-instances ${INFRA_ID}-api-target-pool --instances-
    zone="${ZONE_2}" --instances=${INFRA_ID}-master-2

```

### 7.12.16.1. Deployment Manager template for control plane machines

You can use the following Deployment Manager template to deploy the control plane machines that you need for your OpenShift Container Platform cluster:

#### Example 7.26. 05\_control\_plane.py Deployment Manager template

```

def GenerateConfig(context):

    resources = [{
        'name': context.properties['infra_id'] + '-master-0',
        'type': 'compute.v1.instance',
        'properties': {
            'disks': [{
                'autoDelete': True,
                'boot': True,
                'initializeParams': {
                    'diskSizeGb': context.properties['root_volume_size'],
                    'diskType': 'zones/' + context.properties['zones'][0] + '/diskTypes/pd-ssd',
                    'sourceImage': context.properties['image']
                }
            }
        ],
        'machineType': 'zones/' + context.properties['zones'][0] + '/machineTypes/' +
context.properties['machine_type'],
        'metadata': {
            'items': [{
                'key': 'user-data',
                'value': context.properties['ignition']
            }
        ]
    },
        'networkInterfaces': [{
            'subnetwork': context.properties['control_subnet']
        }
    ],
        'serviceAccounts': [{
            'email': context.properties['service_account_email'],
            'scopes': ['https://www.googleapis.com/auth/cloud-platform']
        }
    ],
        'tags': {
            'items': [
                context.properties['infra_id'] + '-master',
            ]
        }
    ]

```

```

    },
    'zone': context.properties['zones'][0]
  }
}, {
  'name': context.properties['infra_id'] + '-master-1',
  'type': 'compute.v1.instance',
  'properties': {
    'disks': [{
      'autoDelete': True,
      'boot': True,
      'initializeParams': {
        'diskSizeGb': context.properties['root_volume_size'],
        'diskType': 'zones/' + context.properties['zones'][1] + '/diskTypes/pd-ssd',
        'sourceImage': context.properties['image']
      }
    }
  ],
  'machineType': 'zones/' + context.properties['zones'][1] + '/machineTypes/' +
context.properties['machine_type'],
  'metadata': {
    'items': [{
      'key': 'user-data',
      'value': context.properties['ignition']
    }
  ]
},
  'networkInterfaces': [{
    'subnetwork': context.properties['control_subnet']
  }],
  'serviceAccounts': [{
    'email': context.properties['service_account_email'],
    'scopes': ['https://www.googleapis.com/auth/cloud-platform']
  }],
  'tags': {
    'items': [
      context.properties['infra_id'] + '-master',
    ]
  },
  'zone': context.properties['zones'][1]
}
}, {
  'name': context.properties['infra_id'] + '-master-2',
  'type': 'compute.v1.instance',
  'properties': {
    'disks': [{
      'autoDelete': True,
      'boot': True,
      'initializeParams': {
        'diskSizeGb': context.properties['root_volume_size'],
        'diskType': 'zones/' + context.properties['zones'][2] + '/diskTypes/pd-ssd',
        'sourceImage': context.properties['image']
      }
    }
  ],
  'machineType': 'zones/' + context.properties['zones'][2] + '/machineTypes/' +
context.properties['machine_type'],
  'metadata': {
    'items': [{
      'key': 'user-data',

```

```

        'value': context.properties['ignition']
    }
  },
  'networkInterfaces': [{
    'subnetwork': context.properties['control_subnet']
  }],
  'serviceAccounts': [{
    'email': context.properties['service_account_email'],
    'scopes': ['https://www.googleapis.com/auth/cloud-platform']
  }],
  'tags': {
    'items': [
      context.properties['infra_id'] + '-master',
    ]
  },
  'zone': context.properties['zones'][2]
}
]]

return {'resources': resources}

```

### 7.12.17. Wait for bootstrap completion and remove bootstrap resources in GCP

After you create all of the required infrastructure in Google Cloud Platform (GCP), wait for the bootstrap process to complete on the machines that you provisioned by using the Ignition config files that you generated with the installation program.

#### Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.
- Create and configure networking and load balancers in GCP.
- Create control plane and compute roles.
- Create the bootstrap machine.
- Create the control plane machines.

#### Procedure

1. Change to the directory that contains the installation program and run the following command:

```

$ ./openshift-install wait-for bootstrap-complete --dir <installation_directory> \ 1
--log-level info 2

```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

- 2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

If the command exits without a **FATAL** warning, your production control plane has initialized.

2. Delete the bootstrap resources:

```
$ gcloud compute backend-services remove-backend ${INFRA_ID}-api-internal-backend-
service --region=${REGION} --instance-group=${INFRA_ID}-bootstrap-instance-group --
instance-group-zone=${ZONE_0}
$ gsutil rm gs://${INFRA_ID}-bootstrap-ignition/bootstrap.ign
$ gsutil rb gs://${INFRA_ID}-bootstrap-ignition
$ gcloud deployment-manager deployments delete ${INFRA_ID}-bootstrap
```

### 7.12.18. Creating additional worker machines in GCP

You can create worker machines in Google Cloud Platform (GCP) for your cluster to use by launching individual instances discretely or by automated processes outside the cluster, such as auto scaling groups. You can also take advantage of the built-in cluster scaling mechanisms and the machine API in OpenShift Container Platform.

In this example, you manually launch one instance by using the Deployment Manager template. Additional instances can be launched by including additional resources of type **06\_worker.py** in the file.



#### NOTE

If you do not use the provided Deployment Manager template to create your worker machines, you must review the provided information and manually create the infrastructure. If your cluster does not initialize correctly, you might have to contact Red Hat support with your installation logs.

#### Prerequisites

- Configure a GCP account.
- Generate the Ignition config files for your cluster.
- Create and configure a VPC and associated subnets in GCP.
- Create and configure networking and load balancers in GCP.
- Create control plane and compute roles.
- Create the bootstrap machine.
- Create the control plane machines.

#### Procedure

1. Copy the template from the **Deployment Manager template for worker machines** section of this topic and save it as **06\_worker.py** on your computer. This template describes the worker machines that your cluster requires.
2. Export the variables that the resource definition uses.
  - a. Export the subnet that hosts the compute machines:

```
$ export COMPUTE_SUBNET=$(gcloud compute networks subnets describe
${INFRA_ID}-worker-subnet --region=${REGION} --format json | jq -r '.selfLink')
```

- b. Export the email address for your service account:

```
$ export WORKER_SERVICE_ACCOUNT=$(gcloud iam service-accounts list --filter
"email~^${INFRA_ID}-w@${PROJECT_NAME}." --format json | jq -r '.[0].email')
```

- c. Export the location of the compute machine Ignition config file:

```
$ export WORKER_IGNITION=`cat <installation_directory>/worker.ign`
```

3. Create a **06\_worker.yaml** resource definition file:

```
$ cat <<EOF >06_worker.yaml
imports:
- path: 06_worker.py

resources:
- name: 'worker-0' 1
  type: 06_worker.py
  properties:
    infra_id: '${INFRA_ID}' 2
    zone: '${ZONE_0}' 3
    compute_subnet: '${COMPUTE_SUBNET}' 4
    image: '${CLUSTER_IMAGE}' 5
    machine_type: 'n1-standard-4' 6
    root_volume_size: '128'
    service_account_email: '${WORKER_SERVICE_ACCOUNT}' 7
    ignition: '${WORKER_IGNITION}' 8
- name: 'worker-1'
  type: 06_worker.py
  properties:
    infra_id: '${INFRA_ID}' 9
    zone: '${ZONE_1}' 10
    compute_subnet: '${COMPUTE_SUBNET}' 11
    image: '${CLUSTER_IMAGE}' 12
    machine_type: 'n1-standard-4' 13
    root_volume_size: '128'
    service_account_email: '${WORKER_SERVICE_ACCOUNT}' 14
    ignition: '${WORKER_IGNITION}' 15
EOF
```

1 **name** is the name of the worker machine, for example **worker-0**.

2 9 **infra\_id** is the **INFRA\_ID** infrastructure name from the extraction step.

3 10 **zone** is the zone to deploy the worker machine into, for example **us-central1-a**.

4 11 **compute\_subnet** is the **selfLink** URL to the compute subnet.

5 12 **image** is the **selfLink** URL to the RHCOS image. <sup>1</sup>

**6 13** `machine_type` is the machine type of the instance, for example **n1-standard-4**.

**7 14** `service_account_email` is the email address for the worker service account that you created.

**8 15** `ignition` is the contents of the `worker.ign` file.

4. Optional: If you want to launch additional instances, include additional resources of type **06\_worker.py** in your **06\_worker.yaml** resource definition file.
5. Create the deployment by using the **gcloud** CLI:

```
$ gcloud deployment-manager deployments create ${INFRA_ID}-worker --config
06_worker.yaml
```

1. To use a GCP Marketplace image, specify the offer to use:
  - OpenShift Container Platform: <https://www.googleapis.com/compute/v1/projects/redhat-marketplace-public/global/images/redhat-coreos-ocp-48-x86-64-202210040145>
  - OpenShift Platform Plus: <https://www.googleapis.com/compute/v1/projects/redhat-marketplace-public/global/images/redhat-coreos-opp-48-x86-64-202206140145>
  - OpenShift Kubernetes Engine: <https://www.googleapis.com/compute/v1/projects/redhat-marketplace-public/global/images/redhat-coreos-oke-48-x86-64-202206140145>

### 7.12.18.1. Deployment Manager template for worker machines

You can use the following Deployment Manager template to deploy the worker machines that you need for your OpenShift Container Platform cluster:

#### Example 7.27. `06_worker.py` Deployment Manager template

```
def GenerateConfig(context):
    resources = [{
        'name': context.properties['infra_id'] + '-' + context.env['name'],
        'type': 'compute.v1.instance',
        'properties': {
            'disks': [{
                'autoDelete': True,
                'boot': True,
                'initializeParams': {
                    'diskSizeGb': context.properties['root_volume_size'],
                    'sourceImage': context.properties['image']
                }
            }],
            'machineType': 'zones/' + context.properties['zone'] + '/machineTypes/' +
context.properties['machine_type'],
            'metadata': {
                'items': [{
                    'key': 'user-data',
                    'value': context.properties['ignition']
```

```

    }
  },
  'networkInterfaces': [{
    'subnetwork': context.properties['compute_subnet']
  }],
  'serviceAccounts': [{
    'email': context.properties['service_account_email'],
    'scopes': ['https://www.googleapis.com/auth/cloud-platform']
  }],
  'tags': {
    'items': [
      context.properties['infra_id'] + '-worker',
    ]
  },
  'zone': context.properties['zone']
}
]]
return {'resources': resources}

```

### 7.12.19. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

#### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

#### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

#### Example output

```
system:admin
```

### 7.12.20. Disabling the default OperatorHub sources



Operator catalogs that source content provided by Red Hat and community projects are configured for OperatorHub by default during an OpenShift Container Platform installation. In a restricted network environment, you must disable the default catalogs as a cluster administrator.

### Procedure

- Disable the sources for the default catalogs by adding **disableAllDefaultSources: true** to the **OperatorHub** object:

```
$ oc patch OperatorHub cluster --type json \
  -p '[{"op": "add", "path": "/spec/disableAllDefaultSources", "value": true}]'
```

### TIP

Alternatively, you can use the web console to manage catalog sources. From the **Administration** → **Cluster Settings** → **Configuration** → **OperatorHub** page, click the **Sources** tab, where you can create, delete, disable, and enable individual sources.

## 7.12.21. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

### Prerequisites

- You added machines to your cluster.

### Procedure

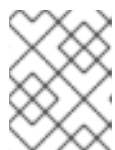
1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

### Example output

```
NAME      STATUS    ROLES    AGE   VERSION
master-0  Ready    master   63m   v1.22.1
master-1  Ready    master   63m   v1.22.1
master-2  Ready    master   64m   v1.22.1
```

The output lists all of the machines that you created.



### NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

2. Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

## Example output

```

NAME      AGE   REQUESTOR                                     CONDITION
csr-8b2br 15m   system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper Pending
csr-8vnps 15m   system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper Pending
...

```

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

- If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:



### NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.



### NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

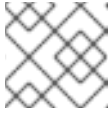
- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{"\n"}
{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```

**NOTE**

Some Operators might not become available until some CSRs are approved.

- Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

**Example output**

```
NAME      AGE   REQUESTOR                                     CONDITION
csr-bfd72 5m26s system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv 5m26s system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

- If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{"\n"}\n{{end}}{{end}}' | xargs oc adm certificate approve
```

- After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

**Example output**

```
NAME      STATUS  ROLES  AGE  VERSION
master-0  Ready   master 73m  v1.22.1
master-1  Ready   master 73m  v1.22.1
master-2  Ready   master 74m  v1.22.1
worker-0  Ready   worker 11m  v1.22.1
worker-1  Ready   worker 11m  v1.22.1
```

**NOTE**

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

## Additional information

- For more information on CSRs, see [Certificate Signing Requests](#).

### 7.12.22. Optional: Adding the ingress DNS records

If you removed the DNS zone configuration when creating Kubernetes manifests and generating Ignition configs, you must manually create DNS records that point at the ingress load balancer. You can create either a wildcard **\*.apps.{baseDomain}**, or specific records. You can use A, CNAME, and other records per your requirements.

#### Prerequisites

- Configure a GCP account.
- Remove the DNS Zone configuration when creating Kubernetes manifests and generating Ignition configs.
- Create and configure a VPC and associated subnets in GCP.
- Create and configure networking and load balancers in GCP.
- Create control plane and compute roles.
- Create the bootstrap machine.
- Create the control plane machines.
- Create the worker machines.

#### Procedure

1. Wait for the Ingress router to create a load balancer and populate the **EXTERNAL-IP** field:

```
$ oc -n openshift-ingress get service router-default
```

#### Example output

```
NAME          TYPE          CLUSTER-IP   EXTERNAL-IP   PORT(S)          AGE
router-default LoadBalancer  172.30.18.154 35.233.157.184 80:32288/TCP,443:31215/TCP 98
```

2. Add the A record to your zones:

- To use A records:
  - i. Export the variable for the router IP address:

```
$ export ROUTER_IP=`oc -n openshift-ingress get service router-default --no-headers | awk '{print $4}'`
```

- ii. Add the A record to the private zones:

```
$ if [ -f transaction.yaml ]; then rm transaction.yaml; fi
$ gcloud dns record-sets transaction start --zone ${INFRA_ID}-private-zone
```

```
$ gcloud dns record-sets transaction add ${ROUTER_IP} --name
\*.apps.${CLUSTER_NAME}.${BASE_DOMAIN}. --ttl 300 --type A --zone
${INFRA_ID}-private-zone
$ gcloud dns record-sets transaction execute --zone ${INFRA_ID}-private-zone
```

- iii. For an external cluster, also add the A record to the public zones:

```
$ if [ -f transaction.yaml ]; then rm transaction.yaml; fi
$ gcloud dns record-sets transaction start --zone ${BASE_DOMAIN_ZONE_NAME}
$ gcloud dns record-sets transaction add ${ROUTER_IP} --name
\*.apps.${CLUSTER_NAME}.${BASE_DOMAIN}. --ttl 300 --type A --zone
${BASE_DOMAIN_ZONE_NAME}
$ gcloud dns record-sets transaction execute --zone
${BASE_DOMAIN_ZONE_NAME}
```

- To add explicit domains instead of using a wildcard, create entries for each of the cluster's current routes:

```
$ oc get --all-namespaces -o jsonpath='{range .items[*]}{range .status.ingress[*]}{.host}
{"\n"}{end}{end}' routes
```

### Example output

```
oauth-openshift.apps.your.cluster.domain.example.com
console-openshift-console.apps.your.cluster.domain.example.com
downloads-openshift-console.apps.your.cluster.domain.example.com
alertmanager-main-openshift-monitoring.apps.your.cluster.domain.example.com
grafana-openshift-monitoring.apps.your.cluster.domain.example.com
prometheus-k8s-openshift-monitoring.apps.your.cluster.domain.example.com
```

## 7.12.23. Completing a GCP installation on user-provisioned infrastructure

After you start the OpenShift Container Platform installation on Google Cloud Platform (GCP) user-provisioned infrastructure, you can monitor the cluster events until the cluster is ready.

### Prerequisites

- Deploy the bootstrap machine for an OpenShift Container Platform cluster on user-provisioned GCP infrastructure.
- Install the **oc** CLI and log in.

### Procedure

1. Complete the cluster installation:

```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

### Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

- 1 For `<installation_directory>`, specify the path to the directory that you stored the installation files in.



## IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Observe the running state of your cluster.

- a. Run the following command to view the current cluster version and status:

```
$ oc get clusterversion
```

### Example output

```
NAME      VERSION  AVAILABLE  PROGRESSING  SINCE  STATUS
version   False    True       24m         Working towards 4.5.4: 99% complete
```

- b. Run the following command to view the Operators managed on the control plane by the Cluster Version Operator (CVO):

```
$ oc get clusteroperators
```

### Example output

```
NAME                               VERSION  AVAILABLE  PROGRESSING  DEGRADED  SINCE
authentication                      4.5.4   True       False        False     7m56s
cloud-credential                     4.5.4   True       False        False     31m
cluster-autoscaler                   4.5.4   True       False        False     16m
console                              4.5.4   True       False        False     10m
csi-snapshot-controller              4.5.4   True       False        False     16m
dns                                  4.5.4   True       False        False     22m
etcd                                  4.5.4   False      False        False     25s
image-registry                       4.5.4   True       False        False     16m
ingress                              4.5.4   True       False        False     16m
insights                             4.5.4   True       False        False     17m
kube-apiserver                       4.5.4   True       False        False     19m
kube-controller-manager              4.5.4   True       False        False     20m
kube-scheduler                       4.5.4   True       False        False     20m
```

kube-storage-version-migrator	4.5.4	True	False	False	16m
machine-api	4.5.4	True	False	False	22m
machine-config	4.5.4	True	False	False	22m
marketplace	4.5.4	True	False	False	16m
monitoring	4.5.4	True	False	False	10m
network	4.5.4	True	False	False	23m
node-tuning	4.5.4	True	False	False	23m
openshift-apiserver	4.5.4	True	False	False	17m
openshift-controller-manager	4.5.4	True	False	False	15m
openshift-samples	4.5.4	True	False	False	16m
operator-lifecycle-manager	4.5.4	True	False	False	22m
operator-lifecycle-manager-catalog	4.5.4	True	False	False	22m
operator-lifecycle-manager-packageserver	4.5.4	True	False	False	18m
service-ca	4.5.4	True	False	False	23m
service-catalog-apiserver	4.5.4	True	False	False	23m
service-catalog-controller-manager	4.5.4	True	False	False	23m
storage	4.5.4	True	False	False	17m

- c. Run the following command to view your cluster pods:

```
$ oc get pods --all-namespaces
```

### Example output

```

NAMESPACE                               NAME
READY STATUS  RESTARTS  AGE
kube-system                               etcd-member-ip-10-0-3-111.us-east-
2.compute.internal                       1/1    Running  0    35m
kube-system                               etcd-member-ip-10-0-3-239.us-east-
2.compute.internal                       1/1    Running  0    37m
kube-system                               etcd-member-ip-10-0-3-24.us-east-
2.compute.internal                       1/1    Running  0    35m
openshift-apiserver-operator              openshift-apiserver-operator-6d6674f4f4-
h7t2t                                     1/1    Running  1    37m
openshift-apiserver                       apiserver-fm48r
1/1    Running  0    30m
openshift-apiserver                       apiserver-fxkvv
1/1    Running  0    29m
openshift-apiserver                       apiserver-q85nm
1/1    Running  0    29m
...
openshift-service-ca-operator              openshift-service-ca-operator-66ff6dc6cd-
9r257                                     1/1    Running  0    37m
openshift-service-ca                      apiservice-cabundle-injector-695b6bcbc-cl5hm
1/1    Running  0    35m
openshift-service-ca                      configmap-cabundle-injector-8498544d7-
25qn6                                     1/1    Running  0    35m
openshift-service-ca                      service-serving-cert-signer-6445fc9c6-wqdqn
1/1    Running  0    35m
openshift-service-catalog-apiserver-operator  openshift-service-catalog-apiserver-
operator-549f44668b-b5q2w                1/1    Running  0    32m
openshift-service-catalog-controller-manager-operator  openshift-service-catalog-
controller-manager-operator-b78cr2lnm    1/1    Running  0    31m

```

When the current cluster version is **AVAILABLE**, the installation is complete.

## 7.12.24. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

## 7.12.25. Next steps

- [Customize your cluster](#).
- [Configure image streams](#) for the Cluster Samples Operator and the **must-gather** tool.
- Learn how to [use Operator Lifecycle Manager \(OLM\) on restricted networks](#).
- If the mirror registry that you used to install your cluster has a trusted CA, add it to the cluster by [configuring additional trust stores](#).
- If necessary, you can [opt out of remote health reporting](#).

## 7.13. UNINSTALLING A CLUSTER ON GCP

You can remove a cluster that you deployed to Google Cloud Platform (GCP).

### 7.13.1. Removing a cluster that uses installer-provisioned infrastructure

You can remove a cluster that uses installer-provisioned infrastructure from your cloud.



#### NOTE

After uninstallation, check your cloud provider for any resources not removed properly, especially with User Provisioned Infrastructure (UPI) clusters. There might be resources that the installer did not create or that the installer is unable to access. For example, some Google Cloud resources require [IAM permissions](#) in shared VPC host projects, or there might be unused [health checks that must be deleted](#).

### Prerequisites

- Have a copy of the installation program that you used to deploy the cluster.
- Have the files that the installation program generated when you created your cluster.

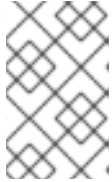
### Procedure

1. From the directory that contains the installation program on the computer that you used to install the cluster, run the following command:



```
$. /openshift-install destroy cluster \  
--dir <installation_directory> --log-level info 1 2
```

- 1 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.
- 2 To view different details, specify **warn**, **debug**, or **error** instead of **info**.



#### NOTE

You must specify the directory that contains the cluster definition files for your cluster. The installation program requires the **metadata.json** file in this directory to delete the cluster.

2. Optional: Delete the **<installation\_directory>** directory and the OpenShift Container Platform installation program.

## CHAPTER 8. INSTALLING ON BARE METAL

### 8.1. PREPARING FOR BARE METAL CLUSTER INSTALLATION

#### 8.1.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You have read the documentation on [selecting a cluster installation method and preparing it for users](#).

#### 8.1.2. Planning a bare metal cluster for OpenShift Virtualization

If you will use OpenShift Virtualization, it is important to be aware of several requirements before you install your bare metal cluster.

- If you want to use live migration features, you must have multiple worker nodes *at the time of cluster installation*. This is because live migration requires the cluster-level high availability (HA) flag to be set to true. The HA flag is set when a cluster is installed and cannot be changed afterwards. If there are fewer than two worker nodes defined when you install your cluster, the HA flag is set to false for the life of the cluster.



#### NOTE

You can install OpenShift Virtualization on a single-node cluster, but single-node OpenShift does not support high availability.

- Live migration requires shared storage. Storage for OpenShift Virtualization must support and use the ReadWriteMany (RWX) access mode.
- If you plan to use Single Root I/O Virtualization (SR-IOV), ensure that your network interface controllers (NICs) are supported by OpenShift Container Platform.

#### Additional resources

- [Preparing your cluster for OpenShift Virtualization](#)
- [About Single Root I/O Virtualization \(SR-IOV\) hardware networks](#)
- [Connecting a virtual machine to an SR-IOV network](#)

#### 8.1.3. Choosing a method to install OpenShift Container Platform on bare metal

You can install OpenShift Container Platform on installer-provisioned or user-provisioned infrastructure. The default installation type uses installer-provisioned infrastructure, where the installation program provisions the underlying infrastructure for the cluster. You can also install OpenShift Container Platform on infrastructure that you provision. If you do not use infrastructure that the installation program provisions, you must manage and maintain the cluster resources yourself.

See [Installation process](#) for more information about installer-provisioned and user-provisioned installation processes.

### 8.1.3.1. Installing a cluster on installer-provisioned infrastructure

You can install a cluster on bare metal infrastructure that is provisioned by the OpenShift Container Platform installation program, by using the following method:

- **Installing an installer-provisioned cluster on bare metal** You can install OpenShift Container Platform on bare metal by using installer provisioning.

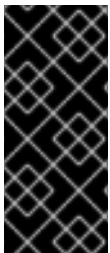
### 8.1.3.2. Installing a cluster on user-provisioned infrastructure

You can install a cluster on bare metal infrastructure that you provision, by using one of the following methods:

- **Installing a user-provisioned cluster on bare metal** You can install OpenShift Container Platform on bare metal infrastructure that you provision. For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.
- **Installing a user-provisioned bare metal cluster with network customizations** You can install a bare metal cluster on user-provisioned infrastructure with network-customizations. By customizing your network configuration, your cluster can coexist with existing IP address allocations in your environment and integrate with existing MTU and VXLAN configurations. Most of the network customizations must be applied at the installation stage.
- **Installing a user-provisioned bare metal cluster on a restricted network** You can install a user-provisioned bare metal cluster on a restricted or disconnected network by using a mirror registry. You can also use this installation method to ensure that your clusters only use container images that satisfy your organizational controls on external content.

## 8.2. INSTALLING A USER-PROVISIONED CLUSTER ON BARE METAL

In OpenShift Container Platform 4.9, you can install a cluster on bare metal infrastructure that you provision.



### IMPORTANT

While you might be able to follow this procedure to deploy a cluster on virtualized or cloud environments, you must be aware of additional considerations for non-bare metal platforms. Review the information in the [guidelines for deploying OpenShift Container Platform on non-tested platforms](#) before you attempt to install an OpenShift Container Platform cluster in such an environment.

### 8.2.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.



### NOTE

Be sure to also review this site list if you are configuring a proxy.

## 8.2.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



### IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

### Additional resources

- See [Installing a user-provisioned bare metal cluster on a restricted network](#) for more information about performing a restricted network installation on bare metal infrastructure that you provision.

## 8.2.3. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

### 8.2.3.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

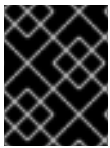
**Table 8.1. Minimum required hosts**

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.

Hosts	Description
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.

**NOTE**

As an exception, you can run zero compute machines in a bare metal cluster that consists of three control plane machines only. This provides smaller, more resource efficient clusters for cluster administrators and developers to use for testing, development, and production. Running one compute machine is not supported.

**IMPORTANT**

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 7.9, or RHEL 8.4.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See [Red Hat Enterprise Linux technology capabilities and limits](#) .

### 8.2.3.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

**Table 8.2. Minimum resource requirements**

Machine	Operating System	CPU [1]	RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 7.9, or RHEL 8.4 [3]	2	8 GB	100 GB	300

1. One CPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = CPUs.
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your

cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.

### 8.2.3.3. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

#### Additional resources

- See [Configuring a three-node cluster](#) for details about deploying three-node clusters in bare metal environments.
- See [Approving the certificate signing requests for your machines](#) for more information about approving cluster certificate signing requests after installation.

### 8.2.3.4. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.

It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.



#### NOTE

If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

#### 8.2.3.4.1. Setting the cluster node hostnames through DHCP

On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

#### 8.2.3.4.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.



#### IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

**Table 8.3. Ports used for all-machine to all-machine communications**

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	<b>1936</b>	Metrics
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> and the Cluster Version Operator on port <b>9099</b> .
	<b>10250-10259</b>	The default ports that Kubernetes reserves
	<b>10256</b>	openshift-sdn
UDP	<b>4789</b>	VXLAN and Geneve
	<b>6081</b>	VXLAN and Geneve
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> .
	<b>500</b>	IPsec IKE packets
	<b>4500</b>	IPsec NAT-T packets
TCP/UDP	<b>30000-32767</b>	Kubernetes node port

Protocol	Port	Description
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 8.4. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	<b>6443</b>	Kubernetes API

Table 8.5. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	<b>2379-2380</b>	etcd server and peer ports

### NTP configuration for user-provisioned infrastructure

OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service*.

If a DHCP server provides NTP server information, the chrony time service on the Red Hat Enterprise Linux CoreOS (RHCOS) machines read the information and can sync the clock with the NTP servers.

### Additional resources

- [Configuring chrony time service](#)

### 8.2.3.5. User-provisioned DNS requirements

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API
- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines

Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.




**NOTE**

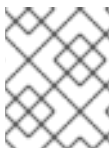
It is recommended to use a DHCP server to provide the hostnames to each cluster node. See the *DHCP recommendations for user-provisioned infrastructure* section for more information.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, **<cluster\_name>** is the cluster name and **<base\_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster\_name>.<base\_domain>.**

**Table 8.6. Required DNS records**

Component	Record	Description
Kubernetes API	<b>api.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
	<b>api-int.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster.
		 <p><b>IMPORTANT</b></p> <p>The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.</p>
Routes	<b>*.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	<p>A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.</p> <p>For example, <b>console-openshift-console.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;</b> is used as a wildcard route to the OpenShift Container Platform console.</p>
Bootstrap machine	<b>bootstrap.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.

Component	Record	Description
Control plane machines	<b>&lt;master&gt;&lt;n&gt;. &lt;cluster_name&gt;. &lt;base_domain&gt;.</b>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.
Compute machines	<b>&lt;worker&gt;&lt;n&gt;. &lt;cluster_name&gt;. &lt;base_domain&gt;.</b>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.



## NOTE

In OpenShift Container Platform 4.4 and later, you do not need to specify etcd host and SRV records in your DNS configuration.

## TIP

You can use the **dig** command to verify name and reverse name resolution. See the section on *Validating DNS resolution for user-provisioned infrastructure* for detailed validation steps.

### 8.2.3.5.1. Example DNS configuration for user-provisioned clusters

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is **ocp4** and the base domain is **example.com**.

#### Example DNS A record configuration for a user-provisioned cluster

The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

##### Example 8.1. Sample DNS zone database

```
$TTL 1W
@ IN SOA ns1.example.com. root (
    2019070700 ; serial
    3H ; refresh (3 hours)
    30M ; retry (30 minutes)
    2W ; expiry (2 weeks)
    1W ) ; minimum (1 week)
IN NS ns1.example.com.
IN MX 10 smtp.example.com.
;
;
ns1.example.com. IN A 192.168.1.5
smtp.example.com. IN A 192.168.1.5
;
helper.example.com. IN A 192.168.1.5
```

```

helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com. IN A 192.168.1.5 1
api-int.ocp4.example.com. IN A 192.168.1.5 2
;
*.apps.ocp4.example.com. IN A 192.168.1.5 3
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 4
;
master0.ocp4.example.com. IN A 192.168.1.97 5
master1.ocp4.example.com. IN A 192.168.1.98 6
master2.ocp4.example.com. IN A 192.168.1.99 7
;
worker0.ocp4.example.com. IN A 192.168.1.11 8
worker1.ocp4.example.com. IN A 192.168.1.7 9
;
;EOF

```

- 1 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.
- 2 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.
- 3 Provides name resolution for the wildcard routes. The record refers to the IP address of the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



#### NOTE

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

- 4 Provides name resolution for the bootstrap machine.
- 5 6 7 Provides name resolution for the control plane machines.
- 8 9 Provides name resolution for the compute machines.

### Example DNS PTR record configuration for a user-provisioned cluster

The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

#### Example 8.2. Sample DNS zone database for reverse records

```

$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial

```

```

3H ; refresh (3 hours)
30M ; retry (30 minutes)
2W ; expiry (2 weeks)
1W ) ; minimum (1 week)
IN NS ns1.example.com.
;
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. 2
;
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. 3
;
97.1.168.192.in-addr.arpa. IN PTR master0.ocp4.example.com. 4
98.1.168.192.in-addr.arpa. IN PTR master1.ocp4.example.com. 5
99.1.168.192.in-addr.arpa. IN PTR master2.ocp4.example.com. 6
;
11.1.168.192.in-addr.arpa. IN PTR worker0.ocp4.example.com. 7
7.1.168.192.in-addr.arpa. IN PTR worker1.ocp4.example.com. 8
;
;EOF

```

- 1 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.
- 2 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.
- 3 Provides reverse DNS resolution for the bootstrap machine.
- 4 5 6 Provides reverse DNS resolution for the control plane machines.
- 7 8 Provides reverse DNS resolution for the compute machines.



#### NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard.

#### Additional resources

- [Validating DNS resolution for user-provisioned infrastructure](#)

#### 8.2.3.6. Load balancing requirements for user-provisioned infrastructure

Before you install OpenShift Container Platform, you must provision the API and application ingress load balancing infrastructure. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

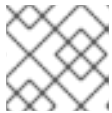


#### NOTE

If you want to deploy the API and application ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer.** Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:
  - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the API routes.
  - A stateless load balancing algorithm. The options vary based on the load balancer implementation.



#### NOTE

Session persistence is not required for the API load balancer to function properly.

Configure the following ports on both the front and back of the load balancers:

**Table 8.7. API load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
<b>6443</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the <b>/readyz</b> endpoint for the API server health check probe.	X	X	Kubernetes API server
<b>22623</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server



#### NOTE

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the **/readyz** endpoint to the removal of the API server instance from the pool. Within the time frame after **/readyz** returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application ingress load balancer.** Provides an ingress point for application traffic flowing in from outside the cluster. Configure the following conditions:
  - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the ingress routes.
  - A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

**TIP**

If the true IP address of the client can be seen by the application ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

Configure the following ports on both the front and back of the load balancers:

**Table 8.8. Application ingress load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
<b>443</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic
<b>80</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic
<b>1936</b>	The worker nodes that run the Ingress Controller pods, by default. You must configure the <b>/healthz/ready</b> endpoint for the ingress health check probe.	X	X	HTTP traffic

**NOTE**

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

**NOTE**

A working configuration for the Ingress router is required for an OpenShift Container Platform cluster. You must configure the Ingress router after the control plane initializes.

### 8.2.3.6.1. Example load balancer configuration for user-provisioned clusters

This section provides an example API and application ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an **/etc/haproxy/haproxy.cfg** configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing one load balancing solution over another.

**NOTE**

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

## Example 8.3. Sample API and application ingress load balancer configuration

```

global
log      127.0.0.1 local2
pidfile  /var/run/haproxy.pid
maxconn  4000
daemon
defaults
mode      http
log       global
option    dontlognull
option    http-server-close
option    redispatch
retries   3
timeout   http-request 10s
timeout   queue        1m
timeout   connect      10s
timeout   client       1m
timeout   server       1m
timeout   http-keep-alive 10s
timeout   check        10s
maxconn   3000
frontend stats
bind *:1936
mode      http
log       global
maxconn  10
stats enable
stats hide-version
stats refresh 30s
stats show-node
stats show-desc Stats for ocp4 cluster ❶
stats auth admin:ocp4
stats uri /stats
listen api-server-6443 ❷
bind *:6443
mode tcp
server bootstrap bootstrap.ocp4.example.com:6443 check inter 1s backup ❸
server master0 master0.ocp4.example.com:6443 check inter 1s
server master1 master1.ocp4.example.com:6443 check inter 1s
server master2 master2.ocp4.example.com:6443 check inter 1s
listen machine-config-server-22623 ❹
bind *:22623
mode tcp
server bootstrap bootstrap.ocp4.example.com:22623 check inter 1s backup ❺
server master0 master0.ocp4.example.com:22623 check inter 1s
server master1 master1.ocp4.example.com:22623 check inter 1s
server master2 master2.ocp4.example.com:22623 check inter 1s
listen ingress-router-443 ❻
bind *:443
mode tcp
balance source
server worker0 worker0.ocp4.example.com:443 check inter 1s
server worker1 worker1.ocp4.example.com:443 check inter 1s
listen ingress-router-80 ❼

```

```
bind *:80
mode tcp
balance source
server worker0 worker0.ocp4.example.com:80 check inter 1s
server worker1 worker1.ocp4.example.com:80 check inter 1s
```

- 1 In the example, the cluster name is **ocp4**.
- 2 Port **6443** handles the Kubernetes API traffic and points to the control plane machines.
- 3 5 The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.
- 4 Port **22623** handles the machine config server traffic and points to the control plane machines.
- 6 Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.
- 7 Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



#### NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

#### TIP

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltp** on the HAProxy node.



#### NOTE

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running **setsebool -P haproxy\_connect\_any=1**.

### 8.2.4. Preparing the user-provisioned infrastructure

Before you install OpenShift Container Platform on user-provisioned infrastructure, you must prepare the underlying infrastructure.

This section provides details about the high-level steps required to set up your cluster infrastructure in preparation for an OpenShift Container Platform installation. This includes configuring IP networking and network connectivity for your cluster nodes, enabling the required ports through your firewall, and setting up the required DNS and load balancing infrastructure.

After preparation, your cluster infrastructure must meet the requirements outlined in the *Requirements for a cluster with user-provisioned infrastructure* section.



## Prerequisites

- You have reviewed the [OpenShift Container Platform 4.x Tested Integrations](#) page.
- You have reviewed the infrastructure requirements detailed in the *Requirements for a cluster with user-provisioned infrastructure* section.

## Procedure

1. If you are using DHCP to provide the IP networking configuration to your cluster nodes, configure your DHCP service.
  - a. Add persistent IP addresses for the nodes to your DHCP server configuration. In your configuration, match the MAC address of the relevant network interface to the intended IP address for each node.
  - b. When you use DHCP to configure IP addressing for the cluster machines, the machines also obtain the DNS server information through DHCP. Define the persistent DNS server address that is used by the cluster nodes through your DHCP server configuration.



### NOTE

If you are not using a DHCP service, you must provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

- c. Define the hostnames of your cluster nodes in your DHCP server configuration. See the *Setting the cluster node hostnames through DHCP* section for details about hostname considerations.



### NOTE

If you are not using a DHCP service, the cluster nodes obtain their hostname through a reverse DNS lookup.

2. Ensure that your network infrastructure provides the required network connectivity between the cluster components. See the *Networking requirements for user-provisioned infrastructure* section for details about the requirements.
3. Configure your firewall to enable the ports required for the OpenShift Container Platform cluster components to communicate. See *Networking requirements for user-provisioned infrastructure* section for details about the ports that are required.
4. Setup the required DNS infrastructure for your cluster.
  - a. Configure DNS name resolution for the Kubernetes API, the application wildcard, the bootstrap machine, the control plane machines, and the compute machines.
  - b. Configure reverse DNS resolution for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.  
See the *User-provisioned DNS requirements* section for more information about the OpenShift Container Platform DNS requirements.

5. Validate your DNS configuration.
  - a. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses in the responses correspond to the correct components.
  - b. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names in the responses correspond to the correct components.  
See the *Validating DNS resolution for user-provisioned infrastructure* section for detailed DNS validation steps.
6. Provision the required API and application ingress load balancing infrastructure. See the *Load balancing requirements for user-provisioned infrastructure* section for more information about the requirements.

**NOTE**

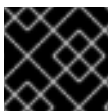
Some load balancing solutions require the DNS name resolution for the cluster nodes to be in place before the load balancing is initialized.

**Additional resources**

- [Requirements for a cluster with user-provisioned infrastructure](#)
- [Installing RHCOS and starting the OpenShift Container Platform bootstrap process](#)
- [Setting the cluster node hostnames through DHCP](#)
- [Advanced RHCOS installation configuration](#)
- [Networking requirements for user-provisioned infrastructure](#)
- [User-provisioned DNS requirements](#)
- [Validating DNS resolution for user-provisioned infrastructure](#)
- [Load balancing requirements for user-provisioned infrastructure](#)

### 8.2.5. Validating DNS resolution for user-provisioned infrastructure

You can validate your DNS configuration before installing OpenShift Container Platform on user-provisioned infrastructure.

**IMPORTANT**

The validation steps detailed in this section must succeed before you install your cluster.

**Prerequisites**

- You have configured the required DNS records for your user-provisioned infrastructure.

**Procedure**

1. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses contained in the responses correspond to the correct components.
  - a. Perform a lookup against the Kubernetes API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api.<cluster_name>.<base_domain> 1
```

- 1 Replace **<nameserver\_ip>** with the IP address of the nameserver, **<cluster\_name>** with your cluster name, and **<base\_domain>** with your base domain name.

### Example output

```
api.ocp4.example.com. 0 IN A 192.168.1.5
```

- b. Perform a lookup against the Kubernetes internal API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api-int.<cluster_name>.<base_domain>
```

### Example output

```
api-int.ocp4.example.com. 0 IN A 192.168.1.5
```

- c. Test an example **\*.apps.<cluster\_name>.<base\_domain>** DNS wildcard lookup. All of the application wildcard lookups must resolve to the IP address of the application ingress load balancer:

```
$ dig +noall +answer @<nameserver_ip> random.apps.<cluster_name>.<base_domain>
```

### Example output

```
random.apps.ocp4.example.com. 0 IN A 192.168.1.5
```



### NOTE

In the example outputs, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

You can replace **random** with another wildcard value. For example, you can query the route to the OpenShift Container Platform console:

```
$ dig +noall +answer @<nameserver_ip> console-openshift-console.apps.<cluster_name>.<base_domain>
```

### Example output

```
console-openshift-console.apps.ocp4.example.com. 0 IN A 192.168.1.5
```

- d. Run a lookup against the bootstrap DNS record name. Check that the result points to the IP address of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> bootstrap.<cluster_name>.<base_domain>
```

### Example output

```
bootstrap.ocp4.example.com. 0 IN A 192.168.1.96
```

- e. Use this method to perform lookups against the DNS record names for the control plane and compute nodes. Check that the results correspond to the IP addresses of each node.
2. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names contained in the responses correspond to the correct components.

- a. Perform a reverse lookup against the IP address of the API load balancer. Check that the response includes the record names for the Kubernetes API and the Kubernetes internal API:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.5
```

### Example output

```
5.1.168.192.in-addr.arpa. 0 IN PTR api-int.ocp4.example.com. 1  
5.1.168.192.in-addr.arpa. 0 IN PTR api.ocp4.example.com. 2
```

- 1** Provides the record name for the Kubernetes internal API.
- 2** Provides the record name for the Kubernetes API.



### NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard. No validation step is needed for reverse DNS resolution against the IP address of the application ingress load balancer.

- b. Perform a reverse lookup against the IP address of the bootstrap node. Check that the result points to the DNS record name of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.96
```

### Example output

```
96.1.168.192.in-addr.arpa. 0 IN PTR bootstrap.ocp4.example.com.
```

- c. Use this method to perform reverse lookups against the IP addresses for the control plane and compute nodes. Check that the results correspond to the DNS record names of each node.

## Additional resources

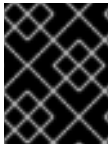
- [User-provisioned DNS requirements](#)
- [Load balancing requirements for user-provisioned infrastructure](#)

## 8.2.6. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.



### IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



### NOTE

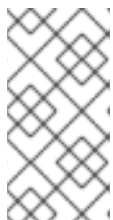
You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

### Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.



### NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

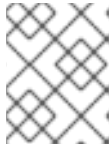
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.



#### NOTE

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the `ssh-agent` process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

#### Example output

```
Agent pid 31874
```



#### NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the `ssh-agent`:

```
$ ssh-add <path>/<file_name> 1
```

- 1** Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

#### Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

#### Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program. If you install a cluster on infrastructure that you provision, you must provide the key to the installation program.

#### Additional resources

- [Verifying node health](#)

### 8.2.7. Obtaining the installation program

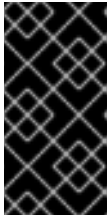
Before you install OpenShift Container Platform, download the installation file on a local computer.

#### Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space

### Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



#### IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



#### IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#). This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

### 8.2.8. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



#### IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

#### Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

```
$ tar xvf <file>
```

5. Place the **oc** binary in a directory that is on your **PATH**.  
To check your **PATH**, execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

### Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.



4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### 8.2.9. Manually creating the installation configuration file

For user-provisioned installations of OpenShift Container Platform, you manually generate your installation configuration file.

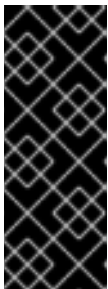
#### Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

#### Procedure

1. Create an installation directory to store your required installation assets in:

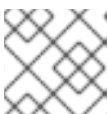
```
$ mkdir <installation_directory>
```



#### IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation\_directory>**.



#### NOTE

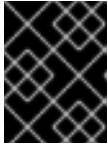
You must name this configuration file **install-config.yaml**.



#### NOTE

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation\_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



### IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

#### 8.2.9.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide a customized **install-config.yaml** installation configuration file that describes the details for your environment.



### NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.



### IMPORTANT

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

##### 8.2.9.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 8.9. Required parameters

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;</b> . <b>&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .

Parameter	Description	Values
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}</b> . <b>{{.baseDomain}}</b> .	String of lowercase letters and hyphens (-), such as <b>dev</b> .
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws</b> , <b>baremetal</b> , <b>azure</b> , <b>gcp</b> , <b>openstack</b> , <b>ovirt</b> , <b>vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } }</pre>


### 8.2.9.1.2. Network configuration parameters


You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

**Table 8.10. Network parameters**

Parameter	Description	Values
-----------	-------------	--------

Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	Object  <b>NOTE</b> You cannot modify parameters specified by the <b>networking</b> object after installation.
<b>networking.networkType</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .
<b>networking.clusterNetwork</b>	The IP address blocks for pods.  The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b> .  If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example:  <pre>networking:   clusterNetwork:   - cidr: 10.128.0.0/14     hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	Required if you use <b>networking.clusterNetwork</b> . An IP address block.  An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b> .
<b>networking.clusterNetwork.hostPrefix</b>	The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b> . A <b>hostPrefix</b> value of <b>23</b> provides 510 ( $2^{(32 - 23)} - 2$ ) pod IP addresses.	A subnet prefix.  The default value is <b>23</b> .
<b>networking.serviceNetwork</b>	The IP address block for services. The default value is <b>172.30.0.0/16</b> .  The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example:  <pre>networking:   serviceNetwork:   - 172.30.0.0/16</pre>


Parameter	Description	Values
<b>networking.machineNetwork</b>	The IP address blocks for machines.  If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example:  <pre>networking:   machineNetwork:   - cidr: 10.0.0.0/16</pre>
<b>networking.machineNetwork.cidr</b>	Required if you use <b>networking.machineNetwork</b> . An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b> .	An IP network block in CIDR notation.  For example, <b>10.0.0.0/16</b> .   <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p>


### 8.2.9.1.3. Optional configuration parameters



Optional installation configuration parameters are described in the following table:

Table 8.11. Optional parameters

Parameter	Description	Values
<b>additionalTrustBundle</b>	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
<b>compute</b>	The configuration for the machines that comprise the compute nodes.	Array of <b>MachinePool</b> objects.
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String


Parameter	Description	Values
<b>compute.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b>
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String

Parameter	Description	Values
<b>controlPlane.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platform</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>controlPlane.replicas</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.

Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.</p> <p> <b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators reference content</i>.</p> <p> <b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p>	<b>Mint, Passthrough, Manual</b> or an empty string ("").



Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start;"> <div style="width: 60px; height: 60px; background-color: black; margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 60px; height: 60px; background-color: black; margin-right: 10px;"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<b>Internal</b> or <b>External</b> . The default value is <b>External</b> .  Setting this field to <b>Internal</b> is not supported on non-cloud platforms.

Parameter	Description	Values
<b>sshKey</b>	<p>The SSH key or keys to authenticate access your cluster machines.</p>  <p><b>NOTE</b></p> <p>For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.</p>	<p>One or more keys. For example:</p> <pre>sshKey:   &lt;key1&gt;   &lt;key2&gt;   &lt;key3&gt;</pre>

### 8.2.9.2. Sample install-config.yaml file for bare metal

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```

apiVersion: v1
baseDomain: example.com 1
compute: 2
- hyperthreading: Enabled 3
  name: worker
  replicas: 0 4
controlPlane: 5
  hyperthreading: Enabled 6
  name: master
  replicas: 3 7
metadata:
  name: test 8
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14 9
    hostPrefix: 23 10
  networkType: OpenShiftSDN
  serviceNetwork: 11
  - 172.30.0.0/16
platform:
  none: {} 12
fips: false 13
pullSecret: '{"auths": ...}' 14
sshKey: 'ssh-ed25519 AAAA...' 15

```

1 The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.

2 5

The **controlPlane** section is a single mapping, but the **compute** section is a sequence of

- 3** **6** Specifies whether to enable or disable simultaneous multithreading (SMT), or hyperthreading. By default, SMT is enabled to increase the performance of the cores in your machines. You can disable it by setting the parameter value to **Disabled**. If you disable SMT, you must disable it in all cluster machines; this includes both control plane and compute machines.



#### NOTE

Simultaneous multithreading (SMT) is enabled by default. If SMT is not enabled in your BIOS settings, the **hyperthreading** parameter has no effect.



#### IMPORTANT

If you disable **hyperthreading**, whether in the BIOS or in the **install-config.yaml** file, ensure that your capacity planning accounts for the dramatically decreased machine performance.

- 4** You must set this value to **0** when you install OpenShift Container Platform on user-provisioned infrastructure. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. In user-provisioned installations, you must manually deploy the compute machines before you finish installing the cluster.



#### NOTE

If you are installing a three-node cluster, do not deploy any compute machines when you install the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

- 7** The number of control plane machines that you add to the cluster. Because the cluster uses these values as the number of etcd endpoints in the cluster, the value must match the number of control plane machines that you deploy.
- 8** The cluster name that you specified in your DNS records.
- 9** A block of IP addresses from which pod IP addresses are allocated. This block must not overlap with existing physical networks. These IP addresses are used for the pod network. If you need to access the pods from an external network, you must configure load balancers and routers to manage the traffic.



#### NOTE

Class E CIDR range is reserved for a future use. To use the Class E CIDR range, you must ensure your networking environment accepts the IP addresses within the Class E CIDR range.

- 10** The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23**, then each node is assigned a **/23** subnet out of the given **cidr**, which allows for 510 ( $2^{(32 - 23)} - 2$ ) pod IP addresses. If you are required to provide access to nodes from an external network, configure load balancers and routers to manage the traffic.
- 11** The IP address pool to use for service IP addresses. You can enter only one IP address pool. This block must not overlap with existing physical networks. If you need to access the services from an external network, configure load balancers and routers to manage the traffic.

- 12 You must set the platform to **none**. You cannot provide additional platform configuration variables for your platform.



### IMPORTANT

Clusters that are installed with the platform type **none** are unable to use some features, such as managing compute machines with the Machine API. This limitation applies even if the compute machines that are attached to the cluster are installed on a platform that would normally support the feature. This parameter cannot be changed after installation.

- 13 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.



### IMPORTANT

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

- 14 The [pull secret from the Red Hat OpenShift Cluster Manager](#) . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

- 15 The SSH public key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).



### NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

#### Additional resources

- See [Load balancing requirements for user-provisioned infrastructure](#) for more information on the API and application ingress load balancing requirements.

#### 8.2.9.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.



### NOTE

For bare metal installations, if you do not assign node IP addresses from the range that is specified in the **networking.machineNetwork[].cidr** field in the **install-config.yaml** file, you must include them in the **proxy.noProxy** field.

#### Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



## NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

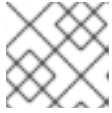
## Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
  additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
...

```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations.
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

**NOTE**

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

**NOTE**

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

**8.2.9.4. Configuring a three-node cluster**

You can optionally deploy zero compute machines in a bare metal cluster that consists of three control plane machines only. This provides smaller, more resource efficient clusters for cluster administrators and developers to use for testing, development, and production.

In three-node OpenShift Container Platform environments, the three control plane machines are schedulable, which means that your application workloads are scheduled to run on them.

**Prerequisites**

- You have an existing **install-config.yaml** file.

**Procedure**

- Ensure that the number of compute replicas is set to **0** in your **install-config.yaml** file, as shown in the following **compute** stanza:

```
compute:
- name: worker
  platform: {}
  replicas: 0
```

**NOTE**

You must set the value of the **replicas** parameter for the compute machines to **0** when you install OpenShift Container Platform on user-provisioned infrastructure, regardless of the number of compute machines you are deploying. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. This does not apply to user-provisioned installations, where the compute machines are deployed manually.

For three-node cluster installations, follow these next steps:

- If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

See the *Load balancing requirements for user-provisioned infrastructure* section for more information.

- When you create the Kubernetes manifest files in the following procedure, ensure that the **mastersSchedulable** parameter in the `<installation_directory>/manifests/cluster-scheduler-02-config.yml` file is set to **true**. This enables your application workloads to run on the control plane nodes.
- Do not deploy any compute nodes when you create the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

### 8.2.10. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.



#### IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

#### Prerequisites

- You obtained the OpenShift Container Platform installation program.
- You created the **install-config.yaml** installation configuration file.

#### Procedure

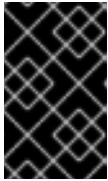
1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

- 1 For `<installation_directory>`, specify the installation directory that contains the **install-config.yaml** file you created.

**WARNING**

If you are installing a three-node cluster, skip the following step to allow the control plane nodes to be schedulable.

**IMPORTANT**

When you configure control plane nodes from the default unschedulable to schedulable, additional subscriptions are required. This is because control plane nodes then become worker nodes.

2. Check that the **mastersSchedulable** parameter in the `<installation_directory>/manifests/cluster-scheduler-02-config.yml` Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:
  - a. Open the `<installation_directory>/manifests/cluster-scheduler-02-config.yml` file.
  - b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.
  - c. Save and exit the file.
3. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

- 1** For `<installation_directory>`, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the `./<installation_directory>/auth` directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

**Additional resources**

- See [Recovering from expired control plane certificates](#) for more information about recovering kubelet certificates.

**8.2.11. Installing RHCOS and starting the OpenShift Container Platform bootstrap process**



To install OpenShift Container Platform on bare metal infrastructure that you provision, you must install Red Hat Enterprise Linux CoreOS (RHCOS) on the machines. When you install RHCOS, you must provide the Ignition config file that was generated by the OpenShift Container Platform installation program for the type of machine you are installing. If you have configured suitable networking, DNS, and load balancing infrastructure, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS machines have rebooted.

To install RHCOS on the machines, follow either the steps to use an ISO image or network PXE booting.



## NOTE

The compute node deployment steps included in this installation document are RHCOS-specific. If you choose instead to deploy RHEL-based compute nodes, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.

You can configure RHCOS during ISO and PXE installations by using the following methods:

- **Kernel arguments:** You can use kernel arguments to provide installation-specific information. For example, you can specify the locations of the RHCOS installation files that you uploaded to your HTTP server and the location of the Ignition config file for the type of node you are installing. For a PXE installation, you can use the **APPEND** parameter to pass the arguments to the kernel of the live installer. For an ISO installation, you can interrupt the live installation boot process to add the kernel arguments. In both installation cases, you can use special **coreos.inst.\*** arguments to direct the live installer, as well as standard installation boot arguments for turning standard kernel services on or off.
- **Ignition configs:** OpenShift Container Platform Ignition config files (**\*.ign**) are specific to the type of node you are installing. You pass the location of a bootstrap, control plane, or compute node Ignition config file during the RHCOS installation so that it takes effect on first boot. In special cases, you can create a separate, limited Ignition config to pass to the live system. That Ignition config could do a certain set of tasks, such as reporting success to a provisioning system after completing installation. This special Ignition config is consumed by the **coreos-installer** to be applied on first boot of the installed system. Do not provide the standard control plane and compute node Ignition configs to the live ISO directly.
- **coreos-installer:** You can boot the live ISO installer to a shell prompt, which allows you to prepare the permanent system in a variety of ways before first boot. In particular, you can run the **coreos-installer** command to identify various artifacts to include, work with disk partitions, and set up networking. In some cases, you can configure features on the live system and copy them to the installed system.

Whether to use an ISO or PXE install depends on your situation. A PXE install requires an available DHCP service and more preparation, but can make the installation process more automated. An ISO install is a more manual process and can be inconvenient if you are setting up more than a few machines.



## NOTE

As of OpenShift Container Platform 4.6, the RHCOS ISO and other installation artifacts provide support for installation on disks with 4K sectors.

### 8.2.11.1. Installing RHCOS by using an ISO image

You can use an ISO image to install RHCOS on the machines.

## Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have an HTTP server that can be accessed from your computer, and from the machines that you create.
- You have reviewed the *Advanced RHCOS installation configuration* section for different ways to configure features, such as networking and disk partitioning.

## Procedure

1. Obtain the SHA512 digest for each of your Ignition config files. For example, you can use the following on a system running Linux to get the SHA512 digest for your **bootstrap.ign** Ignition config file:

```
$ sha512sum <installation_directory>/bootstrap.ign
```

The digests are provided to the **coreos-installer** in a later step to validate the authenticity of the Ignition config files on the cluster nodes.

2. Upload the bootstrap, control plane, and compute node Ignition config files that the installation program created to your HTTP server. Note the URLs of these files.



### IMPORTANT

You can add or change configuration settings in your Ignition configs before saving them to your HTTP server. If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

3. From the installation host, validate that the Ignition config files are available on the URLs. The following example gets the Ignition config file for the bootstrap node:

```
$ curl -k http://<HTTP_server>/bootstrap.ign 1
```

### Example output

```
% Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
           Dload  Upload  Total   Spent    Left   Speed
  0   0   0   0   0   0   0   0  --:--:-- --:--:-- --:--:--    0{"ignition":
{"version":"3.2.0"},"passwd":{"users":[{"name":"core","sshAuthorizedKeys":["ssh-rsa...
```

Replace **bootstrap.ign** with **master.ign** or **worker.ign** in the command to validate that the Ignition config files for the control plane and compute nodes are also available.

4. Although it is possible to obtain the RHCOS images that are required for your preferred method of installing operating system instances from the [RHCOS image mirror](#) page, the recommended way to obtain the correct version of your RHCOS images are from the output of **openshift-install** command:

```
$ openshift-install coreos print-stream-json | grep '\.iso[^\.]'
```

### Example output

```
"location": "<url>/art/storage/releases/rhcos-4.9-aarch64/<release>/aarch64/rhcos-
<release>-live.aarch64.iso",
"location": "<url>/art/storage/releases/rhcos-4.9-ppc64le/<release>/ppc64le/rhcos-<release>-
live.ppc64le.iso",
"location": "<url>/art/storage/releases/rhcos-4.9-s390x/<release>/s390x/rhcos-<release>-
live.s390x.iso",
"location": "<url>/art/storage/releases/rhcos-4.9/<release>/x86_64/rhcos-<release>-
live.x86_64.iso",
```



### IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image versions that match your OpenShift Container Platform version if they are available. Use only ISO images for this procedure. RHCOS qcow2 images are not supported for this installation type.

ISO file names resemble the following example:

#### **rhcos-<version>-live.<architecture>.iso**

5. Use the ISO to start the RHCOS installation. Use one of the following installation options:
  - Burn the ISO image to a disk and boot it directly.
  - Use ISO redirection by using a lights-out management (LOM) interface.
6. Boot the RHCOS ISO image without specifying any options or interrupting the live boot sequence. Wait for the installer to boot into a shell prompt in the RHCOS live environment.



### NOTE

It is possible to interrupt the RHCOS installation boot process to add kernel arguments. However, for this ISO procedure you should use the **coreos-installer** command as outlined in the following steps, instead of adding kernel arguments.

7. Run the **coreos-installer** command and specify the options that meet your installation requirements. At a minimum, you must specify the URL that points to the Ignition config file for the node type, and the device that you are installing to:

```
$ sudo coreos-installer install --ignition-url=http://<HTTP_server>/<node_type>.ign <device>
--ignition-hash=sha512-<digest> 1 2
```

**1** **1** You must run the **coreos-installer** command by using **sudo**, because the **core** user does not have the required root privileges to perform the installation.

**2**

The **--ignition-hash** option is required when the Ignition config file is obtained through an HTTP URL to validate the authenticity of the Ignition config file on the cluster node.



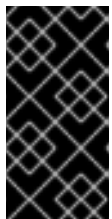
#### NOTE

If you want to provide your Ignition config files through an HTTPS server that uses TLS, you can add the internal certificate authority (CA) to the system trust store before running **coreos-installer**.

The following example initializes a bootstrap node installation to the **/dev/sda** device. The Ignition config file for the bootstrap node is obtained from an HTTP web server with the IP address 192.168.1.2:

```
$ sudo coreos-installer install --ignition-  
url=http://192.168.1.2:80/installation_directory/bootstrap.ign /dev/sda --ignition-hash=sha512-  
a5a2d43879223273c9b60af66b44202a1d1248fc01cf156c46d4a79f552b6bad47bc8cc78ddf011  
6e80c59d2ea9e32ba53bc807afbca581aa059311def2c3e3b
```

8. Monitor the progress of the RHCOS installation on the console of the machine.



#### IMPORTANT

Be sure that the installation is successful on each node before commencing with the OpenShift Container Platform installation. Observing the installation process can also help to determine the cause of RHCOS installation issues that might arise.

9. After RHCOS installs, you must reboot the system. During the system reboot, it applies the Ignition config file that you specified.
10. Continue to create the other machines for your cluster.



#### IMPORTANT

You must create the bootstrap and control plane machines at this time. If the control plane machines are not made schedulable, also create at least two compute machines before you install OpenShift Container Platform.

If the required network, DNS, and load balancer infrastructure are in place, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS nodes have rebooted.

**NOTE**

RHCOS nodes do not include a default password for the **core** user. You can access the nodes by running **ssh core@<node>.<cluster\_name>.<base\_domain>** as a user with access to the SSH private key that is paired to the public key that you specified in your **install\_config.yaml** file. OpenShift Container Platform 4 cluster nodes running RHCOS are immutable and rely on Operators to apply cluster changes. Accessing cluster nodes by using SSH is not recommended. However, when investigating installation issues, if the OpenShift Container Platform API is not available, or the kubelet is not properly functioning on a target node, SSH access might be required for debugging or disaster recovery.

**8.2.11.2. Installing RHCOS by using PXE or iPXE booting**

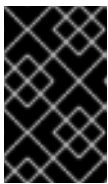
You can use PXE or iPXE booting to install RHCOS on the machines.

**Prerequisites**

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have configured suitable PXE or iPXE infrastructure.
- You have an HTTP server that can be accessed from your computer, and from the machines that you create.
- You have reviewed the *Advanced RHCOS installation configuration* section for different ways to configure features, such as networking and disk partitioning.

**Procedure**

1. Upload the bootstrap, control plane, and compute node Ignition config files that the installation program created to your HTTP server. Note the URLs of these files.

**IMPORTANT**

You can add or change configuration settings in your Ignition configs before saving them to your HTTP server. If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

2. From the installation host, validate that the Ignition config files are available on the URLs. The following example gets the Ignition config file for the bootstrap node:

```
$ curl -k http://<HTTP_server>/bootstrap.ign 1
```

**Example output**

```
% Total    % Received % Xferd Average Speed   Time    Time     Time  Current
           Dload  Upload   Total   Spent    Left    Speed
  0   0   0   0   0   0   0   0   0  --:--:-- --:--:-- --:--:--    0{"ignition":
{"version":"3.2.0"},"passwd":{"users":[{"name":"core","sshAuthorizedKeys":["ssh-rsa...
```

Replace **bootstrap.ign** with **master.ign** or **worker.ign** in the command to validate that the Ignition config files for the control plane and compute nodes are also available.

- Although it is possible to obtain the RHCOS **kernel**, **initramfs** and **rootfs** files that are required for your preferred method of installing operating system instances from the [RHCOS image mirror](#) page, the recommended way to obtain the correct version of your RHCOS files are from the output of **openshift-install** command:

```
$ openshift-install coreos print-stream-json | grep -Eo "https.*(kernel|initramfs|rootfs.)w+(\.img)?"
```

### Example output

```
"<url>/art/storage/releases/rhcos-4.9-aarch64/<release>/aarch64/rhcos-<release>-live-
kernel-aarch64"
"<url>/art/storage/releases/rhcos-4.9-aarch64/<release>/aarch64/rhcos-<release>-live-
initramfs.aarch64.img"
"<url>/art/storage/releases/rhcos-4.9-aarch64/<release>/aarch64/rhcos-<release>-live-
rootfs.aarch64.img"
"<url>/art/storage/releases/rhcos-4.9-ppc64le/49.84.202110081256-0/ppc64le/rhcos-
<release>-live-kernel-ppc64le"
"<url>/art/storage/releases/rhcos-4.9-ppc64le/<release>/ppc64le/rhcos-<release>-live-
initramfs.ppc64le.img"
"<url>/art/storage/releases/rhcos-4.9-ppc64le/<release>/ppc64le/rhcos-<release>-live-
rootfs.ppc64le.img"
"<url>/art/storage/releases/rhcos-4.9-s390x/<release>/s390x/rhcos-<release>-live-kernel-
s390x"
"<url>/art/storage/releases/rhcos-4.9-s390x/<release>/s390x/rhcos-<release>-live-
initramfs.s390x.img"
"<url>/art/storage/releases/rhcos-4.9-s390x/<release>/s390x/rhcos-<release>-live-
rootfs.s390x.img"
"<url>/art/storage/releases/rhcos-4.9/<release>/x86_64/rhcos-<release>-live-kernel-x86_64"
"<url>/art/storage/releases/rhcos-4.9/<release>/x86_64/rhcos-<release>-live-
initramfs.x86_64.img"
"<url>/art/storage/releases/rhcos-4.9/<release>/x86_64/rhcos-<release>-live-
rootfs.x86_64.img"
```



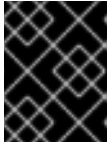
### IMPORTANT

The RHCOS artifacts might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Only use the appropriate **kernel**, **initramfs**, and **rootfs** artifacts described below for this procedure. RHCOS QCOW2 images are not supported for this installation type.

The file names contain the OpenShift Container Platform version number. They resemble the following examples:

- **kernel:** rhcos-<version>-live-kernel-<architecture>
- **initramfs:** rhcos-<version>-live-initramfs.<architecture>.img
- **rootfs:** rhcos-<version>-live-rootfs.<architecture>.img

4. Upload the **rootfs**, **kernel**, and **initramfs** files to your HTTP server.



### IMPORTANT

If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

5. Configure the network boot infrastructure so that the machines boot from their local disks after RHCOS is installed on them.
6. Configure PXE or iPXE installation for the RHCOS images and begin the installation. Modify one of the following example menu entries for your environment and verify that the image and Ignition files are properly accessible:

- For PXE:

```

DEFAULT pxeboot
TIMEOUT 20
PROMPT 0
LABEL pxeboot
  KERNEL http://<HTTP_server>/rhcos-<version>-live-kernel-<architecture> 1
  APPEND initrd=http://<HTTP_server>/rhcos-<version>-live-initramfs.
<architecture>.img coreos.live.rootfs_url=http://<HTTP_server>/rhcos-<version>-live-
rootfs.<architecture>.img coreos.inst.install_dev=/dev/sda
coreos.inst.ignition_url=http://<HTTP_server>/bootstrap.ign 2 3

```

- 1** Specify the location of the live **kernel** file that you uploaded to your HTTP server. The URL must be HTTP, TFTP, or FTP; HTTPS and NFS are not supported.
- 2** If you use multiple NICs, specify a single interface in the **ip** option. For example, to use DHCP on a NIC that is named **eno1**, set **ip=eno1:dhcp**.
- 3** Specify the locations of the RHCOS files that you uploaded to your HTTP server. The **initrd** parameter value is the location of the **initramfs** file, the **coreos.live.rootfs\_url** parameter value is the location of the **rootfs** file, and the **coreos.inst.ignition\_url** parameter value is the location of the bootstrap Ignition config file. You can also add more kernel arguments to the **APPEND** line to configure networking or other boot options.



### NOTE

This configuration does not enable serial console access on machines with a graphical console. To configure a different console, add one or more **console=** arguments to the **APPEND** line. For example, add **console=tty0 console=ttyS0** to set the first PC serial port as the primary console and the graphical console as a secondary console. For more information, see [How does one set up a serial terminal and/or console in Red Hat Enterprise Linux?](#)

- For iPXE:

```

kernel http://<HTTP_server>/rhcos-<version>-live-kernel-<architecture> initrd=main
coreos.live.rootfs_url=http://<HTTP_server>/rhcos-<version>-live-rootfs.

```

```

<architecture>.img coreos.inst.install_dev=/dev/sda
coreos.inst.ignition_url=http://<HTTP_server>/bootstrap.ign 1 2
initrd --name main http://<HTTP_server>/rhcos-<version>-live-initramfs.
<architecture>.img 3
boot

```

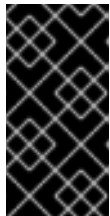
- 1** Specify the locations of the RHCOS files that you uploaded to your HTTP server. The **kernel** parameter value is the location of the **kernel** file, the **initrd=main** argument is needed for booting on UEFI systems, the **coreos.live.rootfs\_url** parameter value is the location of the **rootfs** file, and the **coreos.inst.ignition\_url** parameter value is the location of the bootstrap Ignition config file.
- 2** If you use multiple NICs, specify a single interface in the **ip** option. For example, to use DHCP on a NIC that is named **eno1**, set **ip=eno1:dhcp**.
- 3** Specify the location of the **initramfs** file that you uploaded to your HTTP server.



### NOTE

This configuration does not enable serial console access on machines with a graphical console. To configure a different console, add one or more **console=** arguments to the **kernel** line. For example, add **console=tty0** **console=ttyS0** to set the first PC serial port as the primary console and the graphical console as a secondary console. For more information, see [How does one set up a serial terminal and/or console in Red Hat Enterprise Linux?](#)

7. Monitor the progress of the RHCOS installation on the console of the machine.



### IMPORTANT

Be sure that the installation is successful on each node before commencing with the OpenShift Container Platform installation. Observing the installation process can also help to determine the cause of RHCOS installation issues that might arise.

8. After RHCOS installs, the system reboots. During reboot, the system applies the Ignition config file that you specified.
9. Continue to create the machines for your cluster.



### IMPORTANT

You must create the bootstrap and control plane machines at this time. If the control plane machines are not made schedulable, also create at least two compute machines before you install the cluster.

If the required network, DNS, and load balancer infrastructure are in place, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS nodes have rebooted.





## NOTE

RHCOS nodes do not include a default password for the **core** user. You can access the nodes by running **ssh core@<node>.<cluster\_name>.<base\_domain>** as a user with access to the SSH private key that is paired to the public key that you specified in your **install\_config.yaml** file. OpenShift Container Platform 4 cluster nodes running RHCOS are immutable and rely on Operators to apply cluster changes. Accessing cluster nodes by using SSH is not recommended. However, when investigating installation issues, if the OpenShift Container Platform API is not available, or the kubelet is not properly functioning on a target node, SSH access might be required for debugging or disaster recovery.

### 8.2.11.3. Advanced RHCOS installation configuration

A key benefit for manually provisioning the Red Hat Enterprise Linux CoreOS (RHCOS) nodes for OpenShift Container Platform is to be able to do configuration that is not available through default OpenShift Container Platform installation methods. This section describes some of the configurations that you can do using techniques that include:

- Passing kernel arguments to the live installer
- Running **coreos-installer** manually from the live system
- Embedding Ignition configs in an ISO

The advanced configuration topics for manual Red Hat Enterprise Linux CoreOS (RHCOS) installations detailed in this section relate to disk partitioning, networking, and using Ignition configs in different ways.

#### 8.2.11.3.1. Using advanced networking options for PXE and ISO installations

Networking for OpenShift Container Platform nodes uses DHCP by default to gather all necessary configuration settings. To set up static IP addresses or configure special settings, such as bonding, you can do one of the following:

- Pass special kernel parameters when you boot the live installer.
- Use a machine config to copy networking files to the installed system.
- Configure networking from a live installer shell prompt, then copy those settings to the installed system so that they take effect when the installed system first boots.

To configure a PXE or iPXE installation, use one of the following options:

- See the "Advanced RHCOS installation reference" tables.
- Use a machine config to copy networking files to the installed system.

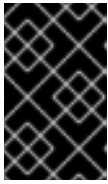
To configure an ISO installation, use the following procedure.

#### Procedure

1. Boot the ISO installer.
2. From the live system shell prompt, configure networking for the live system using available RHEL tools, such as **nmcli** or **nmtui**.

3. Run the **coreos-installer** command to install the system, adding the **--copy-network** option to copy networking configuration. For example:

```
$ sudo coreos-installer install --copy-network \  
--ignition-url=http://host/worker.ign /dev/sda
```



### IMPORTANT

The **--copy-network** option only copies networking configuration found under **/etc/NetworkManager/system-connections**. In particular, it does not copy the system hostname.

4. Reboot into the installed system.

### Additional resources

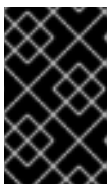
- See [Getting started with nmcli](#) and [Getting started with nmtui](#) in the RHEL 8 documentation for more information about the **nmcli** and **nmtui** tools.

#### 8.2.11.3.2. Disk partitioning

The disk partitions are created on OpenShift Container Platform cluster nodes during the Red Hat Enterprise Linux CoreOS (RHCOS) installation. Each RHCOS node of a particular architecture uses the same partition layout, unless the default partitioning configuration is overridden. During the RHCOS installation, the size of the root file system is increased to use the remaining available space on the target device.

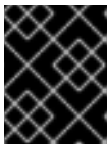
There are two cases where you might want to override the default partitioning when installing RHCOS on an OpenShift Container Platform cluster node:

- **Creating separate partitions:** For greenfield installations on an empty disk, you might want to add separate storage to a partition. This is officially supported for mounting **/var** or a subdirectory of **/var**, such as **/var/lib/etcd**, on a separate partition, but not both.



### IMPORTANT

For disk sizes larger than 100GB, and especially disk sizes larger than 1TB, create a separate **/var** partition. See "Creating a separate **/var** partition" and this [Red Hat Knowledgebase article](#) for more information.



### IMPORTANT

Kubernetes supports only two file system partitions. If you add more than one partition to the original configuration, Kubernetes cannot monitor all of them.

- **Retaining existing partitions:** For a brownfield installation where you are reinstalling OpenShift Container Platform on an existing node and want to retain data partitions installed from your previous operating system, there are both boot arguments and options to **coreos-installer** that allow you to retain existing data partitions.

**WARNING**

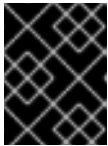
The use of custom partitions could result in those partitions not being monitored by OpenShift Container Platform or alerted on. If you are overriding the default partitioning, see [Understanding OpenShift File System Monitoring \(eviction conditions\)](#) for more information about how OpenShift Container Platform monitors your host file systems.

**8.2.11.3.2.1. Creating a separate `/var` partition**

In general, you should use the default disk partitioning that is created during the RHCOS installation. However, there are cases where you might want to create a separate partition for a directory that you expect to grow.

OpenShift Container Platform supports the addition of a single partition to attach storage to either the `/var` directory or a subdirectory of `/var`. For example:

- **`/var/lib/containers`**: Holds container-related content that can grow as more images and containers are added to a system.
- **`/var/lib/etcd`**: Holds data that you might want to keep separate for purposes such as performance optimization of etcd storage.
- **`/var`**: Holds data that you might want to keep separate for purposes such as auditing.

**IMPORTANT**

For disk sizes larger than 100GB, and especially larger than 1TB, create a separate `/var` partition.

Storing the contents of a `/var` directory separately makes it easier to grow storage for those areas as needed and reinstall OpenShift Container Platform at a later date and keep that data intact. With this method, you will not have to pull all your containers again, nor will you have to copy massive log files when you update systems.

The use of a separate partition for the `/var` directory or a subdirectory of `/var` also prevents data growth in the partitioned directory from filling up the root file system.

The following procedure sets up a separate `/var` partition by adding a machine config manifest that is wrapped into the Ignition config file for a node type during the preparation phase of an installation.

**Procedure**

1. On your installation host, change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ openshift-install create manifests --dir <installation_directory>
```

2. Create a Butane config that configures the additional partition. For example, name the file **`$HOME/clusterconfig/98-var-partition.bu`**, change the disk device name to the name of the storage device on the **worker** systems, and set the storage size as appropriate. This example

places the **/var** directory on a separate partition:

```
variant: openshift
version: 4.9.0
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 98-var-partition
storage:
  disks:
    - device: /dev/<device_name> ❶
      partitions:
        - label: var
          start_mib: <partition_start_offset> ❷
          size_mib: <partition_size> ❸
      filesystems:
        - device: /dev/disk/by-partlabel/var
          path: /var
          format: xfs
          mount_options: [defaults, prjquota] ❹
          with_mount_unit: true
```

- ❶ The storage device name of the disk that you want to partition.
- ❷ When adding a data partition to the boot disk, a minimum offset value of 25000 mebibytes is recommended. The root file system is automatically resized to fill all available space up to the specified offset. If no offset value is specified, or if the specified value is smaller than the recommended minimum, the resulting root file system will be too small, and future reinstalls of RHCOS might overwrite the beginning of the data partition.
- ❸ The size of the data partition in mebibytes.
- ❹ The **prjquota** mount option must be enabled for filesystems used for container storage.



#### NOTE

When creating a separate **/var** partition, you cannot use different instance types for compute nodes, if the different instance types do not have the same device name.

3. Create a manifest from the Butane config and save it to the **clusterconfig/openshift** directory. For example, run the following command:

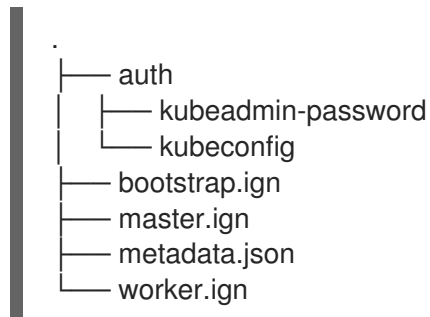
```
$ butane $HOME/clusterconfig/98-var-partition.bu -o $HOME/clusterconfig/openshift/98-var-partition.yaml
```

4. Create the Ignition config files:

```
$ openshift-install create ignition-configs --dir <installation_directory> ❶
```

- ❶ For **<installation\_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory:



The files in the `<installation_directory>/manifest` and `<installation_directory>/openshift` directories are wrapped into the Ignition config files, including the file that contains the **98-var-partition** custom **MachineConfig** object.

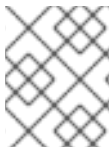
### Next steps

- You can apply the custom disk partitioning by referencing the Ignition config files during the RHCOS installations.

#### 8.2.11.3.2.2. Retaining existing partitions

For an ISO installation, you can add options to the **coreos-installer** command that cause the installer to maintain one or more existing partitions. For a PXE installation, you can add **coreos.inst.\*** options to the **APPEND** parameter to preserve partitions.

Saved partitions might be data partitions from an existing OpenShift Container Platform system. You can identify the disk partitions you want to keep either by partition label or by number.



#### NOTE

If you save existing partitions, and those partitions do not leave enough space for RHCOS, the installation will fail without damaging the saved partitions.

### Retaining existing partitions during an ISO installation

This example preserves any partition in which the partition label begins with **data** (**data\***):

```
# coreos-installer install --ignition-url http://10.0.2.2:8080/user.ign \
  --save-partlabel 'data*' /dev/sda
```

The following example illustrates running the **coreos-installer** in a way that preserves the sixth (6) partition on the disk:

```
# coreos-installer install --ignition-url http://10.0.2.2:8080/user.ign \
  --save-partindex 6 /dev/sda
```

This example preserves partitions 5 and higher:

```
# coreos-installer install --ignition-url http://10.0.2.2:8080/user.ign \
  --save-partindex 5- /dev/sda
```

In the previous examples where partition saving is used, **coreos-installer** recreates the partition immediately.

### Retaining existing partitions during a PXE installation

This **APPEND** option preserves any partition in which the partition label begins with 'data' ('data\*'):

```
coreos.inst.save_partlabel=data*
```

This **APPEND** option preserves partitions 5 and higher:

```
coreos.inst.save_partindex=5-
```

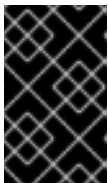
This **APPEND** option preserves partition 6:

```
coreos.inst.save_partindex=6
```

#### 8.2.11.3.3. Identifying Ignition configs

When doing an RHCOS manual installation, there are two types of Ignition configs that you can provide, with different reasons for providing each one:

- **Permanent install Ignition config:** Every manual RHCOS installation needs to pass one of the Ignition config files generated by **openshift-installer**, such as **bootstrap.ign**, **master.ign** and **worker.ign**, to carry out the installation.



#### IMPORTANT

It is not recommended to modify these Ignition config files directly. You can update the manifest files that are wrapped into the Ignition config files, as outlined in examples in the preceding sections.

For PXE installations, you pass the Ignition configs on the **APPEND** line using the **coreos.inst.ignition\_url=** option. For ISO installations, after the ISO boots to the shell prompt, you identify the Ignition config on the **coreos-installer** command line with the **--ignition-url=** option. In both cases, only HTTP and HTTPS protocols are supported.

- **Live install Ignition config:** This type must be created manually and should be avoided if possible, as it is not supported by Red Hat. With this method, the Ignition config passes to the live install medium, runs immediately upon booting, and performs setup tasks before and/or after the RHCOS system installs to disk. This method should only be used for performing tasks that must be done once and not applied again later, such as with advanced partitioning that cannot be done using a machine config.

For PXE or ISO boots, you can create the Ignition config and **APPEND** the **ignition.config.url=** option to identify the location of the Ignition config. You also need to append **ignition.firstboot** **ignition.platform.id=metal** or the **ignition.config.url** option will be ignored.

##### 8.2.11.3.3.1. Embedding a live install Ignition config in the RHCOS ISO

You can embed a live install Ignition config directly in an RHCOS ISO image. When the ISO image is booted, the embedded config will be applied automatically.

#### Procedure

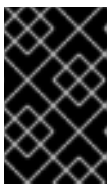
1. Download the **coreos-installer** binary from the following image mirror page:  
<https://mirror.openshift.com/pub/openshift-v4/clients/coreos-installer/latest/>.
2. Retrieve the RHCOS ISO image and the Ignition config file, and copy them into an accessible directory, such as **/mnt**:

```
# cp rhcos-<version>-live.x86_64.iso bootstrap.ign /mnt/
# chmod 644 /mnt/rhcos-<version>-live.x86_64.iso
```

3. Run the following command to embed the Ignition config into the ISO:

```
# ./coreos-installer iso ignition embed -i /mnt/bootstrap.ign \
  /mnt/rhcos-<version>-live.x86_64.iso
```

You can now use that ISO to install RHCOS using the specified live install Ignition config.



### IMPORTANT

Using **coreos-installer iso ignition embed** to embed a file generated by **openshift-installer**, such as **bootstrap.ign**, **master.ign** and **worker.ign**, is unsupported and not recommended.

4. To show the contents of the embedded Ignition config and direct it into a file, run:

```
# ./coreos-installer iso ignition show /mnt/rhcos-<version>-live.x86_64.iso > mybootstrap.ign
# diff -s bootstrap.ign mybootstrap.ign
```

### Example output

```
Files bootstrap.ign and mybootstrap.ign are identical
```

5. To remove the Ignition config and return the ISO to its pristine state so you can reuse it, run:

```
# ./coreos-installer iso ignition remove /mnt/rhcos-<version>-live.x86_64.iso
```

You can now embed another Ignition config into the ISO or use the ISO in its pristine state.

#### 8.2.11.3.4. Advanced RHCOS installation reference

This section illustrates the networking configuration and other advanced options that allow you to modify the Red Hat Enterprise Linux CoreOS (RHCOS) manual installation process. The following tables describe the kernel arguments and command-line options you can use with the RHCOS live installer and the **coreos-installer** command.

##### 8.2.11.3.4.1. Networking and bonding options for ISO installations

If you install RHCOS from an ISO image, you can add kernel arguments manually when you boot the image to configure networking for a node. If no networking arguments are specified, DHCP is activated in the initramfs when RHCOS detects that networking is required to fetch the Ignition config file.

**IMPORTANT**

When adding networking arguments manually, you must also add the **rd.neednet=1** kernel argument to bring the network up in the initramfs.

The following table provides examples for configuring networking and bonding on your RHCOS nodes for ISO installations. The examples describe how to use the **ip=**, **nameserver=**, and **bond=** kernel arguments.

**NOTE**

Ordering is important when adding the kernel arguments: **ip=**, **nameserver=**, and then **bond=**.

The networking options are passed to the **dracut** tool during system boot. For more information about the networking options supported by **dracut**, see the **dracut.cmdline** manual page.

The following information provides examples for configuring networking on your RHCOS nodes for ISO installations. The examples describe how to use the **ip=** and **nameserver=** kernel arguments.

**NOTE**

Ordering is important when adding the kernel arguments: **ip=** and **nameserver=**.

The networking options are passed to the **dracut** tool during system boot. For more information about the networking options supported by **dracut**, see the **dracut.cmdline** manual page.

The following examples are the networking options for ISO installation.

Configuring DHCP or static IP addresses

To configure an IP address, either use DHCP (**ip=dhcp**) or set an individual static IP address (**ip=<host\_ip>**). If setting a static IP, you must then identify the DNS server IP address (**nameserver=<dns\_ip>**) on each node. The following example sets:

- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The hostname to **core0.example.com**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
nameserver=4.4.4.41
```





## NOTE

When you use DHCP to configure IP addressing for the RHCOS machines, the machines also obtain the DNS server information through DHCP. For DHCP-based deployments, you can define the DNS server address that is used by the RHCOS nodes through your DHCP server configuration.

### Configuring an IP address without a static hostname

You can configure an IP address without assigning a static hostname. If a static hostname is not set by the user, it will be picked up and automatically set by a reverse DNS lookup. To configure an IP address without a static hostname refer to the following example:

- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0::enp1s0:none
nameserver=4.4.4.41
```

### Specifying multiple network interfaces

You can specify multiple network interfaces by setting multiple **ip=** entries.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=10.10.10.3::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

### Configuring default gateway and route

Optional: You can configure routes to additional networks by setting an **rd.route=** value.



## NOTE

When you configure one or multiple networks, one default gateway is required. If the additional network gateway is different from the primary network gateway, the default gateway must be the primary network gateway.

- Run the following command to configure the default gateway:

```
ip=::10.10.10.254:::
```

- Enter the following command to configure the route for the additional network:

```
rd.route=20.20.20.0/24:20.20.20.254:enp2s0
```

### Disabling DHCP on a single interface

You can disable DHCP on a single interface, such as when there are two or more network interfaces and only one interface is being used. In the example, the **enp1s0** interface has a static networking configuration and DHCP is disabled for **enp2s0**, which is not used:

■

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=:::core0.example.com:enp2s0:none
```

#### Combining DHCP and static IP configurations

You can combine DHCP and static IP configurations on systems with multiple network interfaces, for example:

```
ip=enp1s0:dhcp
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

#### Configuring VLANs on individual interfaces

Optional: You can configure VLANs on individual interfaces by using the **vlan=** parameter.

- To configure a VLAN on a network interface and use a static IP address, run the following command:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0.100:none
vlan=enp2s0.100:enp2s0
```

- To configure a VLAN on a network interface and to use DHCP, run the following command:

```
ip=enp2s0.100:dhcp
vlan=enp2s0.100:enp2s0
```

#### Providing multiple DNS servers

You can provide multiple DNS servers by adding a **nameserver=** entry for each server, for example:

```
nameserver=1.1.1.1
nameserver=8.8.8.8
```

#### Bonding multiple network interfaces to a single interface

Optional: You can bond multiple network interfaces to a single interface by using the **bond=** option.

Refer to the following examples:

- The syntax for configuring a bonded interface is: **bond=name[:network\_interfaces][:options]** *name* is the bonding device name (**bond0**), *network\_interfaces* represents a comma-separated list of physical (ethernet) interfaces (**em1,em2**), and *options* is a comma-separated list of bonding options. Enter **modinfo bonding** to see available options.
- When you create a bonded interface using **bond=**, you must specify how the IP address is assigned and other information for the bonded interface.
- To configure the bonded interface to use DHCP, set the bond's IP address to **dhcp**. For example:

```
bond=bond0:em1,em2:mode=active-backup
ip=bond0:dhcp
```

- To configure the bonded interface to use a static IP address, enter the specific IP address you want and related information. For example:

```
bond=bond0:em1,em2:mode=active-backup
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0:none
```

Bonding multiple network interfaces to a single interface

Optional: You can configure VLANs on bonded interfaces by using the **vlan=** parameter and to use DHCP, for example:

```
ip=bond0.100:dhcp
bond=bond0:em1,em2:mode=active-backup
vlan=bond0.100:bond0
```

Use the following example to configure the bonded interface with a VLAN and to use a static IP address:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0.100:none
bond=bond0:em1,em2:mode=active-backup
vlan=bond0.100:bond0
```

Using network teaming

Optional: You can use a network teaming as an alternative to bonding by using the **team=** parameter:

- The syntax for configuring a team interface is: **team=name[:network\_interfaces]**  
*name* is the team device name (**team0**) and *network\_interfaces* represents a comma-separated list of physical (ethernet) interfaces (**em1, em2**).

Teaming is planned to be deprecated when RHCOS switches to an upcoming version of RHEL. For more information, see this [Red Hat Knowledgebase Article](#) .

Use the following example to configure a network team:

```
team=team0:em1,em2
ip=team0:dhcp
```


#### 8.2.11.3.4.2. coreos-installer options for ISO installations

You can install RHCOS by running **coreos-installer install <options> <device>** at the command prompt, after booting into the RHCOS live environment from an ISO image.

The following table shows the subcommands, options, and arguments you can pass to the **coreos-installer** command.

**Table 8.12. coreos-installer subcommands, command-line options, and arguments**

coreos-installer install subcommand	
<i>Subcommand</i>	<i>Description</i>
<b>\$ coreos-installer install &lt;options&gt; &lt;device&gt;</b>	Embed an Ignition config in an ISO image.
coreos-installer install subcommand options	
<i>Option</i>	<i>Description</i>
<b>-u, --image-url &lt;url&gt;</b>	Specify the image URL manually.

<b>-f, --image-file &lt;path&gt;</b>	Specify a local image file manually. Used for debugging.
<b>-i, --ignition-file &lt;path&gt;</b>	Embed an Ignition config from a file.
<b>-l, --ignition-url &lt;URL&gt;</b>	Embed an Ignition config from a URL.
<b>--ignition-hash &lt;digest&gt;</b>	Digest <b>type-value</b> of the Ignition config.
<b>-p, --platform &lt;name&gt;</b>	Override the Ignition platform ID for the installed system.
<b>--append-karg &lt;arg&gt;...</b>	Append a default kernel argument to the installed system.
<b>--delete-karg &lt;arg&gt;...</b>	Delete a default kernel argument from the installed system.
<b>-n, --copy-network</b>	Copy the network configuration from the install environment.   <b>IMPORTANT</b> The <b>--copy-network</b> option only copies networking configuration found under <b>/etc/NetworkManager/system-connections</b> . In particular, it does not copy the system hostname.
<b>--network-dir &lt;path&gt;</b>	For use with <b>-n</b> . Default is <b>/etc/NetworkManager/system-connections/</b> .
<b>--save-partlabel &lt;lx&gt;..</b>	Save partitions with this label glob.
<b>--save-partindex &lt;id&gt;...</b>	Save partitions with this number or range.
<b>--insecure</b>	Skip signature verification.
<b>--insecure-ignition</b>	Allow Ignition URL without HTTPS or hash.
<b>--architecture &lt;name&gt;</b>	Target CPU architecture. Default is <b>x86_64</b> .
<b>--preserve-on-error</b>	Do not clear partition table on error.
<b>-h, --help</b>	Print help information.
<b>coreos-install install subcommand argument</b>	

<i>Argument</i>	<i>Description</i>
<b>&lt;device&gt;</b>	The destination device.
coreos-installer ISO Ignition subcommands	
<i>Subcommand</i>	<i>Description</i>
<b>\$ coreos-installer iso ignition embed &lt;options&gt; --ignition-file &lt;file_path&gt; &lt;ISO_image&gt;</b>	Embed an Ignition config in an ISO image.
<b>coreos-installer iso ignition show &lt;options&gt; &lt;ISO_image&gt;</b>	Show the embedded Ignition config from an ISO image.
<b>coreos-installer iso ignition remove &lt;options&gt; &lt;ISO_image&gt;</b>	Remove the embedded Ignition config from an ISO image.
coreos-installer ISO Ignition subcommand options	
<i>Option</i>	<i>Description</i>
<b>-f, --force</b>	Overwrite an existing Ignition config.
<b>-i, --ignition-file &lt;path&gt;</b>	The Ignition config to be used. Default is <b>stdin</b> .
<b>-o, --output &lt;path&gt;</b>	Write the ISO to a new output file.
<b>-h, --help</b>	Print help information.
coreos-installer PXE Ignition subcommands	
<i>Subcommand</i>	<i>Description</i>
Note that not all of these options are accepted by all subcommands.	
<b>coreos-installer pxe ignition wrap &lt;options&gt;</b>	Wrap an Ignition config in an image.
<b>coreos-installer pxe ignition unwrap &lt;options&gt; &lt;image_name&gt;</b>	Show the wrapped Ignition config in an image.
coreos-installer PXE Ignition subcommand options	
<i>Option</i>	<i>Description</i>
Note that not all of these options are accepted by all subcommands.	

<b>-i, --ignition-file &lt;path&gt;</b>	The Ignition config to be used. Default is <b>stdin</b> .
<b>-o, --output &lt;path&gt;</b>	Write the ISO to a new output file.
<b>-h, --help</b>	Print help information.

#### 8.2.11.3.4.3. **coreos.inst** boot options for ISO or PXE installations

You can automatically invoke **coreos-installer** options at boot time by passing **coreos.inst** boot arguments to the RHCOS live installer. These are provided in addition to the standard boot arguments.

- For ISO installations, the **coreos.inst** options can be added by interrupting the automatic boot at the bootloader menu. You can interrupt the automatic boot by pressing **TAB** while the **RHEL CoreOS (Live)** menu option is highlighted.
- For PXE or iPXE installations, the **coreos.inst** options must be added to the **APPEND** line before the RHCOS live installer is booted.

The following table shows the RHCOS live installer **coreos.inst** boot options for ISO and PXE installations.

**Table 8.13. coreos.inst boot options**

Argument	Description
<b>coreos.inst.install_dev</b>	Required. The block device on the system to install to. It is recommended to use the full path, such as <b>/dev/sda</b> , although <b>sda</b> is allowed.
<b>coreos.inst.ignition_url</b>	Optional: The URL of the Ignition config to embed into the installed system. If no URL is specified, no Ignition config is embedded. Only HTTP and HTTPS protocols are supported.
<b>coreos.inst.save_partlabel</b>	Optional: Comma-separated labels of partitions to preserve during the install. Glob-style wildcards are permitted. The specified partitions do not need to exist.
<b>coreos.inst.save_partindex</b>	Optional: Comma-separated indexes of partitions to preserve during the install. Ranges <b>m-n</b> are permitted, and either <b>m</b> or <b>n</b> can be omitted. The specified partitions do not need to exist.
<b>coreos.inst.insecure</b>	Optional: Permits the OS image that is specified by <b>coreos.inst.image_url</b> to be unsigned.

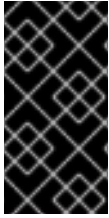
Argument	Description
<b>coreos.inst.image_url</b>	<p>Optional: Download and install the specified RHCOS image.</p> <ul style="list-style-type: none"> <li>• This argument should not be used in production environments and is intended for debugging purposes only.</li> <li>• While this argument can be used to install a version of RHCOS that does not match the live media, it is recommended that you instead use the media that matches the version you want to install.</li> <li>• If you are using <b>coreos.inst.image_url</b>, you must also use <b>coreos.inst.insecure</b>. This is because the bare-metal media are not GPG-signed for OpenShift Container Platform.</li> <li>• Only HTTP and HTTPS protocols are supported.</li> </ul>
<b>coreos.inst.skip_reboot</b>	<p>Optional: The system will not reboot after installing. After the install finishes, you will receive a prompt that allows you to inspect what is happening during installation. This argument should not be used in production environments and is intended for debugging purposes only.</p>
<b>coreos.inst.platform_id</b>	<p>Optional: The Ignition platform ID of the platform the RHCOS image is being installed on. Default is <b>metal</b>. This option determines whether or not to request an Ignition config from the cloud provider, such as VMware. For example: <b>coreos.inst.platform_id=vmware</b>.</p>
<b>ignition.config.url</b>	<p>Optional: The URL of the Ignition config for the live boot. For example, this can be used to customize how <b>coreos-installer</b> is invoked, or to run code before or after the installation. This is different from <b>coreos.inst.ignition_url</b>, which is the Ignition config for the installed system.</p>

#### 8.2.11.4. Enabling multipathing with kernel arguments on RHCOS

RHCOS supports multipathing on the primary disk, allowing stronger resilience to hardware failure to achieve higher host availability.

You can enable multipathing at installation time for nodes that were provisioned in OpenShift Container Platform 4.8 or later. While post-installation support is available by activating multipathing via the machine config, enabling multipathing during installation is recommended.

In setups where any I/O to non-optimized paths results in I/O system errors, you must enable multipathing at installation time.



## IMPORTANT

On IBM Z and LinuxONE, you can enable multipathing only if you configured your cluster for it during installation. For more information, see "Installing RHCOS and starting the OpenShift Container Platform bootstrap process" in *Installing a cluster with z/VM on IBM Z and LinuxONE*.

The following procedure enables multipath at installation time and appends kernel arguments to the **coreos-installer install** command so that the installed system itself will use multipath beginning from the first boot.

### Prerequisites

- You have a running OpenShift Container Platform cluster that uses version 4.8 or later.



## NOTE

OpenShift Container Platform does not support enabling multipathing as a day-2 activity on nodes that have been upgraded from 4.6 or earlier.

- You are logged in to the cluster as a user with administrative privileges.

### Procedure

- To enable multipath and start the **multipathd** daemon, run the following command:

```
$ mpathconf --enable && systemctl start multipathd.service
```

- Optional: If booting the PXE or ISO, you can instead enable multipath by adding **rd.multipath=default** from the kernel command line.
- Append the kernel arguments by invoking the **coreos-installer** program:
    - If there is only one multipath device connected to the machine, it should be available at path **/dev/mapper/mpatha**. For example:

```
$ coreos-installer install /dev/mapper/mpatha \ 1
--append-karg rd.multipath=default \
--append-karg root=/dev/disk/by-label/dm-mpath-root \
--append-karg rw
```

- 1** Indicates the path of the single multipathed device.

- If there are multiple multipath devices connected to the machine, or to be more explicit, instead of using **/dev/mapper/mpatha**, it is recommended to use the World Wide Name (WWN) symlink available in **/dev/disk/by-id**. For example:

```
$ coreos-installer install /dev/disk/by-id/wwn-<wwn_ID> \ 1
--append-karg rd.multipath=default \
--append-karg root=/dev/disk/by-label/dm-mpath-root \
--append-karg rw
```



- 1 Indicates the WWN ID of the target multipathed device. For example, **0xx194e957fcedb4841**.

This symlink can also be used as the **coreos.inst.install\_dev** kernel argument when using special **coreos.inst.\*** arguments to direct the live installer. For more information, see "Installing RHCOS and starting the OpenShift Container Platform bootstrap process".

3. Check that the kernel arguments worked by going to one of the worker nodes and listing the kernel command line arguments (in **/proc/cmdline** on the host):

```
$ oc debug node/ip-10-0-141-105.ec2.internal
```

### Example output

```
Starting pod/ip-10-0-141-105ec2internal-debug ...
To use host binaries, run `chroot /host`

sh-4.2# cat /host/proc/cmdline
...
rd.multipath=default root=/dev/disk/by-label/dm-mpath-root
...

sh-4.2# exit
```

You should see the added kernel arguments.

### Additional resources

- See [Installing RHCOS and starting the OpenShift Container Platform bootstrap process](#) for more information on using special **coreos.inst.\*** arguments to direct the live installer.

### 8.2.11.5. Updating the bootloader using **bootupd**

To update the bootloader by using **bootupd**, you must either install **bootupd** on RHCOS machines manually or provide a machine config with the enabled **systemd** unit. Unlike **grubby** or other bootloader tools, **bootupd** does not manage kernel space configuration such as passing kernel arguments.

After you have installed **bootupd**, you can manage it remotely from the OpenShift Container Platform cluster.



#### NOTE

It is recommended that you use **bootupd** only on bare metal or virtualized hypervisor installations, such as for protection against the BootHole vulnerability.

### Manual install method

You can manually install **bootupd** by using the **bootctl** command-line tool.

1. Inspect the system status:

```
# bootupctl status
```

### Example output

```
Component EFI
  Installed: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
  Update: At latest version
```

- RHCOS images created without **bootupd** installed on them require an explicit adoption phase. If the system status is **Adoptable**, perform the adoption:

```
# bootupctl adopt-and-update
```

### Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

- If an update is available, apply the update so that the changes take effect on the next reboot:

```
# bootupctl update
```

### Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

## Machine config method

Another way to enable **bootupd** is by providing a machine config.

- Provide a machine config file with the enabled **systemd** unit, as shown in the following example:

### Example output

```
variant: rhcos
version: 1.1.0
systemd:
  units:
    - name: custom-bootupd-auto.service
      enabled: true
      contents: |
        [Unit]
        Description=Bootupd automatic update

        [Service]
        ExecStart=/usr/bin/bootupctl update
        RemainAfterExit=yes

        [Install]
        WantedBy=multi-user.target
```

## 8.2.12. Waiting for the bootstrap process to complete

The OpenShift Container Platform bootstrap process begins after the cluster nodes first boot into the persistent RHCOS environment that has been installed to disk. The configuration information provided through the Ignition config files is used to initialize the bootstrap process and install OpenShift

Container Platform on the machines. You must wait for the bootstrap process to complete.

### Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have obtained the installation program and generated the Ignition config files for your cluster.
- You installed RHCOS on your cluster machines and provided the Ignition config files that the OpenShift Container Platform installation program generated.
- Your machines have direct internet access or have an HTTP or HTTPS proxy available.

### Procedure

1. Monitor the bootstrap process:

```
$ ./openshift-install --dir <installation_directory> wait-for bootstrap-complete \ 1
--log-level=info 2
```

- 1 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

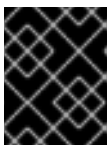
- 2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

### Example output

```
INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...
INFO API v1.22.1 up
INFO Waiting up to 30m0s for bootstrapping to complete...
INFO It is now safe to remove the bootstrap resources
```

The command succeeds when the Kubernetes API server signals that it has been bootstrapped on the control plane machines.

2. After bootstrap process is complete, remove the bootstrap machine from the load balancer.



### IMPORTANT

You must remove the bootstrap machine from the load balancer at this point. You can also remove or reformat the bootstrap machine itself.

### Additional resources

- See [Monitoring installation progress](#) for more information about monitoring the installation logs and retrieving diagnostic data if installation issues arise.

### 8.2.13. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The

**kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

#### Example output

```
system:admin
```

## 8.2.14. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

### Prerequisites

- You added machines to your cluster.

### Procedure

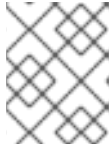
1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

#### Example output

```
NAME      STATUS    ROLES    AGE  VERSION
master-0  Ready     master   63m  v1.22.1
master-1  Ready     master   63m  v1.22.1
master-2  Ready     master   64m  v1.22.1
```

The output lists all of the machines that you created.

**NOTE**

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

- Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

**Example output**

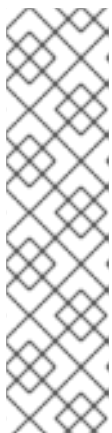
```
NAME      AGE   REQUESTOR                                     CONDITION
csr-8b2br 15m   system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper Pending
csr-8vnps 15m   system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper Pending
...
```

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

- If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:

**NOTE**

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.

**NOTE**

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{\n"}\n' | xargs --no-run-if-empty oc adm certificate approve
```



#### NOTE

Some Operators might not become available until some CSRs are approved.

- Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

#### Example output

```
NAME      AGE   REQUESTOR                                     CONDITION
csr-bfd72 5m26s system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv 5m26s system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

- If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

1 **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{\n"}\n' | xargs oc adm certificate approve
```

- After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

#### Example output

```
NAME      STATUS   ROLES    AGE   VERSION
master-0  Ready   master   73m   v1.22.1
master-1  Ready   master   73m   v1.22.1
```

```

master-2 Ready   master 74m v1.22.1
worker-0 Ready   worker 11m v1.22.1
worker-1 Ready   worker 11m v1.22.1

```

**NOTE**

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

**Additional information**

- For more information on CSRs, see [Certificate Signing Requests](#).

**8.2.15. Initial Operator configuration**

After the control plane initializes, you must immediately configure some Operators so that they all become available.

**Prerequisites**

- Your control plane has initialized.

**Procedure**

1. Watch the cluster components come online:

```
$ watch -n5 oc get clusteroperators
```

**Example output**

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
authentication	4.9.0	True	False	False	19m
baremetal	4.9.0	True	False	False	37m
cloud-credential	4.9.0	True	False	False	40m
cluster-autoscaler	4.9.0	True	False	False	37m
config-operator	4.9.0	True	False	False	38m
console	4.9.0	True	False	False	26m
csi-snapshot-controller	4.9.0	True	False	False	37m
dns	4.9.0	True	False	False	37m
etcd	4.9.0	True	False	False	36m
image-registry	4.9.0	True	False	False	31m
ingress	4.9.0	True	False	False	30m
insights	4.9.0	True	False	False	31m
kube-apiserver	4.9.0	True	False	False	26m
kube-controller-manager	4.9.0	True	False	False	36m
kube-scheduler	4.9.0	True	False	False	36m
kube-storage-version-migrator	4.9.0	True	False	False	37m
machine-api	4.9.0	True	False	False	29m
machine-approver	4.9.0	True	False	False	37m
machine-config	4.9.0	True	False	False	36m
marketplace	4.9.0	True	False	False	37m
monitoring	4.9.0	True	False	False	29m
network	4.9.0	True	False	False	38m

node-tuning	4.9.0	True	False	False	37m
openshift-apiserver	4.9.0	True	False	False	32m
openshift-controller-manager	4.9.0	True	False	False	30m
openshift-samples	4.9.0	True	False	False	32m
operator-lifecycle-manager	4.9.0	True	False	False	37m
operator-lifecycle-manager-catalog	4.9.0	True	False	False	37m
operator-lifecycle-manager-packageserver	4.9.0	True	False	False	32m
service-ca	4.9.0	True	False	False	38m
storage	4.9.0	True	False	False	37m

2. Configure the Operators that are not available.

### Additional resources

- See [Gathering logs from a failed installation](#) for details about gathering data in the event of a failed OpenShift Container Platform installation.
- See [Troubleshooting Operator issues](#) for steps to check Operator pod health across the cluster and gather Operator logs for diagnosis.

#### 8.2.15.1. Image registry removed during installation

On platforms that do not provide shareable object storage, the OpenShift Image Registry Operator bootstraps itself as **Removed**. This allows **openshift-installer** to complete installations on these platform types.

After installation, you must edit the Image Registry Operator configuration to switch the **managementState** from **Removed** to **Managed**.



#### NOTE

The Prometheus console provides an **ImageRegistryRemoved** alert, for example:

"Image Registry has been removed. **ImageStreamTags**, **BuildConfigs** and **DeploymentConfigs** which reference **ImageStreamTags** may not work as expected. Please configure storage and update the config to **Managed** state by editing `configs.imageregistry.operator.openshift.io`."

#### 8.2.15.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

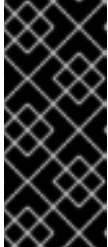
##### 8.2.15.2.1. Configuring registry storage for bare metal and other manual installations

As a cluster administrator, following installation you must configure your registry to use storage.



## Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.
- You have a cluster that uses manually-provisioned Red Hat Enterprise Linux CoreOS (RHCOS) nodes, such as bare metal.
- You have provisioned persistent storage for your cluster, such as Red Hat OpenShift Container Storage.



### IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have 100Gi capacity.

## Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.



### NOTE

When using shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

### Example output

```
No resources found in openshift-image-registry namespace
```



### NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

### Example output

```
storage:
  pvc:
    claim:
```

Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** PVC.

4. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

#### Example output

```
NAME          VERSION          AVAILABLE  PROGRESSING  DEGRADED  SINCE
MESSAGE
image-registry 4.9              True       False        False     6h50m
```

5. Ensure that your registry is set to managed to enable building and pushing of images.

- Run:

```
$ oc edit configs.imageregistry/cluster
```

Then, change the line

```
managementState: Removed
```

to

```
managementState: Managed
```

#### 8.2.15.2.2. Configuring storage for the image registry in non-production clusters

You must configure storage for the Image Registry Operator. For non-production clusters, you can set the image registry to an empty directory. If you do so, all images are lost if you restart the registry.

#### Procedure

- To set the image registry storage to an empty directory:

```
$ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec": {"storage":{"emptyDir":{}}}'
```



#### WARNING

Configure this option for only non-production clusters.

If you run this command before the Image Registry Operator initializes its components, the **oc patch** command fails with the following error:

```
Error from server (NotFound): configs.imageregistry.operator.openshift.io "cluster" not found
```

Wait a few minutes and run the command again.

### 8.2.15.2.3. Configuring block registry storage

To allow the image registry to use block storage types during upgrades as a cluster administrator, you can use the **Recreate** rollout strategy.



#### IMPORTANT

Block storage volumes are supported but not recommended for use with the image registry on production clusters. An installation where the registry is configured on block storage is not highly available because the registry cannot have more than one replica.

#### Procedure

1. To set the image registry storage as a block storage type, patch the registry so that it uses the **Recreate** rollout strategy and runs with only one ( **1** ) replica:

```
$ oc patch config.imageregistry.operator.openshift.io/cluster --type=merge -p '{"spec": {"rolloutStrategy":"Recreate","replicas":1}}'
```

2. Provision the PV for the block storage device, and create a PVC for that volume. The requested block volume uses the ReadWriteOnce (RWO) access mode.
3. Edit the registry configuration so that it references the correct PVC.

## 8.2.16. Completing installation on user-provisioned infrastructure

After you complete the Operator configuration, you can finish installing the cluster on infrastructure that you provide.

#### Prerequisites

- Your control plane has initialized.
- You have completed the initial Operator configuration.

#### Procedure

1. Confirm that all the cluster components are online with the following command:

```
$ watch -n5 oc get clusteroperators
```

#### Example output

NAME SINCE	VERSION	AVAILABLE	PROGRESSING	DEGRADED
authentication	4.9.0	True	False	False 19m
baremetal	4.9.0	True	False	False 37m
cloud-credential	4.9.0	True	False	False 40m
cluster-autoscaler	4.9.0	True	False	False 37m
config-operator	4.9.0	True	False	False 38m
console	4.9.0	True	False	False 26m

csi-snapshot-controller	4.9.0	True	False	False	37m
dns	4.9.0	True	False	False	37m
etcd	4.9.0	True	False	False	36m
image-registry	4.9.0	True	False	False	31m
ingress	4.9.0	True	False	False	30m
insights	4.9.0	True	False	False	31m
kube-apiserver	4.9.0	True	False	False	26m
kube-controller-manager	4.9.0	True	False	False	36m
kube-scheduler	4.9.0	True	False	False	36m
kube-storage-version-migrator	4.9.0	True	False	False	37m
machine-api	4.9.0	True	False	False	29m
machine-approver	4.9.0	True	False	False	37m
machine-config	4.9.0	True	False	False	36m
marketplace	4.9.0	True	False	False	37m
monitoring	4.9.0	True	False	False	29m
network	4.9.0	True	False	False	38m
node-tuning	4.9.0	True	False	False	37m
openshift-apiserver	4.9.0	True	False	False	32m
openshift-controller-manager	4.9.0	True	False	False	30m
openshift-samples	4.9.0	True	False	False	32m
operator-lifecycle-manager	4.9.0	True	False	False	37m
operator-lifecycle-manager-catalog	4.9.0	True	False	False	37m
operator-lifecycle-manager-packageserver	4.9.0	True	False	False	32m
service-ca	4.9.0	True	False	False	38m
storage	4.9.0	True	False	False	37m

Alternatively, the following command notifies you when all of the clusters are available. It also retrieves and displays credentials:

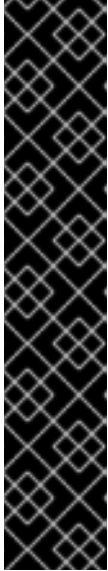
```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

### Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

The command succeeds when the Cluster Version Operator finishes deploying the OpenShift Container Platform cluster from Kubernetes API server.



## IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Confirm that the Kubernetes API server is communicating with the pods.

a. To view a list of all pods, use the following command:

```
$ oc get pods --all-namespaces
```

### Example output

```

NAMESPACE           NAME                                     READY  STATUS
RESTARTS  AGE
openshift-apiserver-operator  openshift-apiserver-operator-85cb746d55-zqhs8  1/1
Running   1    9m
openshift-apiserver          apiserver-67b9g                                1/1  Running  0
3m
openshift-apiserver          apiserver-ljcmx                                1/1  Running  0
1m
openshift-apiserver          apiserver-z25h4                                1/1  Running  0
2m
openshift-authentication-operator  authentication-operator-69d5d8bf84-vh2n8  1/1
Running   0    5m
...

```

b. View the logs for a pod that is listed in the output of the previous command by using the following command:

```
$ oc logs <pod_name> -n <namespace> ❶
```

- ❶ Specify the pod name and namespace, as shown in the output of the previous command.

If the pod logs display, the Kubernetes API server can communicate with the cluster machines.

3. For an installation with Fibre Channel Protocol (FCP), additional steps are required to enable multipathing. Do not enable multipathing during installation. See "Enabling multipathing with kernel arguments on RHCOS" in the *Post-installation machine configuration tasks* documentation for more information.

### 8.2.17. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

#### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

### 8.2.18. Next steps

- [Validating an installation](#).
- [Customize your cluster](#).
- If necessary, you can [opt out of remote health reporting](#) .
- [Set up your registry and configure registry storage](#) .

## 8.3. INSTALLING A USER-PROVISIONED BARE METAL CLUSTER WITH NETWORK CUSTOMIZATIONS

In OpenShift Container Platform 4.9, you can install a cluster on bare metal infrastructure that you provision with customized network configuration options. By customizing your network configuration, your cluster can coexist with existing IP address allocations in your environment and integrate with existing MTU and VXLAN configurations.

When you customize OpenShift Container Platform networking, you must set most of the network configuration parameters during installation. You can modify only **kubeProxy** network configuration parameters in a running cluster.

### 8.3.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- If you use a firewall and plan to use the Telemetry service, you [configured the firewall to allow the sites](#) that your cluster requires access to.

### 8.3.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



### IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

### Additional resources

- See [Installing a user-provisioned bare metal cluster on a restricted network](#) for more information about performing a restricted network installation on bare metal infrastructure that you provision.

## 8.3.3. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

### 8.3.3.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

**Table 8.14. Minimum required hosts**

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.

**NOTE**

As an exception, you can run zero compute machines in a bare metal cluster that consists of three control plane machines only. This provides smaller, more resource efficient clusters for cluster administrators and developers to use for testing, development, and production. Running one compute machine is not supported.

**IMPORTANT**

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 7.9, or RHEL 8.4.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See [Red Hat Enterprise Linux technology capabilities and limits](#) .

**8.3.3.2. Minimum resource requirements for cluster installation**

Each cluster machine must meet the following minimum requirements:

**Table 8.15. Minimum resource requirements**

Machine	Operating System	CPU [1]	RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 7.9, or RHEL 8.4 [3]	2	8 GB	100 GB	300

1. One CPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio:  $(\text{threads per core} \times \text{cores}) \times \text{sockets} = \text{CPUs}$ .
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.

**8.3.3.3. Certificate signing requests management**



Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

### Additional resources

- See [Configuring a three-node cluster](#) for details about deploying three-node clusters in bare metal environments.
- See [Approving the certificate signing requests for your machines](#) for more information about approving cluster certificate signing requests after installation.

#### 8.3.3.4. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.

It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.



#### NOTE

If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

##### 8.3.3.4.1. Setting the cluster node hostnames through DHCP

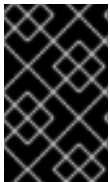
On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

#### 8.3.3.4.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.



#### IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

**Table 8.16. Ports used for all-machine to all-machine communications**

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	<b>1936</b>	Metrics
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> and the Cluster Version Operator on port <b>9099</b> .
	<b>10250-10259</b>	The default ports that Kubernetes reserves
	<b>10256</b>	openshift-sdn
UDP	<b>4789</b>	VXLAN and Geneve
	<b>6081</b>	VXLAN and Geneve
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> .
	<b>500</b>	IPsec IKE packets
	<b>4500</b>	IPsec NAT-T packets
TCP/UDP	<b>30000-32767</b>	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

**Table 8.17. Ports used for all-machine to control plane communications**

Protocol	Port	Description
TCP	<b>6443</b>	Kubernetes API

**Table 8.18. Ports used for control plane machine to control plane machine communications**

Protocol	Port	Description
TCP	<b>2379-2380</b>	etcd server and peer ports

### NTP configuration for user-provisioned infrastructure

OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service*.

If a DHCP server provides NTP server information, the chrony time service on the Red Hat Enterprise Linux CoreOS (RHCOS) machines read the information and can sync the clock with the NTP servers.

### Additional resources

- [Configuring chrony time service](#)

### 8.3.3.5. User-provisioned DNS requirements

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API
- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines

Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.




### NOTE

It is recommended to use a DHCP server to provide the hostnames to each cluster node. See the *DHCP recommendations for user-provisioned infrastructure* section for more information.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, **<cluster\_name>** is the cluster name and **<base\_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS

record takes the form: **<component>.<cluster\_name>.<base\_domain>.**

**Table 8.19. Required DNS records**

Component	Record	Description
Kubernetes API	<b>api.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
	<b>api-int.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster.
		 <p><b>IMPORTANT</b></p> <p>The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.</p>
Routes	<b>*.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	<p>A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.</p> <p>For example, <b>console-openshift-console.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;</b> is used as a wildcard route to the OpenShift Container Platform console.</p>
Bootstrap machine	<b>bootstrap.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.
Control plane machines	<b>&lt;master&gt;&lt;n&gt;.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.
Compute machines	<b>&lt;worker&gt;&lt;n&gt;.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.

**NOTE**

In OpenShift Container Platform 4.4 and later, you do not need to specify `etcd` host and `SRV` records in your DNS configuration.

**TIP**

You can use the **dig** command to verify name and reverse name resolution. See the section on *Validating DNS resolution for user-provisioned infrastructure* for detailed validation steps.

**8.3.3.5.1. Example DNS configuration for user-provisioned clusters**

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is **ocp4** and the base domain is **example.com**.

**Example DNS A record configuration for a user-provisioned cluster**

The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

**Example 8.4. Sample DNS zone database**

```
$TTL 1W
@ IN SOA ns1.example.com. root (
    2019070700 ; serial
    3H ; refresh (3 hours)
    30M ; retry (30 minutes)
    2W ; expiry (2 weeks)
    1W ) ; minimum (1 week)
IN NS ns1.example.com.
IN MX 10 smtp.example.com.
;
;
ns1.example.com. IN A 192.168.1.5
smtp.example.com. IN A 192.168.1.5
;
helper.example.com. IN A 192.168.1.5
helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com. IN A 192.168.1.5 1
api-int.ocp4.example.com. IN A 192.168.1.5 2
;
*.apps.ocp4.example.com. IN A 192.168.1.5 3
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 4
;
master0.ocp4.example.com. IN A 192.168.1.97 5
master1.ocp4.example.com. IN A 192.168.1.98 6
master2.ocp4.example.com. IN A 192.168.1.99 7
;
worker0.ocp4.example.com. IN A 192.168.1.11 8
```

```
worker1.ocp4.example.com. IN A 192.168.1.7 9
```

```
;  
;EOF
```

- 1 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.
- 2 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.
- 3 Provides name resolution for the wildcard routes. The record refers to the IP address of the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



#### NOTE

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

- 4 Provides name resolution for the bootstrap machine.
- 5 6 7 Provides name resolution for the control plane machines.
- 8 9 Provides name resolution for the compute machines.

### Example DNS PTR record configuration for a user-provisioned cluster

The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

#### Example 8.5. Sample DNS zone database for reverse records

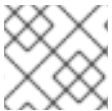
```
$TTL 1W  
@ IN SOA ns1.example.com. root (  
  2019070700 ; serial  
  3H ; refresh (3 hours)  
  30M ; retry (30 minutes)  
  2W ; expiry (2 weeks)  
  1W ) ; minimum (1 week)  
IN NS ns1.example.com.  
;  
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. 1  
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. 2  
;  
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. 3  
;  
97.1.168.192.in-addr.arpa. IN PTR master0.ocp4.example.com. 4  
98.1.168.192.in-addr.arpa. IN PTR master1.ocp4.example.com. 5  
99.1.168.192.in-addr.arpa. IN PTR master2.ocp4.example.com. 6
```

```

;
11.1.168.192.in-addr.arpa. IN PTR worker0.ocp4.example.com. 7
7.1.168.192.in-addr.arpa. IN PTR worker1.ocp4.example.com. 8
;
;EOF

```

- 1 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.
- 2 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.
- 3 Provides reverse DNS resolution for the bootstrap machine.
- 4 5 6 Provides reverse DNS resolution for the control plane machines.
- 7 8 Provides reverse DNS resolution for the compute machines.



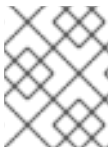
#### NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard.

- [Validating DNS resolution for user-provisioned infrastructure](#)

### 8.3.3.6. Load balancing requirements for user-provisioned infrastructure

Before you install OpenShift Container Platform, you must provision the API and application ingress load balancing infrastructure. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

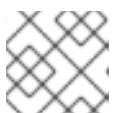


#### NOTE

If you want to deploy the API and application ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer.** Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:
  - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the API routes.
  - A stateless load balancing algorithm. The options vary based on the load balancer implementation.



#### NOTE

Session persistence is not required for the API load balancer to function properly.

Configure the following ports on both the front and back of the load balancers:

Table 8.20. API load balancer

Port	Back-end machines (pool members)	Internal	External	Description
<b>6443</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the <b>/readyz</b> endpoint for the API server health check probe.	X	X	Kubernetes API server
<b>22623</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server

**NOTE**

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the **/readyz** endpoint to the removal of the API server instance from the pool. Within the time frame after **/readyz** returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application ingress load balancer.** Provides an ingress point for application traffic flowing in from outside the cluster. Configure the following conditions:

- Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the ingress routes.
- A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

**TIP**

If the true IP address of the client can be seen by the application ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

Configure the following ports on both the front and back of the load balancers:

Table 8.21. Application ingress load balancer

Port	Back-end machines (pool members)	Internal	External	Description
<b>443</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic



Port	Back-end machines (pool members)	Internal	External	Description
<b>80</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic
<b>1936</b>	The worker nodes that run the Ingress Controller pods, by default. You must configure the <b>/healthz/ready</b> endpoint for the ingress health check probe.	X	X	HTTP traffic

**NOTE**

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

**NOTE**

A working configuration for the Ingress router is required for an OpenShift Container Platform cluster. You must configure the Ingress router after the control plane initializes.

### 8.3.3.6.1. Example load balancer configuration for user-provisioned clusters

This section provides an example API and application ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an **/etc/haproxy/haproxy.cfg** configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing one load balancing solution over another.

**NOTE**

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

#### Example 8.6. Sample API and application ingress load balancer configuration

```
global
  log      127.0.0.1 local2
  pidfile  /var/run/haproxy.pid
  maxconn  4000
  daemon
defaults
  mode      http
  log       global
  option    dontlognull
  option    http-server-close
  option    redispatch
  retries   3
```

```

timeout http-request 10s
timeout queue 1m
timeout connect 10s
timeout client 1m
timeout server 1m
timeout http-keep-alive 10s
timeout check 10s
maxconn 3000

frontend stats
bind *:1936
mode http
log global
maxconn 10
stats enable
stats hide-version
stats refresh 30s
stats show-node
stats show-desc Stats for ocp4 cluster 1
stats auth admin:ocp4
stats uri /stats

listen api-server-6443 2
bind *:6443
mode tcp
server bootstrap bootstrap.ocp4.example.com:6443 check inter 1s backup 3
server master0 master0.ocp4.example.com:6443 check inter 1s
server master1 master1.ocp4.example.com:6443 check inter 1s
server master2 master2.ocp4.example.com:6443 check inter 1s

listen machine-config-server-22623 4
bind *:22623
mode tcp
server bootstrap bootstrap.ocp4.example.com:22623 check inter 1s backup 5
server master0 master0.ocp4.example.com:22623 check inter 1s
server master1 master1.ocp4.example.com:22623 check inter 1s
server master2 master2.ocp4.example.com:22623 check inter 1s

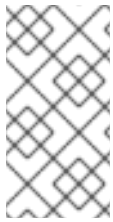
listen ingress-router-443 6
bind *:443
mode tcp
balance source
server worker0 worker0.ocp4.example.com:443 check inter 1s
server worker1 worker1.ocp4.example.com:443 check inter 1s

listen ingress-router-80 7
bind *:80
mode tcp
balance source
server worker0 worker0.ocp4.example.com:80 check inter 1s
server worker1 worker1.ocp4.example.com:80 check inter 1s

```

- 1** In the example, the cluster name is **ocp4**.
- 2** Port **6443** handles the Kubernetes API traffic and points to the control plane machines.
- 3** **5** The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.
- 4** Port **22623** handles the machine config server traffic and points to the control plane machines.

- 6 Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.
- 7 Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



#### NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

#### TIP

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltp** on the HAProxy node.



#### NOTE

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running **setsebool -P haproxy\_connect\_any=1**.

### 8.3.4. Preparing the user-provisioned infrastructure

Before you install OpenShift Container Platform on user-provisioned infrastructure, you must prepare the underlying infrastructure.

This section provides details about the high-level steps required to set up your cluster infrastructure in preparation for an OpenShift Container Platform installation. This includes configuring IP networking and network connectivity for your cluster nodes, enabling the required ports through your firewall, and setting up the required DNS and load balancing infrastructure.

After preparation, your cluster infrastructure must meet the requirements outlined in the *Requirements for a cluster with user-provisioned infrastructure* section.

#### Prerequisites

- You have reviewed the [OpenShift Container Platform 4.x Tested Integrations](#) page.
- You have reviewed the infrastructure requirements detailed in the *Requirements for a cluster with user-provisioned infrastructure* section.

#### Procedure

1. If you are using DHCP to provide the IP networking configuration to your cluster nodes, configure your DHCP service.
  - a. Add persistent IP addresses for the nodes to your DHCP server configuration. In your configuration, match the MAC address of the relevant network interface to the intended IP address for each node.

- b. When you use DHCP to configure IP addressing for the cluster machines, the machines also obtain the DNS server information through DHCP. Define the persistent DNS server address that is used by the cluster nodes through your DHCP server configuration.

**NOTE**

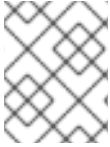
If you are not using a DHCP service, you must provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

- c. Define the hostnames of your cluster nodes in your DHCP server configuration. See the *Setting the cluster node hostnames through DHCP* section for details about hostname considerations.

**NOTE**

If you are not using a DHCP service, the cluster nodes obtain their hostname through a reverse DNS lookup.

2. Ensure that your network infrastructure provides the required network connectivity between the cluster components. See the *Networking requirements for user-provisioned infrastructure* section for details about the requirements.
3. Configure your firewall to enable the ports required for the OpenShift Container Platform cluster components to communicate. See *Networking requirements for user-provisioned infrastructure* section for details about the ports that are required.
4. Setup the required DNS infrastructure for your cluster.
  - a. Configure DNS name resolution for the Kubernetes API, the application wildcard, the bootstrap machine, the control plane machines, and the compute machines.
  - b. Configure reverse DNS resolution for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.  
See the *User-provisioned DNS requirements* section for more information about the OpenShift Container Platform DNS requirements.
5. Validate your DNS configuration.
  - a. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses in the responses correspond to the correct components.
  - b. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names in the responses correspond to the correct components.  
See the *Validating DNS resolution for user-provisioned infrastructure* section for detailed DNS validation steps.
6. Provision the required API and application ingress load balancing infrastructure. See the *Load balancing requirements for user-provisioned infrastructure* section for more information about the requirements.

**NOTE**

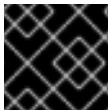
Some load balancing solutions require the DNS name resolution for the cluster nodes to be in place before the load balancing is initialized.

**Additional resources**

- [Requirements for a cluster with user-provisioned infrastructure](#)
- [Installing RHCOS and starting the OpenShift Container Platform bootstrap process](#)
- [Setting the cluster node hostnames through DHCP](#)
- [Advanced RHCOS installation configuration](#)
- [Networking requirements for user-provisioned infrastructure](#)
- [User-provisioned DNS requirements](#)
- [Validating DNS resolution for user-provisioned infrastructure](#)
- [Load balancing requirements for user-provisioned infrastructure](#)

**8.3.5. Validating DNS resolution for user-provisioned infrastructure**

You can validate your DNS configuration before installing OpenShift Container Platform on user-provisioned infrastructure.

**IMPORTANT**

The validation steps detailed in this section must succeed before you install your cluster.

**Prerequisites**

- You have configured the required DNS records for your user-provisioned infrastructure.

**Procedure**

1. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses contained in the responses correspond to the correct components.
  - a. Perform a lookup against the Kubernetes API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api.<cluster_name>.<base_domain> 1
```

- 1** Replace **<nameserver\_ip>** with the IP address of the nameserver, **<cluster\_name>** with your cluster name, and **<base\_domain>** with your base domain name.

**Example output**

```
api.ocp4.example.com. 0 IN A 192.168.1.5
```

- b. Perform a lookup against the Kubernetes internal API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api-int.<cluster_name>.<base_domain>
```

#### Example output

```
api-int.ocp4.example.com. 0 IN A 192.168.1.5
```

- c. Test an example **\*.apps.<cluster\_name>.<base\_domain>** DNS wildcard lookup. All of the application wildcard lookups must resolve to the IP address of the application ingress load balancer:

```
$ dig +noall +answer @<nameserver_ip> random.apps.<cluster_name>.<base_domain>
```

#### Example output

```
random.apps.ocp4.example.com. 0 IN A 192.168.1.5
```



#### NOTE

In the example outputs, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

You can replace **random** with another wildcard value. For example, you can query the route to the OpenShift Container Platform console:

```
$ dig +noall +answer @<nameserver_ip> console-openshift-console.apps.<cluster_name>.<base_domain>
```

#### Example output

```
console-openshift-console.apps.ocp4.example.com. 0 IN A 192.168.1.5
```

- d. Run a lookup against the bootstrap DNS record name. Check that the result points to the IP address of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> bootstrap.<cluster_name>.<base_domain>
```

#### Example output

```
bootstrap.ocp4.example.com. 0 IN A 192.168.1.96
```

- e. Use this method to perform lookups against the DNS record names for the control plane and compute nodes. Check that the results correspond to the IP addresses of each node.
2. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names contained in the responses correspond to the correct components.

- a. Perform a reverse lookup against the IP address of the API load balancer. Check that the response includes the record names for the Kubernetes API and the Kubernetes internal API:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.5
```

#### Example output

```
5.1.168.192.in-addr.arpa. 0 IN PTR api-int.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. 0 IN PTR api.ocp4.example.com. 2
```

- 1 Provides the record name for the Kubernetes internal API.
- 2 Provides the record name for the Kubernetes API.



#### NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard. No validation step is needed for reverse DNS resolution against the IP address of the application ingress load balancer.

- b. Perform a reverse lookup against the IP address of the bootstrap node. Check that the result points to the DNS record name of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.96
```

#### Example output

```
96.1.168.192.in-addr.arpa. 0 IN PTR bootstrap.ocp4.example.com.
```

- c. Use this method to perform reverse lookups against the IP addresses for the control plane and compute nodes. Check that the results correspond to the DNS record names of each node.

#### Additional resources

- [User-provisioned DNS requirements](#)
- [Load balancing requirements for user-provisioned infrastructure](#)

### 8.3.6. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.



### IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



### NOTE

You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

## Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.



### NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.



### NOTE

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

-



```
$ eval "$(ssh-agent -s)"
```

### Example output

```
Agent pid 31874
```



### NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1** Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

### Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

### Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

### Additional resources

- [Verifying node health](#)

## 8.3.7. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

### Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space

### Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.

**IMPORTANT**

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.

**IMPORTANT**

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

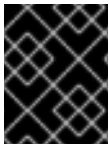
4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#) . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

### 8.3.8. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

**IMPORTANT**

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

#### Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

##### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

```
$ tar xvf <file>
```

5. Place the **oc** binary in a directory that is on your **PATH**.  
To check your **PATH**, execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

### Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your **PATH**.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### 8.3.9. Manually creating the installation configuration file

For user-provisioned installations of OpenShift Container Platform, you manually generate your installation configuration file.

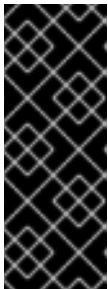
#### Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

#### Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```



#### IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation\_directory>**.



#### NOTE

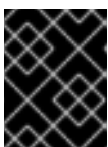
You must name this configuration file **install-config.yaml**.



#### NOTE

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation\_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

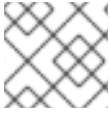


#### IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

#### 8.3.9.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide a customized **install-config.yaml** installation configuration file that describes the details for your environment.

**NOTE**

After installation, you cannot modify these parameters in the **install-config.yaml** file.

**IMPORTANT**

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

**8.3.9.1.1. Required configuration parameters**

Required installation configuration parameters are described in the following table:

**Table 8.22. Required parameters**

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;</b> . <b>&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}</b> . <b>{{.baseDomain}}</b> .	String of lowercase letters and hyphens (-), such as <b>dev</b> .


Parameter	Description	Values
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws</b> , <b>baremetal</b> , <b>azure</b> , <b>gcp</b> , <b>openstack</b> , <b>ovirt</b> , <b>vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } }</pre>

### 8.3.9.1.2. Network configuration parameters


You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

Table 8.23. Network parameters

Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	<p>Object</p>  <p><b>NOTE</b></p> <p>You cannot modify parameters specified by the <b>networking</b> object after installation.</p>

Parameter	Description	Values
<b>networking.networkType</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .
<b>networking.clusterNetwork</b>	The IP address blocks for pods.  The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b> .  If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example:  <pre>networking:   clusterNetwork:     - cidr: 10.128.0.0/14       hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	Required if you use <b>networking.clusterNetwork</b> . An IP address block.  An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b> .
<b>networking.clusterNetwork.hostPrefix</b>	The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b> . A <b>hostPrefix</b> value of <b>23</b> provides 510 ( $2^{(32 - 23)} - 2$ ) pod IP addresses.	A subnet prefix.  The default value is <b>23</b> .
<b>networking.serviceNetwork</b>	The IP address block for services. The default value is <b>172.30.0.0/16</b> .  The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example:  <pre>networking:   serviceNetwork:     - 172.30.0.0/16</pre>
<b>networking.machineNetwork</b>	The IP address blocks for machines.  If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example:  <pre>networking:   machineNetwork:     - cidr: 10.0.0.0/16</pre>

Parameter	Description	Values
<b>networking.machineNetwork.cidr</b>	Required if you use <b>networking.machineNetwork</b> . An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b> .	<p>An IP network block in CIDR notation.</p> <p>For example, <b>10.0.0.0/16</b>.</p>  <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p>


### 8.3.9.1.3. Optional configuration parameters


Optional installation configuration parameters are described in the following table:



Table 8.24. Optional parameters

Parameter	Description	Values
<b>additionalTrustBundle</b>	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
<b>compute</b>	The configuration for the machines that comprise the compute nodes.	Array of <b>MachinePool</b> objects.
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String




Parameter	Description	Values
<b>compute.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b>
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String

Parameter	Description	Values
<b>controlPlane.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platform</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>controlPlane.replicas</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.

Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.</p> <div data-bbox="486 510 595 862" style="border: 1px solid black; padding: 5px; margin-bottom: 10px;">  </div> <p><b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators</i> reference content.</p> <div data-bbox="486 907 595 1258" style="border: 1px solid black; padding: 5px;">  </div> <p><b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p>	<b>Mint, Passthrough, Manual</b> or an empty string ("").

Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start;"> <div style="width: 60px; height: 60px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 60px; height: 60px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings

Parameter	Description	Values
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<b>Internal</b> or <b>External</b> . The default value is <b>External</b> .  Setting this field to <b>Internal</b> is not supported on non-cloud platforms.
<b>sshKey</b>	The SSH key or keys to authenticate access your cluster machines.   <b>NOTE</b>  For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.	One or more keys. For example:  sshKey: <key1> <key2> <key3>

### 8.3.9.2. Sample install-config.yaml file for bare metal

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

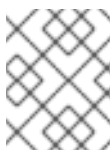
```

apiVersion: v1
baseDomain: example.com 1
compute: 2
- hyperthreading: Enabled 3
  name: worker
  replicas: 0 4
controlPlane: 5
  hyperthreading: Enabled 6
  name: master
  replicas: 3 7
metadata:
  name: test 8
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14 9
    hostPrefix: 23 10
  networkType: OpenShiftSDN
  serviceNetwork: 11
  - 172.30.0.0/16
platform:
  none: {} 12

```

```
fips: false 13
pullSecret: '{"auths": ...}' 14
sshKey: 'ssh-ed25519 AAAA...' 15
```

- 1** The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.
- 2 5** The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. Only one control plane pool is used.
- 3 6** Specifies whether to enable or disable simultaneous multithreading (SMT), or hyperthreading. By default, SMT is enabled to increase the performance of the cores in your machines. You can disable it by setting the parameter value to **Disabled**. If you disable SMT, you must disable it in all cluster machines; this includes both control plane and compute machines.

**NOTE**

Simultaneous multithreading (SMT) is enabled by default. If SMT is not enabled in your BIOS settings, the **hyperthreading** parameter has no effect.

**IMPORTANT**

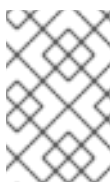
If you disable **hyperthreading**, whether in the BIOS or in the **install-config.yaml** file, ensure that your capacity planning accounts for the dramatically decreased machine performance.

- 4** You must set this value to **0** when you install OpenShift Container Platform on user-provisioned infrastructure. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. In user-provisioned installations, you must manually deploy the compute machines before you finish installing the cluster.

**NOTE**

If you are installing a three-node cluster, do not deploy any compute machines when you install the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

- 7** The number of control plane machines that you add to the cluster. Because the cluster uses these values as the number of etcd endpoints in the cluster, the value must match the number of control plane machines that you deploy.
- 8** The cluster name that you specified in your DNS records.
- 9** A block of IP addresses from which pod IP addresses are allocated. This block must not overlap with existing physical networks. These IP addresses are used for the pod network. If you need to access the pods from an external network, you must configure load balancers and routers to manage the traffic.

**NOTE**

Class E CIDR range is reserved for a future use. To use the Class E CIDR range, you must ensure your networking environment accepts the IP addresses within the Class E CIDR range.

- 10 The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23**, then each node is assigned a **/23** subnet out of the given **cidr**, which allows for 510 ( $2^{(32 - 23)} - 2$ )
- 11 The IP address pool to use for service IP addresses. You can enter only one IP address pool. This block must not overlap with existing physical networks. If you need to access the services from an external network, configure load balancers and routers to manage the traffic.
- 12 You must set the platform to **none**. You cannot provide additional platform configuration variables for your platform.



### IMPORTANT

Clusters that are installed with the platform type **none** are unable to use some features, such as managing compute machines with the Machine API. This limitation applies even if the compute machines that are attached to the cluster are installed on a platform that would normally support the feature. This parameter cannot be changed after installation.

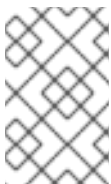
- 13 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.



### IMPORTANT

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

- 14 The [pull secret from the Red Hat OpenShift Cluster Manager](#) . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.
- 15 The SSH public key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).



### NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

#### Additional resources

- See [Load balancing requirements for user-provisioned infrastructure](#) for more information on the API and application ingress load balancing requirements.

### 8.3.10. Network configuration phases

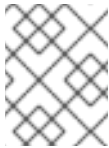
There are two phases prior to OpenShift Container Platform installation where you can customize the network configuration.

#### Phase 1

You can customize the following network-related fields in the **install-config.yaml** file before you create the manifest files:

- **networking.networkType**
- **networking.clusterNetwork**
- **networking.serviceNetwork**
- **networking.machineNetwork**

For more information on these fields, refer to *Installation configuration parameters*.



#### NOTE

Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

## Phase 2

After creating the manifest files by running **openshift-install create manifests**, you can define a customized Cluster Network Operator manifest with only the fields you want to modify. You can use the manifest to specify advanced network configuration.

You cannot override the values specified in phase 1 in the **install-config.yaml** file during phase 2. However, you can further customize the cluster network provider during phase 2.

### 8.3.11. Specifying advanced network configuration

You can use advanced network configuration for your cluster network provider to integrate your cluster into your existing network environment. You can specify advanced network configuration only before you install the cluster.



#### IMPORTANT

Customizing your network configuration by modifying the OpenShift Container Platform manifest files created by the installation program is not supported. Applying a manifest file that you create, as in the following procedure, is supported.

#### Prerequisites

- You have created the **install-config.yaml** file and completed any modifications to it.

#### Procedure

1. Change to the directory that contains the installation program and create the manifests:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

- 1** **<installation\_directory>** specifies the name of the directory that contains the **install-config.yaml** file for your cluster.

2. Create a stub manifest file for the advanced network configuration that is named **cluster-network-03-config.yml** in the **<installation\_directory>/manifests/** directory:



```

apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:

```

3. Specify the advanced network configuration for your cluster in the **cluster-network-03-config.yml** file, such as in the following examples:

#### Specify a different VXLAN port for the OpenShift SDN network provider

```

apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    openshiftSDNConfig:
      vxlanPort: 4800

```

#### Enable IPsec for the OVN-Kubernetes network provider

```

apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    ovnKubernetesConfig:
      ipsecConfig: {}

```

4. Optional: Back up the **manifests/cluster-network-03-config.yml** file. The installation program consumes the **manifests/** directory when you create the Ignition config files.

### 8.3.12. Cluster Network Operator configuration

The configuration for the cluster network is specified as part of the Cluster Network Operator (CNO) configuration and stored in a custom resource (CR) object that is named **cluster**. The CR specifies the fields for the **Network** API in the **operator.openshift.io** API group.

The CNO configuration inherits the following fields during cluster installation from the **Network** API in the **Network.config.openshift.io** API group and these fields cannot be changed:

#### **clusterNetwork**

IP address pools from which pod IP addresses are allocated.

#### **serviceNetwork**

IP address pool for services.

#### **defaultNetwork.type**

Cluster network provider, such as OpenShift SDN or OVN-Kubernetes.

You can specify the cluster network provider configuration for your cluster by setting the fields for the **defaultNetwork** object in the CNO object named **cluster**.

### 8.3.12.1. Cluster Network Operator configuration object

The fields for the Cluster Network Operator (CNO) are described in the following table:


Table 8.25. Cluster Network Operator configuration object

Field	Type	Description
<b>metadata.name</b>	<b>string</b>	The name of the CNO object. This name is always <b>cluster</b> .
<b>spec.clusterNetwork</b>	<b>array</b>	<p>A list specifying the blocks of IP addresses from which pod IP addresses are allocated and the subnet prefix length assigned to each individual node in the cluster. For example:</p> <pre>spec:   clusterNetwork:   - cidr: 10.128.0.0/19     hostPrefix: 23   - cidr: 10.128.32.0/19     hostPrefix: 23</pre> <p>You can customize this field only in the <b>install-config.yaml</b> file before you create the manifests. The value is read-only in the manifest file.</p>
<b>spec.serviceNetwork</b>	<b>array</b>	<p>A block of IP addresses for services. The OpenShift SDN and OVN-Kubernetes Container Network Interface (CNI) network providers support only a single IP address block for the service network. For example:</p> <pre>spec:   serviceNetwork:   - 172.30.0.0/14</pre> <p>You can customize this field only in the <b>install-config.yaml</b> file before you create the manifests. The value is read-only in the manifest file.</p>
<b>spec.defaultNetwork</b>	<b>object</b>	Configures the Container Network Interface (CNI) cluster network provider for the cluster network.
<b>spec.kubeProxyConfig</b>	<b>object</b>	The fields for this object specify the kube-proxy configuration. If you are using the OVN-Kubernetes cluster network provider, the kube-proxy configuration has no effect.

#### defaultNetwork object configuration

The values for the **defaultNetwork** object are defined in the following table:

Table 8.26. defaultNetwork object

Field	Type	Description
<b>type</b>	<b>string</b>	<p>Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b>. The cluster network provider is selected during installation. This value cannot be changed after cluster installation.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>OpenShift Container Platform uses the OpenShift SDN Container Network Interface (CNI) cluster network provider by default.</p> </div> </div>
<b>openshiftSDNConfig</b>	<b>object</b>	This object is only valid for the OpenShift SDN cluster network provider.
<b>ovnKubernetesConfig</b>	<b>object</b>	This object is only valid for the OVN-Kubernetes cluster network provider.

### Configuration for the OpenShift SDN CNI cluster network provider

The following table describes the configuration fields for the OpenShift SDN Container Network Interface (CNI) cluster network provider.

**Table 8.27. openshiftSDNConfig object**

Field	Type	Description
<b>mode</b>	<b>string</b>	<p>Configures the network isolation mode for OpenShift SDN. The default value is <b>NetworkPolicy</b>.</p> <p>The values <b>Multitenant</b> and <b>Subnet</b> are available for backwards compatibility with OpenShift Container Platform 3.x but are not recommended. This value cannot be changed after cluster installation.</p>

Field	Type	Description
<b>mtu</b>	<b>integer</b>	<p>The maximum transmission unit (MTU) for the VXLAN overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU.</p> <p>If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes.</p> <p>If your cluster requires different MTU values for different nodes, you must set this value to <b>50</b> less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of <b>9001</b>, and some have an MTU of <b>1500</b>, you must set this value to <b>1450</b>.</p> <p>This value cannot be changed after cluster installation.</p>
<b>vxlanPort</b>	<b>integer</b>	<p>The port to use for all VXLAN packets. The default value is <b>4789</b>. This value cannot be changed after cluster installation.</p> <p>If you are running in a virtualized environment with existing nodes that are part of another VXLAN network, then you might be required to change this. For example, when running an OpenShift SDN overlay on top of VMware NSX-T, you must select an alternate port for the VXLAN, because both SDNs use the same default VXLAN port number.</p> <p>On Amazon Web Services (AWS), you can select an alternate port for the VXLAN between port <b>9000</b> and port <b>9999</b>.</p>

### Example OpenShift SDN configuration

```
defaultNetwork:
  type: OpenShiftSDN
  openshiftSDNConfig:
    mode: NetworkPolicy
    mtu: 1450
    vxlanPort: 4789
```

### Configuration for the OVN-Kubernetes CNI cluster network provider

The following table describes the configuration fields for the OVN-Kubernetes CNI cluster network provider.

**Table 8.28. ovnKubernetesConfig object**

Field	Type	Description
-------	------	-------------

Field	Type	Description
<b>mtu</b>	<b>integer</b>	<p>The maximum transmission unit (MTU) for the Geneve (Generic Network Virtualization Encapsulation) overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU.</p> <p>If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes.</p> <p>If your cluster requires different MTU values for different nodes, you must set this value to <b>100</b> less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of <b>9001</b>, and some have an MTU of <b>1500</b>, you must set this value to <b>1400</b>.</p> <p>This value cannot be changed after cluster installation.</p>
<b>genevePort</b>	<b>integer</b>	The port to use for all Geneve packets. The default value is <b>6081</b> . This value cannot be changed after cluster installation.
<b>ipsecConfig</b>	<b>object</b>	Specify an empty object to enable IPsec encryption. This value cannot be changed after cluster installation.
<b>policyAuditConfig</b>	<b>object</b>	Specify a configuration object for customizing network policy audit logging. If unset, the defaults audit log settings are used.

Table 8.29. **policyAuditConfig** object

Field	Type	Description
<b>rateLimit</b>	integer	The maximum number of messages to generate every second per node. The default value is <b>20</b> messages per second.
<b>maxFileSize</b>	integer	The maximum size for the audit log in bytes. The default value is <b>50000000</b> or 50 MB.

Field	Type	Description
<b>destination</b>	string	<p>One of the following additional audit log targets:</p> <p><b>libc</b> The libc <b>syslog()</b> function of the journald process on the host.</p> <p><b>udp:&lt;host&gt;:&lt;port&gt;</b> A syslog server. Replace <b>&lt;host&gt;:&lt;port&gt;</b> with the host and port of the syslog server.</p> <p><b>unix:&lt;file&gt;</b> A Unix Domain Socket file specified by <b>&lt;file&gt;</b>.</p> <p><b>null</b> Do not send the audit logs to any additional target.</p>
<b>syslogFacility</b>	string	The syslog facility, such as <b>kern</b> , as defined by RFC5424. The default value is <b>local0</b> .

### Example OVN-Kubernetes configuration

```


defaultNetwork:
  type: OVNKubernetes
  ovnKubernetesConfig:
    mtu: 1400
    genevePort: 6081
    ipsecConfig: {}

```

### kubeProxyConfig object configuration

The values for the **kubeProxyConfig** object are defined in the following table:

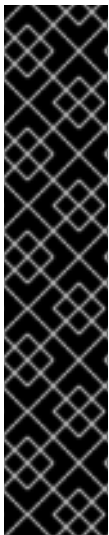
Table 8.30. **kubeProxyConfig** object

Field	Type	Description
<b>iptablesSyncPeriod</b>	<b>string</b>	<p>The refresh period for <b>iptables</b> rules. The default value is <b>30s</b>. Valid suffixes include <b>s</b>, <b>m</b>, and <b>h</b> and are described in the <a href="#">Go time package</a> documentation.</p> <div style="display: flex; align-items: flex-start;"> <div style="flex: 1;">  </div> <div style="flex: 2;"> <p><b>NOTE</b></p> <p>Because of performance improvements introduced in OpenShift Container Platform 4.3 and greater, adjusting the <b>iptablesSyncPeriod</b> parameter is no longer necessary.</p> </div> </div>

Field	Type	Description
<b>proxyArguments.iptables-min-sync-period</b>	<b>array</b>	<p>The minimum duration before refreshing <b>iptables</b> rules. This field ensures that the refresh does not happen too frequently. Valid suffixes include <b>s</b>, <b>m</b>, and <b>h</b> and are described in the <a href="#">Go time package</a>. The default value is:</p> <pre>kubeProxyConfig:   proxyArguments:     iptables-min-sync-period:       - 0s</pre>

### 8.3.13. Creating the Ignition config files

Because you must manually start the cluster machines, you must generate the Ignition config files that the cluster needs to make its machines.



#### IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

#### Prerequisites

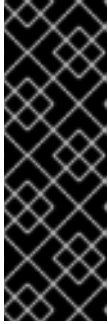
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

#### Procedure

- Obtain the Ignition config files:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

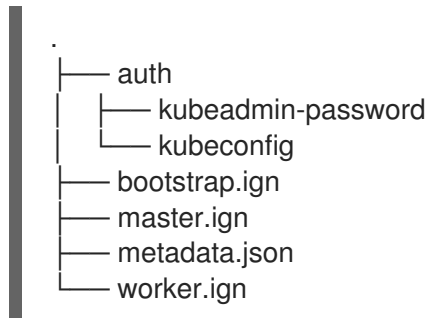
- 1** For **<installation\_directory>**, specify the directory name to store the files that the installation program creates.



## IMPORTANT

If you created an **install-config.yaml** file, specify the directory that contains it. Otherwise, specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

The following files are generated in the directory:



### 8.3.14. Installing RHCOS and starting the OpenShift Container Platform bootstrap process

To install OpenShift Container Platform on bare metal infrastructure that you provision, you must install Red Hat Enterprise Linux CoreOS (RHCOS) on the machines. When you install RHCOS, you must provide the Ignition config file that was generated by the OpenShift Container Platform installation program for the type of machine you are installing. If you have configured suitable networking, DNS, and load balancing infrastructure, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS machines have rebooted.

To install RHCOS on the machines, follow either the steps to use an ISO image or network PXE booting.



## NOTE

The compute node deployment steps included in this installation document are RHCOS-specific. If you choose instead to deploy RHEL-based compute nodes, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.

You can configure RHCOS during ISO and PXE installations by using the following methods:

- **Kernel arguments:** You can use kernel arguments to provide installation-specific information. For example, you can specify the locations of the RHCOS installation files that you uploaded to your HTTP server and the location of the Ignition config file for the type of node you are installing. For a PXE installation, you can use the **APPEND** parameter to pass the arguments to the kernel of the live installer. For an ISO installation, you can interrupt the live installation boot process to add the kernel arguments. In both installation cases, you can use special **coreos.inst.\*** arguments to direct the live installer, as well as standard installation boot arguments for turning standard kernel services on or off.
- **Ignition configs:** OpenShift Container Platform Ignition config files (**\*.ign**) are specific to the



type of node you are installing. You pass the location of a bootstrap, control plane, or compute node Ignition config file during the RHCOS installation so that it takes effect on first boot. In special cases, you can create a separate, limited Ignition config to pass to the live system. That Ignition config could do a certain set of tasks, such as reporting success to a provisioning system after completing installation. This special Ignition config is consumed by the **coreos-installer** to be applied on first boot of the installed system. Do not provide the standard control plane and compute node Ignition configs to the live ISO directly.

- **coreos-installer:** You can boot the live ISO installer to a shell prompt, which allows you to prepare the permanent system in a variety of ways before first boot. In particular, you can run the **coreos-installer** command to identify various artifacts to include, work with disk partitions, and set up networking. In some cases, you can configure features on the live system and copy them to the installed system.

Whether to use an ISO or PXE install depends on your situation. A PXE install requires an available DHCP service and more preparation, but can make the installation process more automated. An ISO install is a more manual process and can be inconvenient if you are setting up more than a few machines.



#### NOTE

As of OpenShift Container Platform 4.6, the RHCOS ISO and other installation artifacts provide support for installation on disks with 4K sectors.

### 8.3.14.1. Installing RHCOS by using an ISO image

You can use an ISO image to install RHCOS on the machines.

#### Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have an HTTP server that can be accessed from your computer, and from the machines that you create.
- You have reviewed the *Advanced RHCOS installation configuration* section for different ways to configure features, such as networking and disk partitioning.

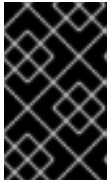
#### Procedure

1. Obtain the SHA512 digest for each of your Ignition config files. For example, you can use the following on a system running Linux to get the SHA512 digest for your **bootstrap.ign** Ignition config file:

```
$ sha512sum <installation_directory>/bootstrap.ign
```

The digests are provided to the **coreos-installer** in a later step to validate the authenticity of the Ignition config files on the cluster nodes.

2. Upload the bootstrap, control plane, and compute node Ignition config files that the installation program created to your HTTP server. Note the URLs of these files.



## IMPORTANT

You can add or change configuration settings in your Ignition configs before saving them to your HTTP server. If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

- From the installation host, validate that the Ignition config files are available on the URLs. The following example gets the Ignition config file for the bootstrap node:

```
$ curl -k http://<HTTP_server>/bootstrap.ign 1
```

### Example output

```
% Total    % Received % Xferd Average Speed   Time    Time     Time  Current
           Dload  Upload  Total   Spent    Left  Speed
  0   0   0   0   0   0   0   0   0  --:--:-- --:--:-- --:--:--    0{"ignition":
{"version":"3.2.0"},"passwd":{"users":[{"name":"core","sshAuthorizedKeys":["ssh-rsa...
```

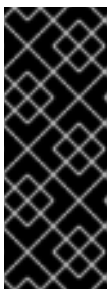
Replace **bootstrap.ign** with **master.ign** or **worker.ign** in the command to validate that the Ignition config files for the control plane and compute nodes are also available.

- Although it is possible to obtain the RHCOS images that are required for your preferred method of installing operating system instances from the [RHCOS image mirror](#) page, the recommended way to obtain the correct version of your RHCOS images are from the output of **openshift-install** command:

```
$ openshift-install coreos print-stream-json | grep '\.iso[^\.]'
```

### Example output

```
"location": "<url>/art/storage/releases/rhcos-4.9-aarch64/<release>/aarch64/rhcos-
<release>-live.aarch64.iso",
"location": "<url>/art/storage/releases/rhcos-4.9-ppc64le/<release>/ppc64le/rhcos-<release>-
live.ppc64le.iso",
"location": "<url>/art/storage/releases/rhcos-4.9-s390x/<release>/s390x/rhcos-<release>-
live.s390x.iso",
"location": "<url>/art/storage/releases/rhcos-4.9/<release>/x86_64/rhcos-<release>-
live.x86_64.iso",
```



## IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image versions that match your OpenShift Container Platform version if they are available. Use only ISO images for this procedure. RHCOS qcow2 images are not supported for this installation type.

ISO file names resemble the following example:

**rhcos-<version>-live.<architecture>.iso**

- Use the ISO to start the RHCOS installation. Use one of the following installation options:

- Burn the ISO image to a disk and boot it directly.
  - Use ISO redirection by using a lights-out management (LOM) interface.
6. Boot the RHCOS ISO image without specifying any options or interrupting the live boot sequence. Wait for the installer to boot into a shell prompt in the RHCOS live environment.



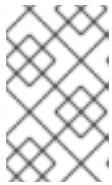
### NOTE

It is possible to interrupt the RHCOS installation boot process to add kernel arguments. However, for this ISO procedure you should use the **coreos-installer** command as outlined in the following steps, instead of adding kernel arguments.

7. Run the **coreos-installer** command and specify the options that meet your installation requirements. At a minimum, you must specify the URL that points to the Ignition config file for the node type, and the device that you are installing to:

```
$ sudo coreos-installer install --ignition-url=http://<HTTP_server>/<node_type>.ign <device>
--ignition-hash=sha512-<digest> 1 2
```

- 1 1** You must run the **coreos-installer** command by using **sudo**, because the **core** user does not have the required root privileges to perform the installation.
- 2** The **--ignition-hash** option is required when the Ignition config file is obtained through an HTTP URL to validate the authenticity of the Ignition config file on the cluster node. **<digest>** is the Ignition config file SHA512 digest obtained in a preceding step.



### NOTE

If you want to provide your Ignition config files through an HTTPS server that uses TLS, you can add the internal certificate authority (CA) to the system trust store before running **coreos-installer**.

The following example initializes a bootstrap node installation to the **/dev/sda** device. The Ignition config file for the bootstrap node is obtained from an HTTP web server with the IP address 192.168.1.2:

```
$ sudo coreos-installer install --ignition-
url=http://192.168.1.2:80/installation_directory/bootstrap.ign /dev/sda --ignition-hash=sha512-
a5a2d43879223273c9b60af66b44202a1d1248fc01cf156c46d4a79f552b6bad47bc8cc78ddf011
6e80c59d2ea9e32ba53bc807afbca581aa059311def2c3e3b
```

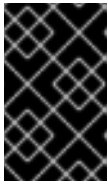
8. Monitor the progress of the RHCOS installation on the console of the machine.



### IMPORTANT

Be sure that the installation is successful on each node before commencing with the OpenShift Container Platform installation. Observing the installation process can also help to determine the cause of RHCOS installation issues that might arise.

9. After RHCOS installs, you must reboot the system. During the system reboot, it applies the Ignition config file that you specified.
10. Continue to create the other machines for your cluster.



### IMPORTANT

You must create the bootstrap and control plane machines at this time. If the control plane machines are not made schedulable, also create at least two compute machines before you install OpenShift Container Platform.

If the required network, DNS, and load balancer infrastructure are in place, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS nodes have rebooted.



### NOTE

RHCOS nodes do not include a default password for the **core** user. You can access the nodes by running **ssh core@<node>.<cluster\_name>.<base\_domain>** as a user with access to the SSH private key that is paired to the public key that you specified in your **install\_config.yaml** file. OpenShift Container Platform 4 cluster nodes running RHCOS are immutable and rely on Operators to apply cluster changes. Accessing cluster nodes by using SSH is not recommended. However, when investigating installation issues, if the OpenShift Container Platform API is not available, or the kubelet is not properly functioning on a target node, SSH access might be required for debugging or disaster recovery.

#### 8.3.14.2. Installing RHCOS by using PXE or iPXE booting

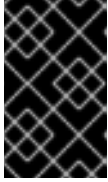
You can use PXE or iPXE booting to install RHCOS on the machines.

##### Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have configured suitable PXE or iPXE infrastructure.
- You have an HTTP server that can be accessed from your computer, and from the machines that you create.
- You have reviewed the *Advanced RHCOS installation configuration* section for different ways to configure features, such as networking and disk partitioning.

##### Procedure

1. Upload the bootstrap, control plane, and compute node Ignition config files that the installation program created to your HTTP server. Note the URLs of these files.



## IMPORTANT

You can add or change configuration settings in your Ignition configs before saving them to your HTTP server. If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

- From the installation host, validate that the Ignition config files are available on the URLs. The following example gets the Ignition config file for the bootstrap node:

```
$ curl -k http://<HTTP_server>/bootstrap.ign 1
```

### Example output

```
% Total    % Received % Xferd Average Speed   Time    Time     Time  Current
           Dload  Upload   Total   Spent    Left  Speed
  0   0   0   0   0   0   0   0   0  --:--:-- --:--:-- --:--:--    0{"ignition":
{"version":"3.2.0"},"passwd":{"users":[{"name":"core","sshAuthorizedKeys":["ssh-rsa...
```

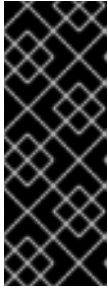
Replace **bootstrap.ign** with **master.ign** or **worker.ign** in the command to validate that the Ignition config files for the control plane and compute nodes are also available.

- Although it is possible to obtain the RHCOS **kernel**, **initramfs** and **rootfs** files that are required for your preferred method of installing operating system instances from the [RHCOS image mirror](#) page, the recommended way to obtain the correct version of your RHCOS files are from the output of **openshift-install** command:

```
$ openshift-install coreos print-stream-json | grep -Eo "https.*(kernel-|initramfs-|rootfs-)\w+(\.img)?"
```

### Example output

```
"<url>/art/storage/releases/rhcos-4.9-aarch64/<release>/aarch64/rhcos-<release>-live-
kernel-aarch64"
"<url>/art/storage/releases/rhcos-4.9-aarch64/<release>/aarch64/rhcos-<release>-live-
initramfs.aarch64.img"
"<url>/art/storage/releases/rhcos-4.9-aarch64/<release>/aarch64/rhcos-<release>-live-
rootfs.aarch64.img"
"<url>/art/storage/releases/rhcos-4.9-ppc64le/49.84.202110081256-0/ppc64le/rhcos-
<release>-live-kernel-ppc64le"
"<url>/art/storage/releases/rhcos-4.9-ppc64le/<release>/ppc64le/rhcos-<release>-live-
initramfs.ppc64le.img"
"<url>/art/storage/releases/rhcos-4.9-ppc64le/<release>/ppc64le/rhcos-<release>-live-
rootfs.ppc64le.img"
"<url>/art/storage/releases/rhcos-4.9-s390x/<release>/s390x/rhcos-<release>-live-kernel-
s390x"
"<url>/art/storage/releases/rhcos-4.9-s390x/<release>/s390x/rhcos-<release>-live-
initramfs.s390x.img"
"<url>/art/storage/releases/rhcos-4.9-s390x/<release>/s390x/rhcos-<release>-live-
rootfs.s390x.img"
"<url>/art/storage/releases/rhcos-4.9/<release>/x86_64/rhcos-<release>-live-kernel-x86_64"
"<url>/art/storage/releases/rhcos-4.9/<release>/x86_64/rhcos-<release>-live-
initramfs.x86_64.img"
"<url>/art/storage/releases/rhcos-4.9/<release>/x86_64/rhcos-<release>-live-
rootfs.x86_64.img"
```



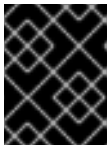
## IMPORTANT

The RHCOS artifacts might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Only use the appropriate **kernel**, **initramfs**, and **rootfs** artifacts described below for this procedure. RHCOS QCOW2 images are not supported for this installation type.

The file names contain the OpenShift Container Platform version number. They resemble the following examples:

- **kernel:** `rhcos-<version>-live-kernel-<architecture>`
- **initramfs:** `rhcos-<version>-live-initramfs.<architecture>.img`
- **rootfs:** `rhcos-<version>-live-rootfs.<architecture>.img`

4. Upload the **rootfs**, **kernel**, and **initramfs** files to your HTTP server.



## IMPORTANT

If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

5. Configure the network boot infrastructure so that the machines boot from their local disks after RHCOS is installed on them.
6. Configure PXE or iPXE installation for the RHCOS images and begin the installation. Modify one of the following example menu entries for your environment and verify that the image and Ignition files are properly accessible:

- For PXE:

```

DEFAULT pxeboot
TIMEOUT 20
PROMPT 0
LABEL pxeboot
  KERNEL http://<HTTP_server>/rhcos-<version>-live-kernel-<architecture> 1
  APPEND initrd=http://<HTTP_server>/rhcos-<version>-live-initramfs.
<architecture>.img coreos.live.rootfs_url=http://<HTTP_server>/rhcos-<version>-live-
rootfs.<architecture>.img coreos.inst.install_dev=/dev/sda
coreos.inst.ignition_url=http://<HTTP_server>/bootstrap.ign 2 3

```

- 1 1 Specify the location of the live **kernel** file that you uploaded to your HTTP server. The URL must be HTTP, TFTP, or FTP; HTTPS and NFS are not supported.
- 2 If you use multiple NICs, specify a single interface in the **ip** option. For example, to use DHCP on a NIC that is named **eno1**, set **ip=eno1:dhcp**.
- 3 Specify the locations of the RHCOS files that you uploaded to your HTTP server. The **initrd** parameter value is the location of the **initramfs** file, the **coreos.live.rootfs\_url** parameter value is the location of the **rootfs** file, and the **coreos.inst.ignition\_url** parameter value is the location of the bootstrap Ignition config file. You can also add more kernel arguments to the **APPEND** line to configure networking or other boot

options.



### NOTE

This configuration does not enable serial console access on machines with a graphical console. To configure a different console, add one or more **console=** arguments to the **APPEND** line. For example, add **console=tty0 console=ttyS0** to set the first PC serial port as the primary console and the graphical console as a secondary console. For more information, see [How does one set up a serial terminal and/or console in Red Hat Enterprise Linux?](#)

- For iPXE:

```
kernel http://<HTTP_server>/rhcos-<version>-live-kernel-<architecture> initrd=main
coreos.live.rootfs_url=http://<HTTP_server>/rhcos-<version>-live-rootfs.
<architecture>.img coreos.inst.install_dev=/dev/sda
coreos.inst.ignition_url=http://<HTTP_server>/bootstrap.ign 1 2
initrd --name main http://<HTTP_server>/rhcos-<version>-live-initramfs.
<architecture>.img 3
boot
```

- 1 Specify the locations of the RHCOS files that you uploaded to your HTTP server. The **kernel** parameter value is the location of the **kernel** file, the **initrd=main** argument is needed for booting on UEFI systems, the **coreos.live.rootfs\_url** parameter value is the location of the **rootfs** file, and the **coreos.inst.ignition\_url** parameter value is the location of the bootstrap Ignition config file.
- 2 If you use multiple NICs, specify a single interface in the **ip** option. For example, to use DHCP on a NIC that is named **eno1**, set **ip=eno1:dhcp**.
- 3 Specify the location of the **initramfs** file that you uploaded to your HTTP server.



### NOTE

This configuration does not enable serial console access on machines with a graphical console. To configure a different console, add one or more **console=** arguments to the **kernel** line. For example, add **console=tty0 console=ttyS0** to set the first PC serial port as the primary console and the graphical console as a secondary console. For more information, see [How does one set up a serial terminal and/or console in Red Hat Enterprise Linux?](#)

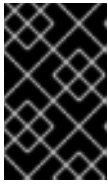
7. Monitor the progress of the RHCOS installation on the console of the machine.



### IMPORTANT

Be sure that the installation is successful on each node before commencing with the OpenShift Container Platform installation. Observing the installation process can also help to determine the cause of RHCOS installation issues that might arise.

8. After RHCOS installs, the system reboots. During reboot, the system applies the Ignition config file that you specified.
9. Continue to create the machines for your cluster.



### IMPORTANT

You must create the bootstrap and control plane machines at this time. If the control plane machines are not made schedulable, also create at least two compute machines before you install the cluster.

If the required network, DNS, and load balancer infrastructure are in place, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS nodes have rebooted.



### NOTE

RHCOS nodes do not include a default password for the **core** user. You can access the nodes by running **ssh core@<node>.<cluster\_name>.<base\_domain>** as a user with access to the SSH private key that is paired to the public key that you specified in your **install\_config.yaml** file. OpenShift Container Platform 4 cluster nodes running RHCOS are immutable and rely on Operators to apply cluster changes. Accessing cluster nodes by using SSH is not recommended. However, when investigating installation issues, if the OpenShift Container Platform API is not available, or the kubelet is not properly functioning on a target node, SSH access might be required for debugging or disaster recovery.

#### 8.3.14.3. Advanced RHCOS installation configuration

A key benefit for manually provisioning the Red Hat Enterprise Linux CoreOS (RHCOS) nodes for OpenShift Container Platform is to be able to do configuration that is not available through default OpenShift Container Platform installation methods. This section describes some of the configurations that you can do using techniques that include:

- Passing kernel arguments to the live installer
- Running **coreos-installer** manually from the live system
- Embedding Ignition configs in an ISO

The advanced configuration topics for manual Red Hat Enterprise Linux CoreOS (RHCOS) installations detailed in this section relate to disk partitioning, networking, and using Ignition configs in different ways.

##### 8.3.14.3.1. Using advanced networking options for PXE and ISO installations

Networking for OpenShift Container Platform nodes uses DHCP by default to gather all necessary configuration settings. To set up static IP addresses or configure special settings, such as bonding, you can do one of the following:

- Pass special kernel parameters when you boot the live installer.
- Use a machine config to copy networking files to the installed system.



- Configure networking from a live installer shell prompt, then copy those settings to the installed system so that they take effect when the installed system first boots.

To configure a PXE or iPXE installation, use one of the following options:

- See the "Advanced RHCOS installation reference" tables.
- Use a machine config to copy networking files to the installed system.

To configure an ISO installation, use the following procedure.

### Procedure

1. Boot the ISO installer.
2. From the live system shell prompt, configure networking for the live system using available RHEL tools, such as **nmcli** or **nmtui**.
3. Run the **coreos-installer** command to install the system, adding the **--copy-network** option to copy networking configuration. For example:

```
$ sudo coreos-installer install --copy-network \
--ignition-url=http://host/worker.ign /dev/sda
```



### IMPORTANT

The **--copy-network** option only copies networking configuration found under **/etc/NetworkManager/system-connections**. In particular, it does not copy the system hostname.

4. Reboot into the installed system.

### Additional resources

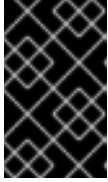
- See [Getting started with nmcli](#) and [Getting started with nmtui](#) in the RHEL 8 documentation for more information about the **nmcli** and **nmtui** tools.

#### 8.3.14.3.2. Disk partitioning

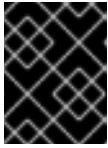
The disk partitions are created on OpenShift Container Platform cluster nodes during the Red Hat Enterprise Linux CoreOS (RHCOS) installation. Each RHCOS node of a particular architecture uses the same partition layout, unless the default partitioning configuration is overridden. During the RHCOS installation, the size of the root file system is increased to use the remaining available space on the target device.

There are two cases where you might want to override the default partitioning when installing RHCOS on an OpenShift Container Platform cluster node:

- Creating separate partitions: For greenfield installations on an empty disk, you might want to add separate storage to a partition. This is officially supported for mounting **/var** or a subdirectory of **/var**, such as **/var/lib/etcd**, on a separate partition, but not both.

**IMPORTANT**

For disk sizes larger than 100GB, and especially disk sizes larger than 1TB, create a separate **/var** partition. See "Creating a separate **/var** partition" and this [Red Hat Knowledgebase article](#) for more information.

**IMPORTANT**

Kubernetes supports only two file system partitions. If you add more than one partition to the original configuration, Kubernetes cannot monitor all of them.

- Retaining existing partitions: For a brownfield installation where you are reinstalling OpenShift Container Platform on an existing node and want to retain data partitions installed from your previous operating system, there are both boot arguments and options to **coreos-installer** that allow you to retain existing data partitions.

**WARNING**

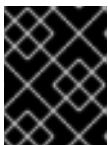
The use of custom partitions could result in those partitions not being monitored by OpenShift Container Platform or alerted on. If you are overriding the default partitioning, see [Understanding OpenShift File System Monitoring \(eviction conditions\)](#) for more information about how OpenShift Container Platform monitors your host file systems.

**8.3.14.3.2.1. Creating a separate /var partition**

In general, you should use the default disk partitioning that is created during the RHCOS installation. However, there are cases where you might want to create a separate partition for a directory that you expect to grow.

OpenShift Container Platform supports the addition of a single partition to attach storage to either the **/var** directory or a subdirectory of **/var**. For example:

- **/var/lib/containers**: Holds container-related content that can grow as more images and containers are added to a system.
- **/var/lib/etcd**: Holds data that you might want to keep separate for purposes such as performance optimization of etcd storage.
- **/var**: Holds data that you might want to keep separate for purposes such as auditing.

**IMPORTANT**

For disk sizes larger than 100GB, and especially larger than 1TB, create a separate **/var** partition.

Storing the contents of a **/var** directory separately makes it easier to grow storage for those areas as needed and reinstall OpenShift Container Platform at a later date and keep that data intact. With this method, you will not have to pull all your containers again, nor will you have to copy massive log files when you update systems.

The use of a separate partition for the **/var** directory or a subdirectory of **/var** also prevents data growth in the partitioned directory from filling up the root file system.

The following procedure sets up a separate **/var** partition by adding a machine config manifest that is wrapped into the Ignition config file for a node type during the preparation phase of an installation.

## Procedure

1. On your installation host, change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ openshift-install create manifests --dir <installation_directory>
```

2. Create a Butane config that configures the additional partition. For example, name the file **\$HOME/clusterconfig/98-var-partition.bu**, change the disk device name to the name of the storage device on the **worker** systems, and set the storage size as appropriate. This example places the **/var** directory on a separate partition:

```
variant: openshift
version: 4.9.0
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 98-var-partition
storage:
  disks:
    - device: /dev/<device_name> 1
      partitions:
        - label: var
          start_mib: <partition_start_offset> 2
          size_mib: <partition_size> 3
      filesystems:
        - device: /dev/disk/by-partlabel/var
          path: /var
          format: xfs
          mount_options: [defaults, prjquota] 4
          with_mount_unit: true
```

- 1 The storage device name of the disk that you want to partition.
- 2 When adding a data partition to the boot disk, a minimum offset value of 25000 mebibytes is recommended. The root file system is automatically resized to fill all available space up to the specified offset. If no offset value is specified, or if the specified value is smaller than the recommended minimum, the resulting root file system will be too small, and future reinstalls of RHCOS might overwrite the beginning of the data partition.
- 3 The size of the data partition in mebibytes.
- 4 The **prjquota** mount option must be enabled for filesystems used for container storage.

**NOTE**

When creating a separate **/var** partition, you cannot use different instance types for compute nodes, if the different instance types do not have the same device name.

3. Create a manifest from the Butane config and save it to the **clusterconfig/openshift** directory. For example, run the following command:

```
$ butane $HOME/clusterconfig/98-var-partition.bu -o $HOME/clusterconfig/openshift/98-var-partition.yaml
```

4. Create the Ignition config files:

```
$ openshift-install create ignition-configs --dir <installation_directory> 1
```

- 1** For **<installation\_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

The files in the **<installation\_directory>/manifest** and **<installation\_directory>/openshift** directories are wrapped into the Ignition config files, including the file that contains the **98-var-partition** custom **MachineConfig** object.

**Next steps**

- You can apply the custom disk partitioning by referencing the Ignition config files during the RHCOS installations.

**8.3.14.3.2.2. Retaining existing partitions**

For an ISO installation, you can add options to the **coreos-installer** command that cause the installer to maintain one or more existing partitions. For a PXE installation, you can add **coreos.inst.\*** options to the **APPEND** parameter to preserve partitions.

Saved partitions might be data partitions from an existing OpenShift Container Platform system. You can identify the disk partitions you want to keep either by partition label or by number.

**NOTE**

If you save existing partitions, and those partitions do not leave enough space for RHCOS, the installation will fail without damaging the saved partitions.

## Retaining existing partitions during an ISO installation

This example preserves any partition in which the partition label begins with **data** (**data\***):

```
# coreos-installer install --ignition-url http://10.0.2.2:8080/user.ign \
  --save-partlabel 'data*' /dev/sda
```

The following example illustrates running the **coreos-installer** in a way that preserves the sixth (6) partition on the disk:

```
# coreos-installer install --ignition-url http://10.0.2.2:8080/user.ign \
  --save-partindex 6 /dev/sda
```

This example preserves partitions 5 and higher:

```
# coreos-installer install --ignition-url http://10.0.2.2:8080/user.ign
  --save-partindex 5- /dev/sda
```

In the previous examples where partition saving is used, **coreos-installer** recreates the partition immediately.

## Retaining existing partitions during a PXE installation

This **APPEND** option preserves any partition in which the partition label begins with 'data' ('data\*'):

```
coreos.inst.save_partlabel=data*
```

This **APPEND** option preserves partitions 5 and higher:

```
coreos.inst.save_partindex=5-
```

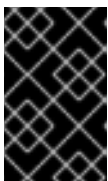
This **APPEND** option preserves partition 6:

```
coreos.inst.save_partindex=6
```

### 8.3.14.3.3. Identifying Ignition configs

When doing an RHCOS manual installation, there are two types of Ignition configs that you can provide, with different reasons for providing each one:

- **Permanent install Ignition config:** Every manual RHCOS installation needs to pass one of the Ignition config files generated by **openshift-installer**, such as **bootstrap.ign**, **master.ign** and **worker.ign**, to carry out the installation.



#### IMPORTANT

It is not recommended to modify these Ignition config files directly. You can update the manifest files that are wrapped into the Ignition config files, as outlined in examples in the preceding sections.

For PXE installations, you pass the Ignition configs on the **APPEND** line using the **coreos.inst.ignition\_url=** option. For ISO installations, after the ISO boots to the shell prompt, you identify the Ignition config on the **coreos-installer** command line with the **--ignition-url=**

option. In both cases, only HTTP and HTTPS protocols are supported.

- **Live install Ignition config:** This type must be created manually and should be avoided if possible, as it is not supported by Red Hat. With this method, the Ignition config passes to the live install medium, runs immediately upon booting, and performs setup tasks before and/or after the RHCOS system installs to disk. This method should only be used for performing tasks that must be done once and not applied again later, such as with advanced partitioning that cannot be done using a machine config.

For PXE or ISO boots, you can create the Ignition config and **APPEND** the **ignition.config.url=** option to identify the location of the Ignition config. You also need to append **ignition.firstboot** **ignition.platform.id=metal** or the **ignition.config.url** option will be ignored.

### 8.3.14.3.3.1. Embedding a live install Ignition config in the RHCOS ISO

You can embed a live install Ignition config directly in an RHCOS ISO image. When the ISO image is booted, the embedded config will be applied automatically.

#### Procedure

1. Download the **coreos-installer** binary from the following image mirror page:  
<https://mirror.openshift.com/pub/openshift-v4/clients/coreos-installer/latest/>.
2. Retrieve the RHCOS ISO image and the Ignition config file, and copy them into an accessible directory, such as **/mnt**:

```
# cp rhcos-<version>-live.x86_64.iso bootstrap.ign /mnt/
# chmod 644 /mnt/rhcos-<version>-live.x86_64.iso
```

3. Run the following command to embed the Ignition config into the ISO:

```
# ./coreos-installer iso ignition embed -i /mnt/bootstrap.ign \
  /mnt/rhcos-<version>-live.x86_64.iso
```

You can now use that ISO to install RHCOS using the specified live install Ignition config.



#### IMPORTANT

Using **coreos-installer iso ignition embed** to embed a file generated by **openshift-installer**, such as **bootstrap.ign**, **master.ign** and **worker.ign**, is unsupported and not recommended.

4. To show the contents of the embedded Ignition config and direct it into a file, run:

```
# ./coreos-installer iso ignition show /mnt/rhcos-<version>-live.x86_64.iso > mybootstrap.ign

# diff -s bootstrap.ign mybootstrap.ign
```

#### Example output

```
Files bootstrap.ign and mybootstrap.ign are identical
```

5. To remove the Ignition config and return the ISO to its pristine state so you can reuse it, run:

```
# ./coreos-installer iso ignition remove /mnt/rhcos-<version>-live.x86_64.iso
```

You can now embed another Ignition config into the ISO or use the ISO in its pristine state.

#### 8.3.14.3.4. Advanced RHCOS installation reference

This section illustrates the networking configuration and other advanced options that allow you to modify the Red Hat Enterprise Linux CoreOS (RHCOS) manual installation process. The following tables describe the kernel arguments and command-line options you can use with the RHCOS live installer and the **coreos-installer** command.

##### 8.3.14.3.4.1. Networking and bonding options for ISO installations

If you install RHCOS from an ISO image, you can add kernel arguments manually when you boot the image to configure networking for a node. If no networking arguments are specified, DHCP is activated in the initramfs when RHCOS detects that networking is required to fetch the Ignition config file.



#### IMPORTANT

When adding networking arguments manually, you must also add the **rd.neednet=1** kernel argument to bring the network up in the initramfs.

The following table provides examples for configuring networking and bonding on your RHCOS nodes for ISO installations. The examples describe how to use the **ip=**, **nameserver=**, and **bond=** kernel arguments.



#### NOTE

Ordering is important when adding the kernel arguments: **ip=**, **nameserver=**, and then **bond=**.

The networking options are passed to the **dracut** tool during system boot. For more information about the networking options supported by **dracut**, see the **dracut.cmdline** manual page.

The following information provides examples for configuring networking on your RHCOS nodes for ISO installations. The examples describe how to use the **ip=** and **nameserver=** kernel arguments.



#### NOTE

Ordering is important when adding the kernel arguments: **ip=** and **nameserver=**.

The networking options are passed to the **dracut** tool during system boot. For more information about the networking options supported by **dracut**, see the **dracut.cmdline** manual page.

The following examples are the networking options for ISO installation.

Configuring DHCP or static IP addresses

To configure an IP address, either use DHCP (**ip=dhcp**) or set an individual static IP address (**ip=<host\_ip>**). If setting a static IP, you must then identify the DNS server IP address (**nameserver=<dns\_ip>**) on each node. The following example sets:

- The node's IP address to **10.10.10.2**

- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The hostname to **core0.example.com**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
nameserver=4.4.4.41
```



#### NOTE

When you use DHCP to configure IP addressing for the RHCOS machines, the machines also obtain the DNS server information through DHCP. For DHCP-based deployments, you can define the DNS server address that is used by the RHCOS nodes through your DHCP server configuration.

#### Configuring an IP address without a static hostname

You can configure an IP address without assigning a static hostname. If a static hostname is not set by the user, it will be picked up and automatically set by a reverse DNS lookup. To configure an IP address without a static hostname refer to the following example:

- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0::enp1s0:none
nameserver=4.4.4.41
```

#### Specifying multiple network interfaces

You can specify multiple network interfaces by setting multiple **ip=** entries.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=10.10.10.3::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

#### Configuring default gateway and route

Optional: You can configure routes to additional networks by setting an **rd.route=** value.



#### NOTE

When you configure one or multiple networks, one default gateway is required. If the additional network gateway is different from the primary network gateway, the default gateway must be the primary network gateway.



- Run the following command to configure the default gateway:

```
ip=::10.10.10.254:::
```

- Enter the following command to configure the route for the additional network:

```
rd.route=20.20.20.0/24:20.20.20.254:enp2s0
```

#### Disabling DHCP on a single interface

You can disable DHCP on a single interface, such as when there are two or more network interfaces and only one interface is being used. In the example, the **enp1s0** interface has a static networking configuration and DHCP is disabled for **enp2s0**, which is not used:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=::::core0.example.com:enp2s0:none
```

#### Combining DHCP and static IP configurations

You can combine DHCP and static IP configurations on systems with multiple network interfaces, for example:

```
ip=enp1s0:dhcp
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

#### Configuring VLANs on individual interfaces

Optional: You can configure VLANs on individual interfaces by using the **vlan=** parameter.

- To configure a VLAN on a network interface and use a static IP address, run the following command:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0.100:none
vlan=enp2s0.100:enp2s0
```

- To configure a VLAN on a network interface and to use DHCP, run the following command:

```
ip=enp2s0.100:dhcp
vlan=enp2s0.100:enp2s0
```

#### Providing multiple DNS servers

You can provide multiple DNS servers by adding a **nameserver=** entry for each server, for example:

```
nameserver=1.1.1.1
nameserver=8.8.8.8
```

#### Bonding multiple network interfaces to a single interface

Optional: You can bond multiple network interfaces to a single interface by using the **bond=** option. Refer to the following examples:

- The syntax for configuring a bonded interface is: **bond=name[:network\_interfaces][:options]** *name* is the bonding device name (**bond0**), *network\_interfaces* represents a comma-separated list of physical (ethernet) interfaces (**em1,em2**), and *options* is a comma-separated list of bonding options. Enter **modinfo bonding** to see available options.

- When you create a bonded interface using **bond=**, you must specify how the IP address is assigned and other information for the bonded interface.
- To configure the bonded interface to use DHCP, set the bond's IP address to **dhcp**. For example:

```
bond=bond0:em1,em2:mode=active-backup
ip=bond0:dhcp
```

- To configure the bonded interface to use a static IP address, enter the specific IP address you want and related information. For example:

```
bond=bond0:em1,em2:mode=active-backup
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0:none
```

Bonding multiple network interfaces to a single interface

Optional: You can configure VLANs on bonded interfaces by using the **vlan=** parameter and to use DHCP, for example:

```
ip=bond0.100:dhcp
bond=bond0:em1,em2:mode=active-backup
vlan=bond0.100:bond0
```

Use the following example to configure the bonded interface with a VLAN and to use a static IP address:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0.100:none
bond=bond0:em1,em2:mode=active-backup
vlan=bond0.100:bond0
```

Using network teaming

Optional: You can use a network teaming as an alternative to bonding by using the **team=** parameter:

- The syntax for configuring a team interface is: **team=name[:network\_interfaces]**  
*name* is the team device name (**team0**) and *network\_interfaces* represents a comma-separated list of physical (ethernet) interfaces (**em1, em2**).

Teaming is planned to be deprecated when RHCOS switches to an upcoming version of RHEL. For more information, see this [Red Hat Knowledgebase Article](#) .

Use the following example to configure a network team:


```
team=team0:em1,em2
ip=team0:dhcp
```

#### 8.3.14.3.4.2. coreos-installer options for ISO installations

You can install RHCOS by running **coreos-installer install <options> <device>** at the command prompt, after booting into the RHCOS live environment from an ISO image.

The following table shows the subcommands, options, and arguments you can pass to the **coreos-installer** command.

**Table 8.31. coreos-installer subcommands, command-line options, and arguments**

coreos-installer install subcommand	
<i>Subcommand</i>	<i>Description</i>
<b>\$ coreos-installer install &lt;options&gt; &lt;device&gt;</b>	Embed an Ignition config in an ISO image.
coreos-installer install subcommand options	
<i>Option</i>	<i>Description</i>
<b>-u, --image-url &lt;url&gt;</b>	Specify the image URL manually.
<b>-f, --image-file &lt;path&gt;</b>	Specify a local image file manually. Used for debugging.
<b>-i, --ignition-file &lt;path&gt;</b>	Embed an Ignition config from a file.
<b>-l, --ignition-url &lt;URL&gt;</b>	Embed an Ignition config from a URL.
<b>--ignition-hash &lt;digest&gt;</b>	Digest <b>type-value</b> of the Ignition config.
<b>-p, --platform &lt;name&gt;</b>	Override the Ignition platform ID for the installed system.
<b>--append-karg &lt;arg&gt;...</b>	Append a default kernel argument to the installed system.
<b>--delete-karg &lt;arg&gt;...</b>	Delete a default kernel argument from the installed system.
<b>-n, --copy-network</b>	Copy the network configuration from the install environment.  <div style="display: flex; align-items: flex-start;"> <div style="flex: 1;">  </div> <div style="flex: 2;"> <p><b>IMPORTANT</b></p> <p>The <b>--copy-network</b> option only copies networking configuration found under <b>/etc/NetworkManager/system-connections</b>. In particular, it does not copy the system hostname.</p> </div> </div>
<b>--network-dir &lt;path&gt;</b>	For use with <b>-n</b> . Default is <b>/etc/NetworkManager/system-connections/</b> .
<b>--save-partlabel &lt;lx&gt;..</b>	Save partitions with this label glob.
<b>--save-partindex &lt;id&gt;...</b>	Save partitions with this number or range.

<b>--insecure</b>	Skip signature verification.
<b>--insecure-ignition</b>	Allow Ignition URL without HTTPS or hash.
<b>--architecture &lt;name&gt;</b>	Target CPU architecture. Default is <b>x86_64</b> .
<b>--preserve-on-error</b>	Do not clear partition table on error.
<b>-h, --help</b>	Print help information.
<b>coreos-install install subcommand argument</b>	
<i>Argument</i>	<i>Description</i>
<b>&lt;device&gt;</b>	The destination device.
<b>coreos-installer ISO Ignition subcommands</b>	
<i>Subcommand</i>	<i>Description</i>
<b>\$ coreos-installer iso ignition embed &lt;options&gt; --ignition-file &lt;file_path&gt; &lt;ISO_image&gt;</b>	Embed an Ignition config in an ISO image.
<b>coreos-installer iso ignition show &lt;options&gt; &lt;ISO_image&gt;</b>	Show the embedded Ignition config from an ISO image.
<b>coreos-installer iso ignition remove &lt;options&gt; &lt;ISO_image&gt;</b>	Remove the embedded Ignition config from an ISO image.
<b>coreos-installer ISO Ignition subcommand options</b>	
<i>Option</i>	<i>Description</i>
<b>-f, --force</b>	Overwrite an existing Ignition config.
<b>-i, --ignition-file &lt;path&gt;</b>	The Ignition config to be used. Default is <b>stdin</b> .
<b>-o, --output &lt;path&gt;</b>	Write the ISO to a new output file.
<b>-h, --help</b>	Print help information.
<b>coreos-installer PXE Ignition subcommands</b>	
<i>Subcommand</i>	<i>Description</i>
Note that not all of these options are accepted by all subcommands.	

<b>coreos-installer pxe ignition wrap &lt;options&gt;</b>	Wrap an Ignition config in an image.
<b>coreos-installer pxe ignition unwrap &lt;options&gt; &lt;image_name&gt;</b>	Show the wrapped Ignition config in an image.
<b>coreos-installer PXE Ignition subcommand options</b>	
<i>Option</i>	<i>Description</i>
Note that not all of these options are accepted by all subcommands.	
<b>-i, --ignition-file &lt;path&gt;</b>	The Ignition config to be used. Default is <b>stdin</b> .
<b>-o, --output &lt;path&gt;</b>	Write the ISO to a new output file.
<b>-h, --help</b>	Print help information.

#### 8.3.14.3.4.3. coreos.inst boot options for ISO or PXE installations

You can automatically invoke **coreos-installer** options at boot time by passing **coreos.inst** boot arguments to the RHCOS live installer. These are provided in addition to the standard boot arguments.

- For ISO installations, the **coreos.inst** options can be added by interrupting the automatic boot at the bootloader menu. You can interrupt the automatic boot by pressing **TAB** while the **RHEL CoreOS (Live)** menu option is highlighted.
- For PXE or iPXE installations, the **coreos.inst** options must be added to the **APPEND** line before the RHCOS live installer is booted.

The following table shows the RHCOS live installer **coreos.inst** boot options for ISO and PXE installations.

**Table 8.32. coreos.inst boot options**

Argument	Description
<b>coreos.inst.install_dev</b>	Required. The block device on the system to install to. It is recommended to use the full path, such as <b>/dev/sda</b> , although <b>sda</b> is allowed.
<b>coreos.inst.ignition_url</b>	Optional: The URL of the Ignition config to embed into the installed system. If no URL is specified, no Ignition config is embedded. Only HTTP and HTTPS protocols are supported.
<b>coreos.inst.save_partlabel</b>	Optional: Comma-separated labels of partitions to preserve during the install. Glob-style wildcards are permitted. The specified partitions do not need to exist.

Argument	Description
<b>coreos.inst.save_partindex</b>	Optional: Comma-separated indexes of partitions to preserve during the install. Ranges <b>m-n</b> are permitted, and either <b>m</b> or <b>n</b> can be omitted. The specified partitions do not need to exist.
<b>coreos.inst.insecure</b>	Optional: Permits the OS image that is specified by <b>coreos.inst.image_url</b> to be unsigned.
<b>coreos.inst.image_url</b>	<p>Optional: Download and install the specified RHCOS image.</p> <ul style="list-style-type: none"> <li>● This argument should not be used in production environments and is intended for debugging purposes only.</li> <li>● While this argument can be used to install a version of RHCOS that does not match the live media, it is recommended that you instead use the media that matches the version you want to install.</li> <li>● If you are using <b>coreos.inst.image_url</b>, you must also use <b>coreos.inst.insecure</b>. This is because the bare-metal media are not GPG-signed for OpenShift Container Platform.</li> <li>● Only HTTP and HTTPS protocols are supported.</li> </ul>
<b>coreos.inst.skip_reboot</b>	Optional: The system will not reboot after installing. After the install finishes, you will receive a prompt that allows you to inspect what is happening during installation. This argument should not be used in production environments and is intended for debugging purposes only.
<b>coreos.inst.platform_id</b>	Optional: The Ignition platform ID of the platform the RHCOS image is being installed on. Default is <b>metal</b> . This option determines whether or not to request an Ignition config from the cloud provider, such as VMware. For example: <b>coreos.inst.platform_id=vmware</b> .
<b>ignition.config.url</b>	Optional: The URL of the Ignition config for the live boot. For example, this can be used to customize how <b>coreos-installer</b> is invoked, or to run code before or after the installation. This is different from <b>coreos.inst.ignition_url</b> , which is the Ignition config for the installed system.

### 8.3.14.4. Enabling multipathing with kernel arguments on RHCOS

RHCOS supports multipathing on the primary disk, allowing stronger resilience to hardware failure to achieve higher host availability.

You can enable multipathing at installation time for nodes that were provisioned in OpenShift Container Platform 4.8 or later. While post-installation support is available by activating multipathing via the machine config, enabling multipathing during installation is recommended.

In setups where any I/O to non-optimized paths results in I/O system errors, you must enable multipathing at installation time.



#### IMPORTANT

On IBM Z and LinuxONE, you can enable multipathing only if you configured your cluster for it during installation. For more information, see "Installing RHCOS and starting the OpenShift Container Platform bootstrap process" in *Installing a cluster with z/VM on IBM Z and LinuxONE*.

The following procedure enables multipath at installation time and appends kernel arguments to the **coreos-installer install** command so that the installed system itself will use multipath beginning from the first boot.

#### Prerequisites

- You have a running OpenShift Container Platform cluster that uses version 4.8 or later.



#### NOTE

OpenShift Container Platform does not support enabling multipathing as a day-2 activity on nodes that have been upgraded from 4.6 or earlier.

- You are logged in to the cluster as a user with administrative privileges.

#### Procedure

1. To enable multipath and start the **multipathd** daemon, run the following command:

```
$ mpathconf --enable && systemctl start multipathd.service
```

- Optional: If booting the PXE or ISO, you can instead enable multipath by adding **rd.multipath=default** from the kernel command line.
2. Append the kernel arguments by invoking the **coreos-installer** program:
    - If there is only one multipath device connected to the machine, it should be available at path **/dev/mapper/mpatha**. For example:

```
$ coreos-installer install /dev/mapper/mpatha \ 1
--append-karg rd.multipath=default \
--append-karg root=/dev/disk/by-label/dm-mpath-root \
--append-karg rw
```

- 1 Indicates the path of the single multipathed device.

- If there are multiple multipath devices connected to the machine, or to be more explicit, instead of using `/dev/mapper/mpatha`, it is recommended to use the World Wide Name (WWN) symlink available in `/dev/disk/by-id`. For example:

```
$ coreos-installer install /dev/disk/by-id/wwn-<wwn_ID> \ 1
--append-karg rd.multipath=default \
--append-karg root=/dev/disk/by-label/dm-mpath-root \
--append-karg rw
```

- 1 Indicates the WWN ID of the target multipathed device. For example, **0xx194e957fcedb4841**.

This symlink can also be used as the `coreos.inst.install_dev` kernel argument when using special `coreos.inst.*` arguments to direct the live installer. For more information, see "Installing RHCOS and starting the OpenShift Container Platform bootstrap process".

3. Check that the kernel arguments worked by going to one of the worker nodes and listing the kernel command line arguments (in `/proc/cmdline` on the host):

```
$ oc debug node/ip-10-0-141-105.ec2.internal
```

### Example output

```
Starting pod/ip-10-0-141-105ec2internal-debug ...
To use host binaries, run `chroot /host`

sh-4.2# cat /host/proc/cmdline
...
rd.multipath=default root=/dev/disk/by-label/dm-mpath-root
...

sh-4.2# exit
```

You should see the added kernel arguments.

### 8.3.14.5. Updating the bootloader using bootupd

To update the bootloader by using **bootupd**, you must either install **bootupd** on RHCOS machines manually or provide a machine config with the enabled **systemd** unit. Unlike **grubby** or other bootloader tools, **bootupd** does not manage kernel space configuration such as passing kernel arguments.

After you have installed **bootupd**, you can manage it remotely from the OpenShift Container Platform cluster.



#### NOTE

It is recommended that you use **bootupd** only on bare metal or virtualized hypervisor installations, such as for protection against the BootHole vulnerability.

### Manual install method

You can manually install **bootupd** by using the **bootctl** command-line tool.



1. Inspect the system status:

```
# bootupctl status
```

### Example output

```
Component EFI
  Installed: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
  Update: At latest version
```

2. RHCOS images created without **bootupd** installed on them require an explicit adoption phase. If the system status is **Adoptable**, perform the adoption:

```
# bootupctl adopt-and-update
```

### Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

3. If an update is available, apply the update so that the changes take effect on the next reboot:

```
# bootupctl update
```

### Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

## Machine config method

Another way to enable **bootupd** is by providing a machine config.

- Provide a machine config file with the enabled **systemd** unit, as shown in the following example:

### Example output

```
variant: rhcos
version: 1.1.0
systemd:
  units:
    - name: custom-bootupd-auto.service
      enabled: true
      contents: |
        [Unit]
        Description=Bootupd automatic update

        [Service]
        ExecStart=/usr/bin/bootupctl update
        RemainAfterExit=yes

        [Install]
        WantedBy=multi-user.target
```

### 8.3.15. Waiting for the bootstrap process to complete

The OpenShift Container Platform bootstrap process begins after the cluster nodes first boot into the persistent RHCOS environment that has been installed to disk. The configuration information provided through the Ignition config files is used to initialize the bootstrap process and install OpenShift Container Platform on the machines. You must wait for the bootstrap process to complete.

#### Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have obtained the installation program and generated the Ignition config files for your cluster.
- You installed RHCOS on your cluster machines and provided the Ignition config files that the OpenShift Container Platform installation program generated.
- Your machines have direct internet access or have an HTTP or HTTPS proxy available.

#### Procedure

1. Monitor the bootstrap process:

```
$ ./openshift-install --dir <installation_directory> wait-for bootstrap-complete \ 1  
--log-level=info 2
```

1 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

#### Example output

```
INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...  
INFO API v1.22.1 up  
INFO Waiting up to 30m0s for bootstrapping to complete...  
INFO It is now safe to remove the bootstrap resources
```

The command succeeds when the Kubernetes API server signals that it has been bootstrapped on the control plane machines.

2. After bootstrap process is complete, remove the bootstrap machine from the load balancer.



#### IMPORTANT

You must remove the bootstrap machine from the load balancer at this point. You can also remove or reformat the bootstrap machine itself.

#### Additional resources

- See [Monitoring installation progress](#) for more information about monitoring the installation logs and retrieving diagnostic data if installation issues arise.

### 8.3.16. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

#### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

#### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

#### Example output

```
system:admin
```

### 8.3.17. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

#### Prerequisites

- You added machines to your cluster.

#### Procedure

1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

#### Example output

```
NAME      STATUS  ROLES  AGE  VERSION
master-0  Ready   master  63m  v1.22.1
master-1  Ready   master  63m  v1.22.1
master-2  Ready   master  64m  v1.22.1
```

The output lists all of the machines that you created.



### NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

- Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

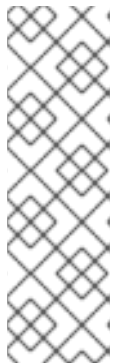
```
$ oc get csr
```

### Example output

```
NAME          AGE   REQUESTOR                                     CONDITION
csr-8b2br     15m   system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper  Pending
csr-8vnps     15m   system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper  Pending
...
```

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

- If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:



### NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.



### NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

**1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{\n"}\n{{end}}\n{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```



#### NOTE

Some Operators might not become available until some CSRs are approved.

- Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

#### Example output

```
NAME      AGE   REQUESTOR                                     CONDITION
csr-bfd72 5m26s system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv 5m26s system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

- If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

**1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{\n"}\n{{end}}\n{{end}}' | xargs oc adm certificate approve
```

- After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

#### Example output

```
NAME      STATUS   ROLES    AGE   VERSION
master-0 Ready    master   73m   v1.22.1
```

```

master-1 Ready   master 73m v1.22.1
master-2 Ready   master 74m v1.22.1
worker-0 Ready   worker 11m v1.22.1
worker-1 Ready   worker 11m v1.22.1

```

**NOTE**

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

**Additional information**

- For more information on CSRs, see [Certificate Signing Requests](#).

**8.3.18. Initial Operator configuration**

After the control plane initializes, you must immediately configure some Operators so that they all become available.

**Prerequisites**

- Your control plane has initialized.

**Procedure**

1. Watch the cluster components come online:

```
$ watch -n5 oc get clusteroperators
```

**Example output**

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
authentication	4.9.0	True	False	False	19m
baremetal	4.9.0	True	False	False	37m
cloud-credential	4.9.0	True	False	False	40m
cluster-autoscaler	4.9.0	True	False	False	37m
config-operator	4.9.0	True	False	False	38m
console	4.9.0	True	False	False	26m
csi-snapshot-controller	4.9.0	True	False	False	37m
dns	4.9.0	True	False	False	37m
etcd	4.9.0	True	False	False	36m
image-registry	4.9.0	True	False	False	31m
ingress	4.9.0	True	False	False	30m
insights	4.9.0	True	False	False	31m
kube-apiserver	4.9.0	True	False	False	26m
kube-controller-manager	4.9.0	True	False	False	36m
kube-scheduler	4.9.0	True	False	False	36m
kube-storage-version-migrator	4.9.0	True	False	False	37m
machine-api	4.9.0	True	False	False	29m
machine-approver	4.9.0	True	False	False	37m
machine-config	4.9.0	True	False	False	36m
marketplace	4.9.0	True	False	False	37m
monitoring	4.9.0	True	False	False	29m

network	4.9.0	True	False	False	38m
node-tuning	4.9.0	True	False	False	37m
openshift-apiserver	4.9.0	True	False	False	32m
openshift-controller-manager	4.9.0	True	False	False	30m
openshift-samples	4.9.0	True	False	False	32m
operator-lifecycle-manager	4.9.0	True	False	False	37m
operator-lifecycle-manager-catalog	4.9.0	True	False	False	37m
operator-lifecycle-manager-packageserver	4.9.0	True	False	False	32m
service-ca	4.9.0	True	False	False	38m
storage	4.9.0	True	False	False	37m

2. Configure the Operators that are not available.

### Additional resources

- See [Gathering logs from a failed installation](#) for details about gathering data in the event of a failed OpenShift Container Platform installation.
- See [Troubleshooting Operator issues](#) for steps to check Operator pod health across the cluster and gather Operator logs for diagnosis.

#### 8.3.18.1. Image registry removed during installation

On platforms that do not provide shareable object storage, the OpenShift Image Registry Operator bootstraps itself as **Removed**. This allows **openshift-installer** to complete installations on these platform types.

After installation, you must edit the Image Registry Operator configuration to switch the **managementState** from **Removed** to **Managed**.



#### NOTE

The Prometheus console provides an **ImageRegistryRemoved** alert, for example:

"Image Registry has been removed. **ImageStreamTags**, **BuildConfigs** and **DeploymentConfigs** which reference **ImageStreamTags** may not work as expected. Please configure storage and update the config to **Managed** state by editing `configs.imageregistry.operator.openshift.io`."

#### 8.3.18.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

#### 8.3.18.3. Configuring block registry storage

To allow the image registry to use block storage types during upgrades as a cluster administrator, you can use the **Recreate** rollout strategy.



### IMPORTANT

Block storage volumes are supported but not recommended for use with the image registry on production clusters. An installation where the registry is configured on block storage is not highly available because the registry cannot have more than one replica.

### Procedure

1. To set the image registry storage as a block storage type, patch the registry so that it uses the **Recreate** rollout strategy and runs with only one ( **1** ) replica:

```
$ oc patch config.imageregistry.operator.openshift.io/cluster --type=merge -p '{"spec": {"rolloutStrategy": "Recreate", "replicas": 1}}'
```

2. Provision the PV for the block storage device, and create a PVC for that volume. The requested block volume uses the ReadWriteOnce (RWO) access mode.
3. Edit the registry configuration so that it references the correct PVC.

## 8.3.19. Completing installation on user-provisioned infrastructure

After you complete the Operator configuration, you can finish installing the cluster on infrastructure that you provide.

### Prerequisites

- Your control plane has initialized.
- You have completed the initial Operator configuration.

### Procedure

1. Confirm that all the cluster components are online with the following command:

```
$ watch -n5 oc get clusteroperators
```

### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
authentication	4.9.0	True	False	False	19m
baremetal	4.9.0	True	False	False	37m
cloud-credential	4.9.0	True	False	False	40m
cluster-autoscaler	4.9.0	True	False	False	37m
config-operator	4.9.0	True	False	False	38m
console	4.9.0	True	False	False	26m
csi-snapshot-controller	4.9.0	True	False	False	37m
dns	4.9.0	True	False	False	37m
etcd	4.9.0	True	False	False	36m
image-registry	4.9.0	True	False	False	31m
ingress	4.9.0	True	False	False	30m



insights	4.9.0	True	False	False	31m
kube-apiserver	4.9.0	True	False	False	26m
kube-controller-manager	4.9.0	True	False	False	36m
kube-scheduler	4.9.0	True	False	False	36m
kube-storage-version-migrator	4.9.0	True	False	False	37m
machine-api	4.9.0	True	False	False	29m
machine-approver	4.9.0	True	False	False	37m
machine-config	4.9.0	True	False	False	36m
marketplace	4.9.0	True	False	False	37m
monitoring	4.9.0	True	False	False	29m
network	4.9.0	True	False	False	38m
node-tuning	4.9.0	True	False	False	37m
openshift-apiserver	4.9.0	True	False	False	32m
openshift-controller-manager	4.9.0	True	False	False	30m
openshift-samples	4.9.0	True	False	False	32m
operator-lifecycle-manager	4.9.0	True	False	False	37m
operator-lifecycle-manager-catalog	4.9.0	True	False	False	37m
operator-lifecycle-manager-packageserver	4.9.0	True	False	False	32m
service-ca	4.9.0	True	False	False	38m
storage	4.9.0	True	False	False	37m

Alternatively, the following command notifies you when all of the clusters are available. It also retrieves and displays credentials:

```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

### Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

The command succeeds when the Cluster Version Operator finishes deploying the OpenShift Container Platform cluster from Kubernetes API server.

### IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Confirm that the Kubernetes API server is communicating with the pods.

a. To view a list of all pods, use the following command:

```
$ oc get pods --all-namespaces
```

#### Example output

```

NAMESPACE           NAME                                     READY  STATUS   RESTARTS  AGE
openshift-apiserver-operator  openshift-apiserver-operator-85cb746d55-zqhs8  1/1    Running   0          9m
openshift-apiserver          apiserver-67b9g                               1/1    Running   0          3m
openshift-apiserver          apiserver-ljcmx                               1/1    Running   0          1m
openshift-apiserver          apiserver-z25h4                               1/1    Running   0          2m
openshift-authentication-operator  authentication-operator-69d5d8bf84-vh2n8  1/1    Running   0          5m
...

```

b. View the logs for a pod that is listed in the output of the previous command by using the following command:

```
$ oc logs <pod_name> -n <namespace> 1
```

**1** Specify the pod name and namespace, as shown in the output of the previous command.

If the pod logs display, the Kubernetes API server can communicate with the cluster machines.

3. For an installation with Fibre Channel Protocol (FCP), additional steps are required to enable multipathing. Do not enable multipathing during installation. See "Enabling multipathing with kernel arguments on RHCOS" in the *Post-installation machine configuration tasks* documentation for more information.

### 8.3.20. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

#### Additional resources

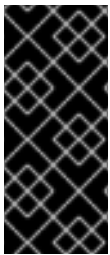
- See [About remote health monitoring](#) for more information about the Telemetry service

### 8.3.21. Next steps

- [Validating an installation.](#)
- [Customize your cluster.](#)
- If necessary, you can [opt out of remote health reporting](#) .
- [Set up your registry and configure registry storage](#) .

## 8.4. INSTALLING A USER-PROVISIONED BARE METAL CLUSTER ON A RESTRICTED NETWORK

In OpenShift Container Platform 4.9, you can install a cluster on bare metal infrastructure that you provision in a restricted network.



### IMPORTANT

While you might be able to follow this procedure to deploy a cluster on virtualized or cloud environments, you must be aware of additional considerations for non-bare metal platforms. Review the information in the [guidelines for deploying OpenShift Container Platform on non-tested platforms](#) before you attempt to install an OpenShift Container Platform cluster in such an environment.

### 8.4.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You [created a registry on your mirror host](#) and obtained the **imageContentSources** data for your version of OpenShift Container Platform.



### IMPORTANT

Because the installation media is on the mirror host, you can use that computer to complete all installation steps.

- You provisioned [persistent storage](#) for your cluster. To deploy a private image registry, your storage must provide ReadWriteMany access modes.
- If you use a firewall and plan to use the Telemetry service, you [configured the firewall to allow the sites](#) that your cluster requires access to.



### NOTE

Be sure to also review this site list if you are configuring a proxy.

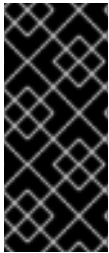
### 8.4.2. About installations in restricted networks

In OpenShift Container Platform 4.9, you can perform an installation that does not require an active connection to the internet to obtain software components. Restricted network installations can be completed using installer-provisioned infrastructure or user-provisioned infrastructure, depending on

the cloud platform to which you are installing the cluster.

If you choose to perform a restricted network installation on a cloud platform, you still require access to its cloud APIs. Some cloud functions, like Amazon Web Service's Route 53 DNS and IAM services, require internet access. Depending on your network, you might require less internet access for an installation on bare metal hardware or on VMware vSphere.

To complete a restricted network installation, you must create a registry that mirrors the contents of the OpenShift Container Platform registry and contains the installation media. You can create this registry on a mirror host, which can access both the internet and your closed network, or by using other methods that meet your restrictions.



### IMPORTANT

Because of the complexity of the configuration for user-provisioned installations, consider completing a standard user-provisioned infrastructure installation before you attempt a restricted network installation using user-provisioned infrastructure. Completing this test installation might make it easier to isolate and troubleshoot any issues that might arise during your installation in a restricted network.

#### 8.4.2.1. Additional limits

Clusters in restricted networks have the following additional limitations and restrictions:

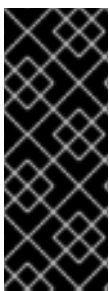
- The **ClusterVersion** status includes an **Unable to retrieve available updates** error.
- By default, you cannot use the contents of the Developer Catalog because you cannot access the required image stream tags.

#### 8.4.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to obtain the images that are necessary to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



### IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

#### 8.4.4. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

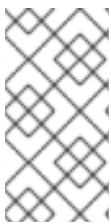
This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

#### 8.4.4.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

**Table 8.33. Minimum required hosts**

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.



#### NOTE

As an exception, you can run zero compute machines in a bare metal cluster that consists of three control plane machines only. This provides smaller, more resource efficient clusters for cluster administrators and developers to use for testing, development, and production. Running one compute machine is not supported.



#### IMPORTANT

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 7.9, or RHEL 8.4.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See [Red Hat Enterprise Linux technology capabilities and limits](#) .

#### 8.4.4.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

**Table 8.34. Minimum resource requirements**

Machine	Operating System	CPU [1]	RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 7.9, or RHEL 8.4 [3]	2	8 GB	100 GB	300

1. One CPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = CPUs.
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.

#### 8.4.4.3. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

#### Additional resources

- See [Configuring a three-node cluster](#) for details about deploying three-node clusters in bare metal environments.
- See [Approving the certificate signing requests for your machines](#) for more information about approving cluster certificate signing requests after installation.

#### 8.4.4.4. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **inittamfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The

Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.

It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.



## NOTE

If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

### 8.4.4.4.1. Setting the cluster node hostnames through DHCP

On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

### 8.4.4.4.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.

**Table 8.35. Ports used for all-machine to all-machine communications**

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	<b>1936</b>	Metrics
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> and the Cluster Version Operator on port <b>9099</b> .

Protocol	Port	Description
	<b>10250-10259</b>	The default ports that Kubernetes reserves
	<b>10256</b>	openshift-sdn
UDP	<b>4789</b>	VXLAN and Geneve
	<b>6081</b>	VXLAN and Geneve
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> .
	<b>500</b>	IPsec IKE packets
	<b>4500</b>	IPsec NAT-T packets
TCP/UDP	<b>30000-32767</b>	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 8.36. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	<b>6443</b>	Kubernetes API

Table 8.37. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	<b>2379-2380</b>	etcd server and peer ports

### NTP configuration for user-provisioned infrastructure

OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service*.

If a DHCP server provides NTP server information, the chrony time service on the Red Hat Enterprise Linux CoreOS (RHCOS) machines read the information and can sync the clock with the NTP servers.

### Additional resources

- [Configuring chrony time service](#)

### 8.4.4.5. User-provisioned DNS requirements



In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API
- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines

Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.




#### NOTE

It is recommended to use a DHCP server to provide the hostnames to each cluster node. See the *DHCP recommendations for user-provisioned infrastructure* section for more information.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, **<cluster\_name>** is the cluster name and **<base\_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster\_name>.<base\_domain>..**

**Table 8.38. Required DNS records**

Component	Record	Description
Kubernetes API	<b>api.&lt;cluster_name&gt;.&lt;base_domain&gt;..</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
	<b>api-int.&lt;cluster_name&gt;.&lt;base_domain&gt;..</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster.
		 <p><b>IMPORTANT</b></p> <p>The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.</p>

Component	Record	Description
Routes	<b>*.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	<p>A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.</p> <p>For example, <b>console-openshift-console.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;</b> is used as a wildcard route to the OpenShift Container Platform console.</p>
Bootstrap machine	<b>bootstrap.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.
Control plane machines	<b>&lt;master&gt;&lt;n&gt;.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.
Compute machines	<b>&lt;worker&gt;&lt;n&gt;.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.



#### NOTE

In OpenShift Container Platform 4.4 and later, you do not need to specify etcd host and SRV records in your DNS configuration.

#### TIP

You can use the **dig** command to verify name and reverse name resolution. See the section on *Validating DNS resolution for user-provisioned infrastructure* for detailed validation steps.

#### 8.4.4.5.1. Example DNS configuration for user-provisioned clusters

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is **ocp4** and the base domain is **example.com**.

#### Example DNS A record configuration for a user-provisioned cluster

The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

### Example 8.7. Sample DNS zone database

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H ; refresh (3 hours)
  30M ; retry (30 minutes)
  2W ; expiry (2 weeks)
  1W ) ; minimum (1 week)
IN NS ns1.example.com.
IN MX 10 smtp.example.com.
;
;
ns1.example.com. IN A 192.168.1.5
smtp.example.com. IN A 192.168.1.5
;
helper.example.com. IN A 192.168.1.5
helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com. IN A 192.168.1.5 1
api-int.ocp4.example.com. IN A 192.168.1.5 2
;
*.apps.ocp4.example.com. IN A 192.168.1.5 3
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 4
;
master0.ocp4.example.com. IN A 192.168.1.97 5
master1.ocp4.example.com. IN A 192.168.1.98 6
master2.ocp4.example.com. IN A 192.168.1.99 7
;
worker0.ocp4.example.com. IN A 192.168.1.11 8
worker1.ocp4.example.com. IN A 192.168.1.7 9
;
;EOF
```

- 1 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.
- 2 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.
- 3 Provides name resolution for the wildcard routes. The record refers to the IP address of the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

**NOTE**

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

- 4 Provides name resolution for the bootstrap machine.
- 5 6 7 Provides name resolution for the control plane machines.
- 8 9 Provides name resolution for the compute machines.

**Example DNS PTR record configuration for a user-provisioned cluster**

The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

**Example 8.8. Sample DNS zone database for reverse records**

```
$TTL 1W
@ IN SOA ns1.example.com. root (
    2019070700 ; serial
    3H ; refresh (3 hours)
    30M ; retry (30 minutes)
    2W ; expiry (2 weeks)
    1W ) ; minimum (1 week)
IN NS ns1.example.com.
;
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. 2
;
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. 3
;
97.1.168.192.in-addr.arpa. IN PTR master0.ocp4.example.com. 4
98.1.168.192.in-addr.arpa. IN PTR master1.ocp4.example.com. 5
99.1.168.192.in-addr.arpa. IN PTR master2.ocp4.example.com. 6
;
11.1.168.192.in-addr.arpa. IN PTR worker0.ocp4.example.com. 7
7.1.168.192.in-addr.arpa. IN PTR worker1.ocp4.example.com. 8
;
;EOF
```

- 1 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.
- 2 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.
- 3 Provides reverse DNS resolution for the bootstrap machine.
- 4 5 6 Provides reverse DNS resolution for the control plane machines.

**7 8** Provides reverse DNS resolution for the compute machines.



#### NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard.

#### Additional resources

- [Validating DNS resolution for user-provisioned infrastructure](#)

#### 8.4.4.6. Load balancing requirements for user-provisioned infrastructure

Before you install OpenShift Container Platform, you must provision the API and application ingress load balancing infrastructure. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.



#### NOTE

If you want to deploy the API and application ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer.** Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:
  - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the API routes.
  - A stateless load balancing algorithm. The options vary based on the load balancer implementation.



#### NOTE

Session persistence is not required for the API load balancer to function properly.

Configure the following ports on both the front and back of the load balancers:

**Table 8.39. API load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
<b>6443</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the <b>/readyz</b> endpoint for the API server health check probe.	X	X	Kubernetes API server

Port	Back-end machines (pool members)	Internal	External	Description
<b>22623</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server

**NOTE**

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the **/readyz** endpoint to the removal of the API server instance from the pool. Within the time frame after **/readyz** returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application ingress load balancer.** Provides an ingress point for application traffic flowing in from outside the cluster. Configure the following conditions:

- Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the ingress routes.
- A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

**TIP**

If the true IP address of the client can be seen by the application ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

Configure the following ports on both the front and back of the load balancers:

**Table 8.40. Application ingress load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
<b>443</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic
<b>80</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic

Port	Back-end machines (pool members)	Internal	External	Description
1936	The worker nodes that run the Ingress Controller pods, by default. You must configure the <b>/healthz/ready</b> endpoint for the ingress health check probe.	X	X	HTTP traffic

**NOTE**

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

**NOTE**

A working configuration for the Ingress router is required for an OpenShift Container Platform cluster. You must configure the Ingress router after the control plane initializes.

#### 8.4.4.6.1. Example load balancer configuration for user-provisioned clusters

This section provides an example API and application ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an **/etc/haproxy/haproxy.cfg** configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing one load balancing solution over another.

**NOTE**

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

#### Example 8.9. Sample API and application ingress load balancer configuration

```

global
  log      127.0.0.1 local2
  pidfile /var/run/haproxy.pid
  maxconn 4000
  daemon
defaults
  mode          http
  log           global
  option        dontlognull
  option http-server-close
  option        redispatch
  retries       3
  timeout http-request 10s
  timeout queue      1m
  timeout connect    10s
  timeout client     1m

```

```

timeout server      1m
timeout http-keep-alive 10s
timeout check      10s
maxconn            3000
frontend stats
bind *:1936
mode              http
log               global
maxconn 10
stats enable
stats hide-version
stats refresh 30s
stats show-node
stats show-desc Stats for ocp4 cluster ❶
stats auth admin:ocp4
stats uri /stats
listen api-server-6443 ❷
bind *:6443
mode tcp
server bootstrap bootstrap.ocp4.example.com:6443 check inter 1s backup ❸
server master0 master0.ocp4.example.com:6443 check inter 1s
server master1 master1.ocp4.example.com:6443 check inter 1s
server master2 master2.ocp4.example.com:6443 check inter 1s
listen machine-config-server-22623 ❹
bind *:22623
mode tcp
server bootstrap bootstrap.ocp4.example.com:22623 check inter 1s backup ❺
server master0 master0.ocp4.example.com:22623 check inter 1s
server master1 master1.ocp4.example.com:22623 check inter 1s
server master2 master2.ocp4.example.com:22623 check inter 1s
listen ingress-router-443 ❻
bind *:443
mode tcp
balance source
server worker0 worker0.ocp4.example.com:443 check inter 1s
server worker1 worker1.ocp4.example.com:443 check inter 1s
listen ingress-router-80 ❼
bind *:80
mode tcp
balance source
server worker0 worker0.ocp4.example.com:80 check inter 1s
server worker1 worker1.ocp4.example.com:80 check inter 1s

```

- ❶ In the example, the cluster name is **ocp4**.
- ❷ Port **6443** handles the Kubernetes API traffic and points to the control plane machines.
- ❸ ❺ The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.
- ❹ Port **22623** handles the machine config server traffic and points to the control plane machines.
- ❻ Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



- 7** Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



#### NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

#### TIP

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltp** on the HAProxy node.



#### NOTE

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running **setsebool -P haproxy\_connect\_any=1**.

### 8.4.5. Preparing the user-provisioned infrastructure

Before you install OpenShift Container Platform on user-provisioned infrastructure, you must prepare the underlying infrastructure.

This section provides details about the high-level steps required to set up your cluster infrastructure in preparation for an OpenShift Container Platform installation. This includes configuring IP networking and network connectivity for your cluster nodes, enabling the required ports through your firewall, and setting up the required DNS and load balancing infrastructure.

After preparation, your cluster infrastructure must meet the requirements outlined in the *Requirements for a cluster with user-provisioned infrastructure* section.

#### Prerequisites

- You have reviewed the [OpenShift Container Platform 4.x Tested Integrations](#) page.
- You have reviewed the infrastructure requirements detailed in the *Requirements for a cluster with user-provisioned infrastructure* section.

#### Procedure

1. If you are using DHCP to provide the IP networking configuration to your cluster nodes, configure your DHCP service.
  - a. Add persistent IP addresses for the nodes to your DHCP server configuration. In your configuration, match the MAC address of the relevant network interface to the intended IP address for each node.

- b. When you use DHCP to configure IP addressing for the cluster machines, the machines also obtain the DNS server information through DHCP. Define the persistent DNS server address that is used by the cluster nodes through your DHCP server configuration.

**NOTE**

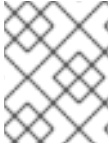
If you are not using a DHCP service, you must provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

- c. Define the hostnames of your cluster nodes in your DHCP server configuration. See the *Setting the cluster node hostnames through DHCP* section for details about hostname considerations.

**NOTE**

If you are not using a DHCP service, the cluster nodes obtain their hostname through a reverse DNS lookup.

2. Ensure that your network infrastructure provides the required network connectivity between the cluster components. See the *Networking requirements for user-provisioned infrastructure* section for details about the requirements.
3. Configure your firewall to enable the ports required for the OpenShift Container Platform cluster components to communicate. See *Networking requirements for user-provisioned infrastructure* section for details about the ports that are required.
4. Setup the required DNS infrastructure for your cluster.
  - a. Configure DNS name resolution for the Kubernetes API, the application wildcard, the bootstrap machine, the control plane machines, and the compute machines.
  - b. Configure reverse DNS resolution for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.  
See the *User-provisioned DNS requirements* section for more information about the OpenShift Container Platform DNS requirements.
5. Validate your DNS configuration.
  - a. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses in the responses correspond to the correct components.
  - b. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names in the responses correspond to the correct components.  
See the *Validating DNS resolution for user-provisioned infrastructure* section for detailed DNS validation steps.
6. Provision the required API and application ingress load balancing infrastructure. See the *Load balancing requirements for user-provisioned infrastructure* section for more information about the requirements.

**NOTE**

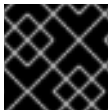
Some load balancing solutions require the DNS name resolution for the cluster nodes to be in place before the load balancing is initialized.

**Additional resources**

- [Requirements for a cluster with user-provisioned infrastructure](#)
- [Installing RHCOS and starting the OpenShift Container Platform bootstrap process](#)
- [Setting the cluster node hostnames through DHCP](#)
- [Advanced RHCOS installation configuration](#)
- [Networking requirements for user-provisioned infrastructure](#)
- [User-provisioned DNS requirements](#)
- [Validating DNS resolution for user-provisioned infrastructure](#)
- [Load balancing requirements for user-provisioned infrastructure](#)

**8.4.6. Validating DNS resolution for user-provisioned infrastructure**

You can validate your DNS configuration before installing OpenShift Container Platform on user-provisioned infrastructure.

**IMPORTANT**

The validation steps detailed in this section must succeed before you install your cluster.

**Prerequisites**

- You have configured the required DNS records for your user-provisioned infrastructure.

**Procedure**

1. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses contained in the responses correspond to the correct components.
  - a. Perform a lookup against the Kubernetes API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api.<cluster_name>.<base_domain> 1
```

- 1** Replace **<nameserver\_ip>** with the IP address of the nameserver, **<cluster\_name>** with your cluster name, and **<base\_domain>** with your base domain name.

**Example output**

```
api.ocp4.example.com. 0 IN A 192.168.1.5
```

- b. Perform a lookup against the Kubernetes internal API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api-int.<cluster_name>.<base_domain>
```

#### Example output

```
api-int.ocp4.example.com. 0 IN A 192.168.1.5
```

- c. Test an example **\*.apps.<cluster\_name>.<base\_domain>** DNS wildcard lookup. All of the application wildcard lookups must resolve to the IP address of the application ingress load balancer:

```
$ dig +noall +answer @<nameserver_ip> random.apps.<cluster_name>.<base_domain>
```

#### Example output

```
random.apps.ocp4.example.com. 0 IN A 192.168.1.5
```



#### NOTE

In the example outputs, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

You can replace **random** with another wildcard value. For example, you can query the route to the OpenShift Container Platform console:

```
$ dig +noall +answer @<nameserver_ip> console-openshift-console.apps.<cluster_name>.<base_domain>
```

#### Example output

```
console-openshift-console.apps.ocp4.example.com. 0 IN A 192.168.1.5
```

- d. Run a lookup against the bootstrap DNS record name. Check that the result points to the IP address of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> bootstrap.<cluster_name>.<base_domain>
```

#### Example output

```
bootstrap.ocp4.example.com. 0 IN A 192.168.1.96
```

- e. Use this method to perform lookups against the DNS record names for the control plane and compute nodes. Check that the results correspond to the IP addresses of each node.
2. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names contained in the responses correspond to the correct components.

- a. Perform a reverse lookup against the IP address of the API load balancer. Check that the response includes the record names for the Kubernetes API and the Kubernetes internal API:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.5
```

#### Example output

```
5.1.168.192.in-addr.arpa. 0 IN PTR api-int.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. 0 IN PTR api.ocp4.example.com. 2
```

- 1 Provides the record name for the Kubernetes internal API.
- 2 Provides the record name for the Kubernetes API.



#### NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard. No validation step is needed for reverse DNS resolution against the IP address of the application ingress load balancer.

- b. Perform a reverse lookup against the IP address of the bootstrap node. Check that the result points to the DNS record name of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.96
```

#### Example output

```
96.1.168.192.in-addr.arpa. 0 IN PTR bootstrap.ocp4.example.com.
```

- c. Use this method to perform reverse lookups against the IP addresses for the control plane and compute nodes. Check that the results correspond to the DNS record names of each node.

#### Additional resources

- [User-provisioned DNS requirements](#)
- [Load balancing requirements for user-provisioned infrastructure](#)

### 8.4.7. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.



### IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



### NOTE

You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

## Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.



### NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.



### NOTE

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

-

```
$ eval "$(ssh-agent -s)"
```

### Example output

```
Agent pid 31874
```



### NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1** Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

### Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

### Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program. If you install a cluster on infrastructure that you provision, you must provide the key to the installation program.

### Additional resources

- [Verifying node health](#)

## 8.4.8. Manually creating the installation configuration file

For user-provisioned installations of OpenShift Container Platform, you manually generate your installation configuration file.

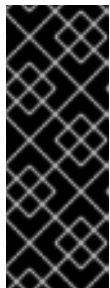
### Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain the **imageContentSources** section from the output of the command to mirror the repository.
- Obtain the contents of the certificate for your mirror registry.

### Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```



### IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation\_directory>**.



### NOTE

You must name this configuration file **install-config.yaml**.

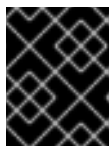
- Unless you use a registry that RHCOS trusts by default, such as **docker.io**, you must provide the contents of the certificate for your mirror repository in the **additionalTrustBundle** section. In most cases, you must provide the certificate for your mirror.
- You must include the **imageContentSources** section from the output of the command to mirror the repository.



### NOTE

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation\_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



### IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

#### 8.4.8.1. Installation configuration parameters

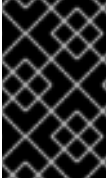
Before you deploy an OpenShift Container Platform cluster, you provide a customized **install-config.yaml** installation configuration file that describes the details for your environment.



### NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.





## IMPORTANT

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

### 8.4.8.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 8.41. Required parameters

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;</b> . <b>&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}</b> . <b>{{.baseDomain}}</b> .	String of lowercase letters and hyphens (-), such as <b>dev</b> .


Parameter	Description	Values
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws</b> , <b>baremetal</b> , <b>azure</b> , <b>gcp</b> , <b>openstack</b> , <b>ovirt</b> , <b>vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } }</pre>

#### 8.4.8.1.2. Network configuration parameters


You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

Table 8.42. Network parameters

Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	<p>Object</p>  <p><b>NOTE</b></p> <p>You cannot modify parameters specified by the <b>networking</b> object after installation.</p>

Parameter	Description	Values
<b>networking.networkType</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .
<b>networking.clusterNetwork</b>	The IP address blocks for pods.  The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b> .  If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example:  <pre>networking:   clusterNetwork:     - cidr: 10.128.0.0/14       hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	Required if you use <b>networking.clusterNetwork</b> . An IP address block.  An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b> .
<b>networking.clusterNetwork.hostPrefix</b>	The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b> . A <b>hostPrefix</b> value of <b>23</b> provides 510 ( $2^{(32 - 23)} - 2$ ) pod IP addresses.	A subnet prefix.  The default value is <b>23</b> .
<b>networking.serviceNetwork</b>	The IP address block for services. The default value is <b>172.30.0.0/16</b> .  The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example:  <pre>networking:   serviceNetwork:     - 172.30.0.0/16</pre>
<b>networking.machineNetwork</b>	The IP address blocks for machines.  If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example:  <pre>networking:   machineNetwork:     - cidr: 10.0.0.0/16</pre>


Parameter	Description	Values
<b>networking.machineNetwork.cidr</b>	Required if you use <b>networking.machineNetwork</b> . An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b> .	<p>An IP network block in CIDR notation.</p> <p>For example, <b>10.0.0.0/16</b>.</p>  <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p>


#### 8.4.8.1.3. Optional configuration parameters



Optional installation configuration parameters are described in the following table:

Table 8.43. Optional parameters

Parameter	Description	Values
<b>additionalTrustBundle</b>	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
<b>compute</b>	The configuration for the machines that comprise the compute nodes.	Array of <b>MachinePool</b> objects.
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String

Parameter	Description	Values
<b>compute.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b>
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String

Parameter	Description	Values
<b>controlPlane.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platform</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>controlPlane.replicas</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.

Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.</p> <div data-bbox="485 510 593 864" style="border: 1px solid black; padding: 5px; margin-bottom: 10px;">  </div> <p><b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators reference content</i>.</p> <div data-bbox="485 909 593 1263" style="border: 1px solid black; padding: 5px;">  </div> <p><b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p>	<b>Mint, Passthrough, Manual</b> or an empty string ("").

Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start;"> <div style="width: 60px; height: 100px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 60px; height: 100px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<b>Internal</b> or <b>External</b> . The default value is <b>External</b> .  Setting this field to <b>Internal</b> is not supported on non-cloud platforms.





- mirrors:
  - <local\_registry>/<local\_repository\_name>/release
  - source: quay.io/openshift-release-dev/ocp-release
- mirrors:
  - <local\_registry>/<local\_repository\_name>/release
  - source: quay.io/openshift-release-dev/ocp-v4.0-art-dev

- 1 The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.
- 2 5 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. Only one control plane pool is used.
- 3 6 Specifies whether to enable or disable simultaneous multithreading (SMT), or hyperthreading. By default, SMT is enabled to increase the performance of the cores in your machines. You can disable it by setting the parameter value to **Disabled**. If you disable SMT, you must disable it in all cluster machines; this includes both control plane and compute machines.



#### NOTE

Simultaneous multithreading (SMT) is enabled by default. If SMT is not enabled in your BIOS settings, the **hyperthreading** parameter has no effect.



#### IMPORTANT

If you disable **hyperthreading**, whether in the BIOS or in the **install-config.yaml** file, ensure that your capacity planning accounts for the dramatically decreased machine performance.

- 4 You must set this value to **0** when you install OpenShift Container Platform on user-provisioned infrastructure. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. In user-provisioned installations, you must manually deploy the compute machines before you finish installing the cluster.



#### NOTE

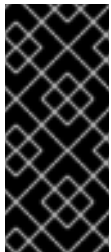
If you are installing a three-node cluster, do not deploy any compute machines when you install the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

- 7 The number of control plane machines that you add to the cluster. Because the cluster uses these values as the number of etcd endpoints in the cluster, the value must match the number of control plane machines that you deploy.
- 8 The cluster name that you specified in your DNS records.
- 9 A block of IP addresses from which pod IP addresses are allocated. This block must not overlap with existing physical networks. These IP addresses are used for the pod network. If you need to access the pods from an external network, you must configure load balancers and routers to manage the traffic.

**NOTE**

Class E CIDR range is reserved for a future use. To use the Class E CIDR range, you must ensure your networking environment accepts the IP addresses within the Class E CIDR range.

- 10 The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23**, then each node is assigned a **/23** subnet out of the given **cidr**, which allows for 510 ( $2^{(32 - 23)} - 2$ ) pod IP addresses. If you are required to provide access to nodes from an external network, configure load balancers and routers to manage the traffic.
- 11 The IP address pool to use for service IP addresses. You can enter only one IP address pool. This block must not overlap with existing physical networks. If you need to access the services from an external network, configure load balancers and routers to manage the traffic.
- 12 You must set the platform to **none**. You cannot provide additional platform configuration variables for your platform.

**IMPORTANT**

Clusters that are installed with the platform type **none** are unable to use some features, such as managing compute machines with the Machine API. This limitation applies even if the compute machines that are attached to the cluster are installed on a platform that would normally support the feature. This parameter cannot be changed after installation.

- 13 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

**IMPORTANT**

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

- 14 For **<local\_registry>**, specify the registry domain name, and optionally the port, that your mirror registry uses to serve content. For example, **registry.example.com** or **registry.example.com:5000**. For **<credentials>**, specify the base64-encoded user name and password for your mirror registry.
- 15 The SSH public key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).

**NOTE**

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

- 16 Provide the contents of the certificate file that you used for your mirror registry.
- 17 Provide the **imageContentSources** section from the output of the command to mirror the repository.

## Additional resources

- See [Load balancing requirements for user-provisioned infrastructure](#) for more information on the API and application ingress load balancing requirements.

### 8.4.8.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.



#### NOTE

For bare metal installations, if you do not assign node IP addresses from the range that is specified in the **networking.machineNetwork[].cidr** field in the **install-config.yaml** file, you must include them in the **proxy.noProxy** field.

## Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



#### NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

## Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
  additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
  ...
```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations.
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

**NOTE**

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

**NOTE**

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

#### 8.4.8.4. Configuring a three-node cluster

You can optionally deploy zero compute machines in a bare metal cluster that consists of three control plane machines only. This provides smaller, more resource efficient clusters for cluster administrators and developers to use for testing, development, and production.

In three-node OpenShift Container Platform environments, the three control plane machines are schedulable, which means that your application workloads are scheduled to run on them.

#### Prerequisites

- You have an existing **install-config.yaml** file.

#### Procedure

- Ensure that the number of compute replicas is set to **0** in your **install-config.yaml** file, as shown in the following **compute** stanza:

```
compute:
- name: worker
```

```
platform: {}
replicas: 0
```



## NOTE

You must set the value of the **replicas** parameter for the compute machines to **0** when you install OpenShift Container Platform on user-provisioned infrastructure, regardless of the number of compute machines you are deploying. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. This does not apply to user-provisioned installations, where the compute machines are deployed manually.

For three-node cluster installations, follow these next steps:

- If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes. See the *Load balancing requirements for user-provisioned infrastructure* section for more information.
- When you create the Kubernetes manifest files in the following procedure, ensure that the **mastersSchedulable** parameter in the `<installation_directory>/manifests/cluster-scheduler-02-config.yml` file is set to **true**. This enables your application workloads to run on the control plane nodes.
- Do not deploy any compute nodes when you create the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

### 8.4.9. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.



## IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

## Prerequisites

- You obtained the OpenShift Container Platform installation program. For a restricted network installation, these files are on your mirror host.
- You created the **install-config.yaml** installation configuration file.

## Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

- 1 For **<installation\_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.



### WARNING

If you are installing a three-node cluster, skip the following step to allow the control plane nodes to be schedulable.



### IMPORTANT

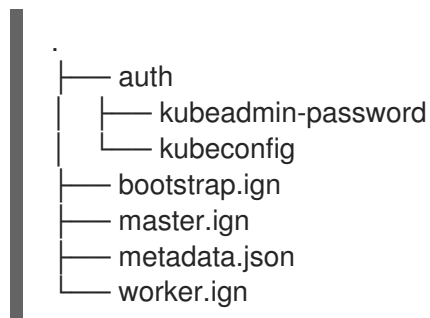
When you configure control plane nodes from the default unschedulable to schedulable, additional subscriptions are required. This is because control plane nodes then become worker nodes.

2. Check that the **mastersSchedulable** parameter in the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:
  - a. Open the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** file.
  - b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.
  - c. Save and exit the file.
3. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

- 1 For **<installation\_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the `./<installation_directory>/auth` directory:



### Additional resources

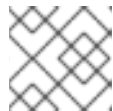
- See [Recovering from expired control plane certificates](#) for more information about recovering kubelet certificates.

## 8.4.10. Configuring chrony time service

You must set the time server and related settings used by the chrony time service (**chronyd**) by modifying the contents of the **chrony.conf** file and passing those contents to your nodes as a machine config.

### Procedure

1. Create a Butane config including the contents of the **chrony.conf** file. For example, to configure chrony on worker nodes, create a **99-worker-chrony.bu** file.



### NOTE

See "Creating machine configs with Butane" for information about Butane.

```

variant: openshift
version: 4.9.0
metadata:
  name: 99-worker-chrony 1
  labels:
    machineconfiguration.openshift.io/role: worker 2
storage:
  files:
  - path: /etc/chrony.conf
    mode: 0644 3
    overwrite: true
  contents:
    inline: |
      pool 0.rhel.pool.ntp.org iburst 4
      driftfile /var/lib/chrony/drift
      makestep 1.0 3
      rtsync
      logdir /var/log/chrony
  
```

- 1 2** On control plane nodes, substitute **master** for **worker** in both of these locations.



- 3 Specify an octal value mode for the **mode** field in the machine config file. After creating the file and applying the changes, the **mode** is converted to a decimal value. You can check
  - 4 Specify any valid, reachable time source, such as the one provided by your DHCP server.
2. Use Butane to generate a **MachineConfig** object file, **99-worker-chrony.yaml**, containing the configuration to be delivered to the nodes:

```
$ butane 99-worker-chrony.bu -o 99-worker-chrony.yaml
```

3. Apply the configurations in one of two ways:
  - If the cluster is not running yet, after you generate manifest files, add the **MachineConfig** object file to the **<installation\_directory>/openshift** directory, and then continue to create the cluster.
  - If the cluster is already running, apply the file:

```
$ oc apply -f ./99-worker-chrony.yaml
```

### 8.4.11. Installing RHCOS and starting the OpenShift Container Platform bootstrap process

To install OpenShift Container Platform on bare metal infrastructure that you provision, you must install Red Hat Enterprise Linux CoreOS (RHCOS) on the machines. When you install RHCOS, you must provide the Ignition config file that was generated by the OpenShift Container Platform installation program for the type of machine you are installing. If you have configured suitable networking, DNS, and load balancing infrastructure, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS machines have rebooted.

To install RHCOS on the machines, follow either the steps to use an ISO image or network PXE booting.



#### NOTE

The compute node deployment steps included in this installation document are RHCOS-specific. If you choose instead to deploy RHEL-based compute nodes, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.

You can configure RHCOS during ISO and PXE installations by using the following methods:

- **Kernel arguments:** You can use kernel arguments to provide installation-specific information. For example, you can specify the locations of the RHCOS installation files that you uploaded to your HTTP server and the location of the Ignition config file for the type of node you are installing. For a PXE installation, you can use the **APPEND** parameter to pass the arguments to the kernel of the live installer. For an ISO installation, you can interrupt the live installation boot process to add the kernel arguments. In both installation cases, you can use special **coreos.inst.\*** arguments to direct the live installer, as well as standard installation boot arguments for turning standard kernel services on or off.
- **Ignition configs:** OpenShift Container Platform Ignition config files (**\*.ign**) are specific to the type of node you are installing. You pass the location of a bootstrap, control plane, or compute

node Ignition config file during the RHCOS installation so that it takes effect on first boot. In special cases, you can create a separate, limited Ignition config to pass to the live system. That Ignition config could do a certain set of tasks, such as reporting success to a provisioning system after completing installation. This special Ignition config is consumed by the **coreos-installer** to be applied on first boot of the installed system. Do not provide the standard control plane and compute node Ignition configs to the live ISO directly.

- **coreos-installer**: You can boot the live ISO installer to a shell prompt, which allows you to prepare the permanent system in a variety of ways before first boot. In particular, you can run the **coreos-installer** command to identify various artifacts to include, work with disk partitions, and set up networking. In some cases, you can configure features on the live system and copy them to the installed system.

Whether to use an ISO or PXE install depends on your situation. A PXE install requires an available DHCP service and more preparation, but can make the installation process more automated. An ISO install is a more manual process and can be inconvenient if you are setting up more than a few machines.



## NOTE

As of OpenShift Container Platform 4.6, the RHCOS ISO and other installation artifacts provide support for installation on disks with 4K sectors.

### 8.4.11.1. Installing RHCOS by using an ISO image

You can use an ISO image to install RHCOS on the machines.

#### Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have an HTTP server that can be accessed from your computer, and from the machines that you create.
- You have reviewed the *Advanced RHCOS installation configuration* section for different ways to configure features, such as networking and disk partitioning.

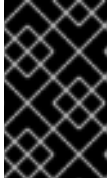
#### Procedure

1. Obtain the SHA512 digest for each of your Ignition config files. For example, you can use the following on a system running Linux to get the SHA512 digest for your **bootstrap.ign** Ignition config file:

```
$ sha512sum <installation_directory>/bootstrap.ign
```

The digests are provided to the **coreos-installer** in a later step to validate the authenticity of the Ignition config files on the cluster nodes.

2. Upload the bootstrap, control plane, and compute node Ignition config files that the installation program created to your HTTP server. Note the URLs of these files.

**IMPORTANT**

You can add or change configuration settings in your Ignition configs before saving them to your HTTP server. If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

- From the installation host, validate that the Ignition config files are available on the URLs. The following example gets the Ignition config file for the bootstrap node:

```
$ curl -k http://<HTTP_server>/bootstrap.ign 1
```

**Example output**

```
% Total % Received % Xferd Average Speed Time Time Time Current
          Dload Upload Total Spent Left Speed
 0  0  0  0  0  0  0  0  0  --:--:-- --:--:-- --:--:--  0{"ignition":
{"version":"3.2.0"},"passwd":{"users":[{"name":"core","sshAuthorizedKeys":["ssh-rsa...
```

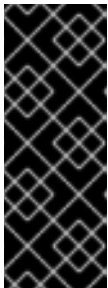
Replace **bootstrap.ign** with **master.ign** or **worker.ign** in the command to validate that the Ignition config files for the control plane and compute nodes are also available.

- Although it is possible to obtain the RHCOS images that are required for your preferred method of installing operating system instances from the [RHCOS image mirror](#) page, the recommended way to obtain the correct version of your RHCOS images are from the output of **openshift-install** command:

```
$ openshift-install coreos print-stream-json | grep '\.iso[^\.]'
```

**Example output**

```
"location": "<url>/art/storage/releases/rhcos-4.9-aarch64/<release>/aarch64/rhcos-
<release>-live.aarch64.iso",
"location": "<url>/art/storage/releases/rhcos-4.9-ppc64le/<release>/ppc64le/rhcos-<release>-
live.ppc64le.iso",
"location": "<url>/art/storage/releases/rhcos-4.9-s390x/<release>/s390x/rhcos-<release>-
live.s390x.iso",
"location": "<url>/art/storage/releases/rhcos-4.9/<release>/x86_64/rhcos-<release>-
live.x86_64.iso",
```

**IMPORTANT**

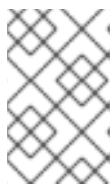
The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image versions that match your OpenShift Container Platform version if they are available. Use only ISO images for this procedure. RHCOS qcow2 images are not supported for this installation type.

ISO file names resemble the following example:

**rhcos-<version>-live.<architecture>.iso**

- Use the ISO to start the RHCOS installation. Use one of the following installation options:

- Burn the ISO image to a disk and boot it directly.
  - Use ISO redirection by using a lights-out management (LOM) interface.
6. Boot the RHCOS ISO image without specifying any options or interrupting the live boot sequence. Wait for the installer to boot into a shell prompt in the RHCOS live environment.



### NOTE

It is possible to interrupt the RHCOS installation boot process to add kernel arguments. However, for this ISO procedure you should use the **coreos-installer** command as outlined in the following steps, instead of adding kernel arguments.

7. Run the **coreos-installer** command and specify the options that meet your installation requirements. At a minimum, you must specify the URL that points to the Ignition config file for the node type, and the device that you are installing to:

```
$ sudo coreos-installer install --ignition-url=http://<HTTP_server>/<node_type>.ign <device>
--ignition-hash=sha512-<digest> 1 2
```

- 1 1 You must run the **coreos-installer** command by using **sudo**, because the **core** user does not have the required root privileges to perform the installation.

- 2 The **--ignition-hash** option is required when the Ignition config file is obtained through an HTTP URL to validate the authenticity of the Ignition config file on the cluster node. **<digest>** is the Ignition config file SHA512 digest obtained in a preceding step.



### NOTE

If you want to provide your Ignition config files through an HTTPS server that uses TLS, you can add the internal certificate authority (CA) to the system trust store before running **coreos-installer**.

The following example initializes a bootstrap node installation to the **/dev/sda** device. The Ignition config file for the bootstrap node is obtained from an HTTP web server with the IP address 192.168.1.2:

```
$ sudo coreos-installer install --ignition-
url=http://192.168.1.2:80/installation_directory/bootstrap.ign /dev/sda --ignition-hash=sha512-
a5a2d43879223273c9b60af66b44202a1d1248fc01cf156c46d4a79f552b6bad47bc8cc78ddf011
6e80c59d2ea9e32ba53bc807afbca581aa059311def2c3e3b
```

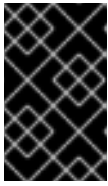
8. Monitor the progress of the RHCOS installation on the console of the machine.



### IMPORTANT

Be sure that the installation is successful on each node before commencing with the OpenShift Container Platform installation. Observing the installation process can also help to determine the cause of RHCOS installation issues that might arise.

9. After RHCOS installs, you must reboot the system. During the system reboot, it applies the Ignition config file that you specified.
10. Continue to create the other machines for your cluster.



### IMPORTANT

You must create the bootstrap and control plane machines at this time. If the control plane machines are not made schedulable, also create at least two compute machines before you install OpenShift Container Platform.

If the required network, DNS, and load balancer infrastructure are in place, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS nodes have rebooted.



### NOTE

RHCOS nodes do not include a default password for the **core** user. You can access the nodes by running **ssh core@<node>.<cluster\_name>.<base\_domain>** as a user with access to the SSH private key that is paired to the public key that you specified in your **install\_config.yaml** file. OpenShift Container Platform 4 cluster nodes running RHCOS are immutable and rely on Operators to apply cluster changes. Accessing cluster nodes by using SSH is not recommended. However, when investigating installation issues, if the OpenShift Container Platform API is not available, or the kubelet is not properly functioning on a target node, SSH access might be required for debugging or disaster recovery.

#### 8.4.11.2. Installing RHCOS by using PXE or iPXE booting

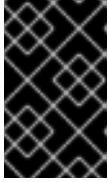
You can use PXE or iPXE booting to install RHCOS on the machines.

##### Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have configured suitable PXE or iPXE infrastructure.
- You have an HTTP server that can be accessed from your computer, and from the machines that you create.
- You have reviewed the *Advanced RHCOS installation configuration* section for different ways to configure features, such as networking and disk partitioning.

##### Procedure

1. Upload the bootstrap, control plane, and compute node Ignition config files that the installation program created to your HTTP server. Note the URLs of these files.



## IMPORTANT

You can add or change configuration settings in your Ignition configs before saving them to your HTTP server. If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

- From the installation host, validate that the Ignition config files are available on the URLs. The following example gets the Ignition config file for the bootstrap node:

```
$ curl -k http://<HTTP_server>/bootstrap.ign 1
```

### Example output

```
% Total    % Received % Xferd Average Speed   Time    Time     Time  Current
           Dload  Upload  Total   Spent    Left  Speed
  0   0   0   0   0   0   0   0   0  --:--:-- --:--:-- --:--:--    0{"ignition":
{"version":"3.2.0"},"passwd":{"users":[{"name":"core","sshAuthorizedKeys":["ssh-rsa...
```

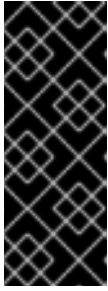
Replace **bootstrap.ign** with **master.ign** or **worker.ign** in the command to validate that the Ignition config files for the control plane and compute nodes are also available.

- Although it is possible to obtain the RHCOS **kernel**, **initramfs** and **rootfs** files that are required for your preferred method of installing operating system instances from the [RHCOS image mirror](#) page, the recommended way to obtain the correct version of your RHCOS files are from the output of **openshift-install** command:

```
$ openshift-install coreos print-stream-json | grep -Eo "https.*(kernel-|initramfs-|rootfs-)\w+(\.img)?"
```

### Example output

```
"<url>/art/storage/releases/rhcos-4.9-aarch64/<release>/aarch64/rhcos-<release>-live-kernel-aarch64"
"<url>/art/storage/releases/rhcos-4.9-aarch64/<release>/aarch64/rhcos-<release>-live-initramfs.aarch64.img"
"<url>/art/storage/releases/rhcos-4.9-aarch64/<release>/aarch64/rhcos-<release>-live-rootfs.aarch64.img"
"<url>/art/storage/releases/rhcos-4.9-ppc64le/49.84.202110081256-0/ppc64le/rhcos-<release>-live-kernel-ppc64le"
"<url>/art/storage/releases/rhcos-4.9-ppc64le/<release>/ppc64le/rhcos-<release>-live-initramfs.ppc64le.img"
"<url>/art/storage/releases/rhcos-4.9-ppc64le/<release>/ppc64le/rhcos-<release>-live-rootfs.ppc64le.img"
"<url>/art/storage/releases/rhcos-4.9-s390x/<release>/s390x/rhcos-<release>-live-kernel-s390x"
"<url>/art/storage/releases/rhcos-4.9-s390x/<release>/s390x/rhcos-<release>-live-initramfs.s390x.img"
"<url>/art/storage/releases/rhcos-4.9-s390x/<release>/s390x/rhcos-<release>-live-rootfs.s390x.img"
"<url>/art/storage/releases/rhcos-4.9/<release>/x86_64/rhcos-<release>-live-kernel-x86_64"
"<url>/art/storage/releases/rhcos-4.9/<release>/x86_64/rhcos-<release>-live-initramfs.x86_64.img"
"<url>/art/storage/releases/rhcos-4.9/<release>/x86_64/rhcos-<release>-live-rootfs.x86_64.img"
```



## IMPORTANT

The RHCOS artifacts might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Only use the appropriate **kernel**, **initramfs**, and **rootfs** artifacts described below for this procedure. RHCOS QCOW2 images are not supported for this installation type.

The file names contain the OpenShift Container Platform version number. They resemble the following examples:

- **kernel:** `rhcos-<version>-live-kernel-<architecture>`
- **initramfs:** `rhcos-<version>-live-initramfs.<architecture>.img`
- **rootfs:** `rhcos-<version>-live-rootfs.<architecture>.img`

4. Upload the **rootfs**, **kernel**, and **initramfs** files to your HTTP server.



## IMPORTANT

If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

5. Configure the network boot infrastructure so that the machines boot from their local disks after RHCOS is installed on them.
6. Configure PXE or iPXE installation for the RHCOS images and begin the installation. Modify one of the following example menu entries for your environment and verify that the image and Ignition files are properly accessible:

- For PXE:

```

DEFAULT pxeboot
TIMEOUT 20
PROMPT 0
LABEL pxeboot
  KERNEL http://<HTTP_server>/rhcos-<version>-live-kernel-<architecture> 1
  APPEND initrd=http://<HTTP_server>/rhcos-<version>-live-initramfs.
<architecture>.img coreos.live.rootfs_url=http://<HTTP_server>/rhcos-<version>-live-
rootfs.<architecture>.img coreos.inst.install_dev=/dev/sda
coreos.inst.ignition_url=http://<HTTP_server>/bootstrap.ign 2 3

```

- 1 1 Specify the location of the live **kernel** file that you uploaded to your HTTP server. The URL must be HTTP, TFTP, or FTP; HTTPS and NFS are not supported.
- 2 If you use multiple NICs, specify a single interface in the **ip** option. For example, to use DHCP on a NIC that is named **eno1**, set **ip=eno1:dhcp**.
- 3 Specify the locations of the RHCOS files that you uploaded to your HTTP server. The **initrd** parameter value is the location of the **initramfs** file, the **coreos.live.rootfs\_url** parameter value is the location of the **rootfs** file, and the **coreos.inst.ignition\_url** parameter value is the location of the bootstrap Ignition config file. You can also add more kernel arguments to the **APPEND** line to configure networking or other boot

options.



### NOTE

This configuration does not enable serial console access on machines with a graphical console. To configure a different console, add one or more **console=** arguments to the **APPEND** line. For example, add **console=tty0 console=ttyS0** to set the first PC serial port as the primary console and the graphical console as a secondary console. For more information, see [How does one set up a serial terminal and/or console in Red Hat Enterprise Linux?](#)

- For iPXE:

```
kernel http://<HTTP_server>/rhcos-<version>-live-kernel-<architecture> initrd=main
coreos.live.rootfs_url=http://<HTTP_server>/rhcos-<version>-live-rootfs.
<architecture>.img coreos.inst.install_dev=/dev/sda
coreos.inst.ignition_url=http://<HTTP_server>/bootstrap.ign 1 2
initrd --name main http://<HTTP_server>/rhcos-<version>-live-initramfs.
<architecture>.img 3
boot
```

- 1 Specify the locations of the RHCOS files that you uploaded to your HTTP server. The **kernel** parameter value is the location of the **kernel** file, the **initrd=main** argument is needed for booting on UEFI systems, the **coreos.live.rootfs\_url** parameter value is the location of the **rootfs** file, and the **coreos.inst.ignition\_url** parameter value is the location of the bootstrap Ignition config file.
- 2 If you use multiple NICs, specify a single interface in the **ip** option. For example, to use DHCP on a NIC that is named **eno1**, set **ip=eno1:dhcp**.
- 3 Specify the location of the **initramfs** file that you uploaded to your HTTP server.



### NOTE

This configuration does not enable serial console access on machines with a graphical console. To configure a different console, add one or more **console=** arguments to the **kernel** line. For example, add **console=tty0 console=ttyS0** to set the first PC serial port as the primary console and the graphical console as a secondary console. For more information, see [How does one set up a serial terminal and/or console in Red Hat Enterprise Linux?](#)

7. Monitor the progress of the RHCOS installation on the console of the machine.

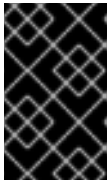


### IMPORTANT

Be sure that the installation is successful on each node before commencing with the OpenShift Container Platform installation. Observing the installation process can also help to determine the cause of RHCOS installation issues that might arise.



8. After RHCOS installs, the system reboots. During reboot, the system applies the Ignition config file that you specified.
9. Continue to create the machines for your cluster.



### IMPORTANT

You must create the bootstrap and control plane machines at this time. If the control plane machines are not made schedulable, also create at least two compute machines before you install the cluster.

If the required network, DNS, and load balancer infrastructure are in place, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS nodes have rebooted.



### NOTE

RHCOS nodes do not include a default password for the **core** user. You can access the nodes by running **ssh core@<node>.<cluster\_name>.<base\_domain>** as a user with access to the SSH private key that is paired to the public key that you specified in your **install\_config.yaml** file. OpenShift Container Platform 4 cluster nodes running RHCOS are immutable and rely on Operators to apply cluster changes. Accessing cluster nodes by using SSH is not recommended. However, when investigating installation issues, if the OpenShift Container Platform API is not available, or the kubelet is not properly functioning on a target node, SSH access might be required for debugging or disaster recovery.

#### 8.4.11.3. Advanced RHCOS installation configuration

A key benefit for manually provisioning the Red Hat Enterprise Linux CoreOS (RHCOS) nodes for OpenShift Container Platform is to be able to do configuration that is not available through default OpenShift Container Platform installation methods. This section describes some of the configurations that you can do using techniques that include:

- Passing kernel arguments to the live installer
- Running **coreos-installer** manually from the live system
- Embedding Ignition configs in an ISO

The advanced configuration topics for manual Red Hat Enterprise Linux CoreOS (RHCOS) installations detailed in this section relate to disk partitioning, networking, and using Ignition configs in different ways.

##### 8.4.11.3.1. Using advanced networking options for PXE and ISO installations

Networking for OpenShift Container Platform nodes uses DHCP by default to gather all necessary configuration settings. To set up static IP addresses or configure special settings, such as bonding, you can do one of the following:

- Pass special kernel parameters when you boot the live installer.
- Use a machine config to copy networking files to the installed system.

- Configure networking from a live installer shell prompt, then copy those settings to the installed system so that they take effect when the installed system first boots.

To configure a PXE or iPXE installation, use one of the following options:

- See the "Advanced RHCOS installation reference" tables.
- Use a machine config to copy networking files to the installed system.

To configure an ISO installation, use the following procedure.

### Procedure

1. Boot the ISO installer.
2. From the live system shell prompt, configure networking for the live system using available RHEL tools, such as **nmcli** or **nmtui**.
3. Run the **coreos-installer** command to install the system, adding the **--copy-network** option to copy networking configuration. For example:

```
$ sudo coreos-installer install --copy-network \  
--ignition-url=http://host/worker.ign /dev/sda
```



#### IMPORTANT

The **--copy-network** option only copies networking configuration found under **/etc/NetworkManager/system-connections**. In particular, it does not copy the system hostname.

4. Reboot into the installed system.

### Additional resources

- See [Getting started with nmcli](#) and [Getting started with nmtui](#) in the RHEL 8 documentation for more information about the **nmcli** and **nmtui** tools.

#### 8.4.11.3.2. Disk partitioning

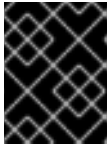
The disk partitions are created on OpenShift Container Platform cluster nodes during the Red Hat Enterprise Linux CoreOS (RHCOS) installation. Each RHCOS node of a particular architecture uses the same partition layout, unless the default partitioning configuration is overridden. During the RHCOS installation, the size of the root file system is increased to use the remaining available space on the target device.

There are two cases where you might want to override the default partitioning when installing RHCOS on an OpenShift Container Platform cluster node:

- Creating separate partitions: For greenfield installations on an empty disk, you might want to add separate storage to a partition. This is officially supported for mounting **/var** or a subdirectory of **/var**, such as **/var/lib/etcd**, on a separate partition, but not both.

**IMPORTANT**

For disk sizes larger than 100GB, and especially disk sizes larger than 1TB, create a separate **/var** partition. See "Creating a separate **/var** partition" and this [Red Hat Knowledgebase article](#) for more information.

**IMPORTANT**

Kubernetes supports only two file system partitions. If you add more than one partition to the original configuration, Kubernetes cannot monitor all of them.

- Retaining existing partitions: For a brownfield installation where you are reinstalling OpenShift Container Platform on an existing node and want to retain data partitions installed from your previous operating system, there are both boot arguments and options to **coreos-installer** that allow you to retain existing data partitions.

**WARNING**

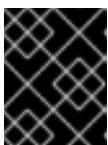
The use of custom partitions could result in those partitions not being monitored by OpenShift Container Platform or alerted on. If you are overriding the default partitioning, see [Understanding OpenShift File System Monitoring \(eviction conditions\)](#) for more information about how OpenShift Container Platform monitors your host file systems.

**8.4.11.3.2.1. Creating a separate /var partition**

In general, you should use the default disk partitioning that is created during the RHCOS installation. However, there are cases where you might want to create a separate partition for a directory that you expect to grow.

OpenShift Container Platform supports the addition of a single partition to attach storage to either the **/var** directory or a subdirectory of **/var**. For example:

- **/var/lib/containers**: Holds container-related content that can grow as more images and containers are added to a system.
- **/var/lib/etcd**: Holds data that you might want to keep separate for purposes such as performance optimization of etcd storage.
- **/var**: Holds data that you might want to keep separate for purposes such as auditing.

**IMPORTANT**

For disk sizes larger than 100GB, and especially larger than 1TB, create a separate **/var** partition.

Storing the contents of a **/var** directory separately makes it easier to grow storage for those areas as needed and reinstall OpenShift Container Platform at a later date and keep that data intact. With this method, you will not have to pull all your containers again, nor will you have to copy massive log files when you update systems.

The use of a separate partition for the **/var** directory or a subdirectory of **/var** also prevents data growth in the partitioned directory from filling up the root file system.

The following procedure sets up a separate **/var** partition by adding a machine config manifest that is wrapped into the Ignition config file for a node type during the preparation phase of an installation.

## Procedure

1. On your installation host, change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ openshift-install create manifests --dir <installation_directory>
```

2. Create a Butane config that configures the additional partition. For example, name the file **\$HOME/clusterconfig/98-var-partition.bu**, change the disk device name to the name of the storage device on the **worker** systems, and set the storage size as appropriate. This example places the **/var** directory on a separate partition:

```
variant: openshift
version: 4.9.0
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 98-var-partition
storage:
  disks:
    - device: /dev/<device_name> 1
      partitions:
        - label: var
          start_mib: <partition_start_offset> 2
          size_mib: <partition_size> 3
      filesystems:
        - device: /dev/disk/by-partlabel/var
          path: /var
          format: xfs
          mount_options: [defaults, prjquota] 4
          with_mount_unit: true
```

- 1 The storage device name of the disk that you want to partition.
- 2 When adding a data partition to the boot disk, a minimum offset value of 25000 mebibytes is recommended. The root file system is automatically resized to fill all available space up to the specified offset. If no offset value is specified, or if the specified value is smaller than the recommended minimum, the resulting root file system will be too small, and future reinstalls of RHCOS might overwrite the beginning of the data partition.
- 3 The size of the data partition in mebibytes.
- 4 The **prjquota** mount option must be enabled for filesystems used for container storage.

**NOTE**

When creating a separate **/var** partition, you cannot use different instance types for compute nodes, if the different instance types do not have the same device name.

3. Create a manifest from the Butane config and save it to the **clusterconfig/openshift** directory. For example, run the following command:

```
$ butane $HOME/clusterconfig/98-var-partition.bu -o $HOME/clusterconfig/openshift/98-var-partition.yaml
```

4. Create the Ignition config files:

```
$ openshift-install create ignition-configs --dir <installation_directory> 1
```

- 1** For **<installation\_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

The files in the **<installation\_directory>/manifest** and **<installation\_directory>/openshift** directories are wrapped into the Ignition config files, including the file that contains the **98-var-partition** custom **MachineConfig** object.

**Next steps**

- You can apply the custom disk partitioning by referencing the Ignition config files during the RHCOS installations.

**8.4.11.3.2.2. Retaining existing partitions**

For an ISO installation, you can add options to the **coreos-installer** command that cause the installer to maintain one or more existing partitions. For a PXE installation, you can add **coreos.inst.\*** options to the **APPEND** parameter to preserve partitions.

Saved partitions might be data partitions from an existing OpenShift Container Platform system. You can identify the disk partitions you want to keep either by partition label or by number.

**NOTE**

If you save existing partitions, and those partitions do not leave enough space for RHCOS, the installation will fail without damaging the saved partitions.

## Retaining existing partitions during an ISO installation

This example preserves any partition in which the partition label begins with **data** (**data\***):

```
# coreos-installer install --ignition-url http://10.0.2.2:8080/user.ign \
  --save-partlabel 'data*' /dev/sda
```

The following example illustrates running the **coreos-installer** in a way that preserves the sixth (6) partition on the disk:

```
# coreos-installer install --ignition-url http://10.0.2.2:8080/user.ign \
  --save-partindex 6 /dev/sda
```

This example preserves partitions 5 and higher:

```
# coreos-installer install --ignition-url http://10.0.2.2:8080/user.ign
  --save-partindex 5- /dev/sda
```

In the previous examples where partition saving is used, **coreos-installer** recreates the partition immediately.

## Retaining existing partitions during a PXE installation

This **APPEND** option preserves any partition in which the partition label begins with 'data' ('data\*'):

```
coreos.inst.save_partlabel=data*
```

This **APPEND** option preserves partitions 5 and higher:

```
coreos.inst.save_partindex=5-
```

This **APPEND** option preserves partition 6:

```
coreos.inst.save_partindex=6
```

### 8.4.11.3.3. Identifying Ignition configs

When doing an RHCOS manual installation, there are two types of Ignition configs that you can provide, with different reasons for providing each one:

- **Permanent install Ignition config:** Every manual RHCOS installation needs to pass one of the Ignition config files generated by **openshift-installer**, such as **bootstrap.ign**, **master.ign** and **worker.ign**, to carry out the installation.



#### IMPORTANT

It is not recommended to modify these Ignition config files directly. You can update the manifest files that are wrapped into the Ignition config files, as outlined in examples in the preceding sections.

For PXE installations, you pass the Ignition configs on the **APPEND** line using the **coreos.inst.ignition\_url=** option. For ISO installations, after the ISO boots to the shell prompt, you identify the Ignition config on the **coreos-installer** command line with the **--ignition-url=**

option. In both cases, only HTTP and HTTPS protocols are supported.

- **Live install Ignition config:** This type must be created manually and should be avoided if possible, as it is not supported by Red Hat. With this method, the Ignition config passes to the live install medium, runs immediately upon booting, and performs setup tasks before and/or after the RHCOS system installs to disk. This method should only be used for performing tasks that must be done once and not applied again later, such as with advanced partitioning that cannot be done using a machine config.

For PXE or ISO boots, you can create the Ignition config and **APPEND** the `ignition.config.url=` option to identify the location of the Ignition config. You also need to append `ignition.firstboot` `ignition.platform.id=metal` or the `ignition.config.url` option will be ignored.

#### 8.4.11.3.3.1. Embedding a live install Ignition config in the RHCOS ISO

You can embed a live install Ignition config directly in an RHCOS ISO image. When the ISO image is booted, the embedded config will be applied automatically.

##### Procedure

1. Download the **coreos-installer** binary from the following image mirror page:  
<https://mirror.openshift.com/pub/openshift-v4/clients/coreos-installer/latest/>.
2. Retrieve the RHCOS ISO image and the Ignition config file, and copy them into an accessible directory, such as `/mnt`:

```
# cp rhcos-<version>-live.x86_64.iso bootstrap.ign /mnt/
# chmod 644 /mnt/rhcos-<version>-live.x86_64.iso
```

3. Run the following command to embed the Ignition config into the ISO:

```
# ./coreos-installer iso ignition embed -i /mnt/bootstrap.ign \
  /mnt/rhcos-<version>-live.x86_64.iso
```

You can now use that ISO to install RHCOS using the specified live install Ignition config.



#### IMPORTANT

Using **coreos-installer iso ignition embed** to embed a file generated by **openshift-installer**, such as **bootstrap.ign**, **master.ign** and **worker.ign**, is unsupported and not recommended.

4. To show the contents of the embedded Ignition config and direct it into a file, run:

```
# ./coreos-installer iso ignition show /mnt/rhcos-<version>-live.x86_64.iso > mybootstrap.ign

# diff -s bootstrap.ign mybootstrap.ign
```

##### Example output

```
Files bootstrap.ign and mybootstrap.ign are identical
```

5. To remove the Ignition config and return the ISO to its pristine state so you can reuse it, run:

```
# ./coreos-installer iso ignition remove /mnt/rhcos-<version>-live.x86_64.iso
```

You can now embed another Ignition config into the ISO or use the ISO in its pristine state.

#### 8.4.11.3.4. Advanced RHCOS installation reference

This section illustrates the networking configuration and other advanced options that allow you to modify the Red Hat Enterprise Linux CoreOS (RHCOS) manual installation process. The following tables describe the kernel arguments and command-line options you can use with the RHCOS live installer and the **coreos-installer** command.

##### 8.4.11.3.4.1. Networking and bonding options for ISO installations

If you install RHCOS from an ISO image, you can add kernel arguments manually when you boot the image to configure networking for a node. If no networking arguments are specified, DHCP is activated in the initramfs when RHCOS detects that networking is required to fetch the Ignition config file.



#### IMPORTANT

When adding networking arguments manually, you must also add the **rd.neednet=1** kernel argument to bring the network up in the initramfs.

The following table provides examples for configuring networking and bonding on your RHCOS nodes for ISO installations. The examples describe how to use the **ip=**, **nameserver=**, and **bond=** kernel arguments.



#### NOTE

Ordering is important when adding the kernel arguments: **ip=**, **nameserver=**, and then **bond=**.

The networking options are passed to the **dracut** tool during system boot. For more information about the networking options supported by **dracut**, see the **dracut.cmdline** manual page.

The following information provides examples for configuring networking on your RHCOS nodes for ISO installations. The examples describe how to use the **ip=** and **nameserver=** kernel arguments.



#### NOTE

Ordering is important when adding the kernel arguments: **ip=** and **nameserver=**.

The networking options are passed to the **dracut** tool during system boot. For more information about the networking options supported by **dracut**, see the **dracut.cmdline** manual page.

The following examples are the networking options for ISO installation.

Configuring DHCP or static IP addresses

To configure an IP address, either use DHCP (**ip=dhcp**) or set an individual static IP address (**ip=<host\_ip>**). If setting a static IP, you must then identify the DNS server IP address (**nameserver=<dns\_ip>**) on each node. The following example sets:

- The node's IP address to **10.10.10.2**



- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The hostname to **core0.example.com**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
nameserver=4.4.4.41
```



## NOTE

When you use DHCP to configure IP addressing for the RHCOS machines, the machines also obtain the DNS server information through DHCP. For DHCP-based deployments, you can define the DNS server address that is used by the RHCOS nodes through your DHCP server configuration.

### Configuring an IP address without a static hostname

You can configure an IP address without assigning a static hostname. If a static hostname is not set by the user, it will be picked up and automatically set by a reverse DNS lookup. To configure an IP address without a static hostname refer to the following example:

- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0::enp1s0:none
nameserver=4.4.4.41
```

### Specifying multiple network interfaces

You can specify multiple network interfaces by setting multiple **ip=** entries.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=10.10.10.3::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

### Configuring default gateway and route

Optional: You can configure routes to additional networks by setting an **rd.route=** value.



## NOTE

When you configure one or multiple networks, one default gateway is required. If the additional network gateway is different from the primary network gateway, the default gateway must be the primary network gateway.

- Run the following command to configure the default gateway:

```
ip=::10.10.10.254:::
```

- Enter the following command to configure the route for the additional network:

```
rd.route=20.20.20.0/24:20.20.20.254:enp2s0
```

#### Disabling DHCP on a single interface

You can disable DHCP on a single interface, such as when there are two or more network interfaces and only one interface is being used. In the example, the **enp1s0** interface has a static networking configuration and DHCP is disabled for **enp2s0**, which is not used:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=::::core0.example.com:enp2s0:none
```

#### Combining DHCP and static IP configurations

You can combine DHCP and static IP configurations on systems with multiple network interfaces, for example:

```
ip=enp1s0:dhcp
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

#### Configuring VLANs on individual interfaces

Optional: You can configure VLANs on individual interfaces by using the **vlan=** parameter.

- To configure a VLAN on a network interface and use a static IP address, run the following command:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0.100:none
vlan=enp2s0.100:enp2s0
```

- To configure a VLAN on a network interface and to use DHCP, run the following command:

```
ip=enp2s0.100:dhcp
vlan=enp2s0.100:enp2s0
```

#### Providing multiple DNS servers

You can provide multiple DNS servers by adding a **nameserver=** entry for each server, for example:

```
nameserver=1.1.1.1
nameserver=8.8.8.8
```

#### Bonding multiple network interfaces to a single interface

Optional: You can bond multiple network interfaces to a single interface by using the **bond=** option. Refer to the following examples:

- The syntax for configuring a bonded interface is: **bond=name[:network\_interfaces][:options]** *name* is the bonding device name (**bond0**), *network\_interfaces* represents a comma-separated list of physical (ethernet) interfaces (**em1,em2**), and *options* is a comma-separated list of bonding options. Enter **modinfo bonding** to see available options.

- When you create a bonded interface using **bond=**, you must specify how the IP address is assigned and other information for the bonded interface.
- To configure the bonded interface to use DHCP, set the bond's IP address to **dhcp**. For example:

```
bond=bond0:em1,em2:mode=active-backup
ip=bond0:dhcp
```

- To configure the bonded interface to use a static IP address, enter the specific IP address you want and related information. For example:

```
bond=bond0:em1,em2:mode=active-backup
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0:none
```

Bonding multiple network interfaces to a single interface

Optional: You can configure VLANs on bonded interfaces by using the **vlan=** parameter and to use DHCP, for example:

```
ip=bond0.100:dhcp
bond=bond0:em1,em2:mode=active-backup
vlan=bond0.100:bond0
```

Use the following example to configure the bonded interface with a VLAN and to use a static IP address:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0.100:none
bond=bond0:em1,em2:mode=active-backup
vlan=bond0.100:bond0
```

Using network teaming

Optional: You can use a network teaming as an alternative to bonding by using the **team=** parameter:

- The syntax for configuring a team interface is: **team=name[:network\_interfaces]**  
*name* is the team device name (**team0**) and *network\_interfaces* represents a comma-separated list of physical (ethernet) interfaces (**em1, em2**).

Teaming is planned to be deprecated when RHCOS switches to an upcoming version of RHEL. For more information, see this [Red Hat Knowledgebase Article](#) .

Use the following example to configure a network team:

```
team=team0:em1,em2
ip=team0:dhcp
```

#### 8.4.11.3.4.2. coreos-installer options for ISO installations

You can install RHCOS by running **coreos-installer install <options> <device>** at the command prompt, after booting into the RHCOS live environment from an ISO image.

The following table shows the subcommands, options, and arguments you can pass to the **coreos-installer** command.

**Table 8.44. coreos-installer subcommands, command-line options, and arguments**

coreos-installer install subcommand	
<i>Subcommand</i>	<i>Description</i>
<b>\$ coreos-installer install &lt;options&gt; &lt;device&gt;</b>	Embed an Ignition config in an ISO image.
coreos-installer install subcommand options	
<i>Option</i>	<i>Description</i>
<b>-u, --image-url &lt;url&gt;</b>	Specify the image URL manually.
<b>-f, --image-file &lt;path&gt;</b>	Specify a local image file manually. Used for debugging.
<b>-i, --ignition-file &lt;path&gt;</b>	Embed an Ignition config from a file.
<b>-l, --ignition-url &lt;URL&gt;</b>	Embed an Ignition config from a URL.
<b>--ignition-hash &lt;digest&gt;</b>	Digest <b>type-value</b> of the Ignition config.
<b>-p, --platform &lt;name&gt;</b>	Override the Ignition platform ID for the installed system.
<b>--append-karg &lt;arg&gt;...</b>	Append a default kernel argument to the installed system.
<b>--delete-karg &lt;arg&gt;...</b>	Delete a default kernel argument from the installed system.
<b>-n, --copy-network</b>	Copy the network configuration from the install environment.  <div data-bbox="815 1489 922 1744" data-label="Image"></div> <p><b>IMPORTANT</b></p> <p>The <b>--copy-network</b> option only copies networking configuration found under <b>/etc/NetworkManager/system-connections</b>. In particular, it does not copy the system hostname.</p>
<b>--network-dir &lt;path&gt;</b>	For use with <b>-n</b> . Default is <b>/etc/NetworkManager/system-connections/</b> .
<b>--save-partlabel &lt;lx&gt;..</b>	Save partitions with this label glob.
<b>--save-partindex &lt;id&gt;...</b>	Save partitions with this number or range.

<b>--insecure</b>	Skip signature verification.
<b>--insecure-ignition</b>	Allow Ignition URL without HTTPS or hash.
<b>--architecture &lt;name&gt;</b>	Target CPU architecture. Default is <b>x86_64</b> .
<b>--preserve-on-error</b>	Do not clear partition table on error.
<b>-h, --help</b>	Print help information.
coreos-install install subcommand argument	
<i>Argument</i>	<i>Description</i>
<b>&lt;device&gt;</b>	The destination device.
coreos-installer ISO Ignition subcommands	
<i>Subcommand</i>	<i>Description</i>
<b>\$ coreos-installer iso ignition embed &lt;options&gt; --ignition-file &lt;file_path&gt; &lt;ISO_image&gt;</b>	Embed an Ignition config in an ISO image.
<b>coreos-installer iso ignition show &lt;options&gt; &lt;ISO_image&gt;</b>	Show the embedded Ignition config from an ISO image.
<b>coreos-installer iso ignition remove &lt;options&gt; &lt;ISO_image&gt;</b>	Remove the embedded Ignition config from an ISO image.
coreos-installer ISO Ignition subcommand options	
<i>Option</i>	<i>Description</i>
<b>-f, --force</b>	Overwrite an existing Ignition config.
<b>-i, --ignition-file &lt;path&gt;</b>	The Ignition config to be used. Default is <b>stdin</b> .
<b>-o, --output &lt;path&gt;</b>	Write the ISO to a new output file.
<b>-h, --help</b>	Print help information.
coreos-installer PXE Ignition subcommands	
<i>Subcommand</i>	<i>Description</i>
Note that not all of these options are accepted by all subcommands.	

<b>coreos-installer pxe ignition wrap &lt;options&gt;</b>	Wrap an Ignition config in an image.
<b>coreos-installer pxe ignition unwrap &lt;options&gt; &lt;image_name&gt;</b>	Show the wrapped Ignition config in an image.
<b>coreos-installer PXE Ignition subcommand options</b>	
<i>Option</i>	<i>Description</i>
Note that not all of these options are accepted by all subcommands.	
<b>-i, --ignition-file &lt;path&gt;</b>	The Ignition config to be used. Default is <b>stdin</b> .
<b>-o, --output &lt;path&gt;</b>	Write the ISO to a new output file.
<b>-h, --help</b>	Print help information.

#### 8.4.11.3.4.3. coreos.inst boot options for ISO or PXE installations

You can automatically invoke **coreos-installer** options at boot time by passing **coreos.inst** boot arguments to the RHCOS live installer. These are provided in addition to the standard boot arguments.

- For ISO installations, the **coreos.inst** options can be added by interrupting the automatic boot at the bootloader menu. You can interrupt the automatic boot by pressing **TAB** while the **RHEL CoreOS (Live)** menu option is highlighted.
- For PXE or iPXE installations, the **coreos.inst** options must be added to the **APPEND** line before the RHCOS live installer is booted.

The following table shows the RHCOS live installer **coreos.inst** boot options for ISO and PXE installations.

**Table 8.45. coreos.inst boot options**

Argument	Description
<b>coreos.inst.install_dev</b>	Required. The block device on the system to install to. It is recommended to use the full path, such as <b>/dev/sda</b> , although <b>sda</b> is allowed.
<b>coreos.inst.ignition_url</b>	Optional: The URL of the Ignition config to embed into the installed system. If no URL is specified, no Ignition config is embedded. Only HTTP and HTTPS protocols are supported.
<b>coreos.inst.save_partlabel</b>	Optional: Comma-separated labels of partitions to preserve during the install. Glob-style wildcards are permitted. The specified partitions do not need to exist.

Argument	Description
<b>coreos.inst.save_partindex</b>	Optional: Comma-separated indexes of partitions to preserve during the install. Ranges <b>m-n</b> are permitted, and either <b>m</b> or <b>n</b> can be omitted. The specified partitions do not need to exist.
<b>coreos.inst.insecure</b>	Optional: Permits the OS image that is specified by <b>coreos.inst.image_url</b> to be unsigned.
<b>coreos.inst.image_url</b>	<p>Optional: Download and install the specified RHCOS image.</p> <ul style="list-style-type: none"> <li>● This argument should not be used in production environments and is intended for debugging purposes only.</li> <li>● While this argument can be used to install a version of RHCOS that does not match the live media, it is recommended that you instead use the media that matches the version you want to install.</li> <li>● If you are using <b>coreos.inst.image_url</b>, you must also use <b>coreos.inst.insecure</b>. This is because the bare-metal media are not GPG-signed for OpenShift Container Platform.</li> <li>● Only HTTP and HTTPS protocols are supported.</li> </ul>
<b>coreos.inst.skip_reboot</b>	Optional: The system will not reboot after installing. After the install finishes, you will receive a prompt that allows you to inspect what is happening during installation. This argument should not be used in production environments and is intended for debugging purposes only.
<b>coreos.inst.platform_id</b>	Optional: The Ignition platform ID of the platform the RHCOS image is being installed on. Default is <b>metal</b> . This option determines whether or not to request an Ignition config from the cloud provider, such as VMware. For example: <b>coreos.inst.platform_id=vmware</b> .
<b>ignition.config.url</b>	Optional: The URL of the Ignition config for the live boot. For example, this can be used to customize how <b>coreos-installer</b> is invoked, or to run code before or after the installation. This is different from <b>coreos.inst.ignition_url</b> , which is the Ignition config for the installed system.

### 8.4.11.4. Enabling multipathing with kernel arguments on RHCOS

RHCOS supports multipathing on the primary disk, allowing stronger resilience to hardware failure to achieve higher host availability.

You can enable multipathing at installation time for nodes that were provisioned in OpenShift Container Platform 4.8 or later. While post-installation support is available by activating multipathing via the machine config, enabling multipathing during installation is recommended.

In setups where any I/O to non-optimized paths results in I/O system errors, you must enable multipathing at installation time.



#### IMPORTANT

On IBM Z and LinuxONE, you can enable multipathing only if you configured your cluster for it during installation. For more information, see "Installing RHCOS and starting the OpenShift Container Platform bootstrap process" in *Installing a cluster with z/VM on IBM Z and LinuxONE*.

The following procedure enables multipath at installation time and appends kernel arguments to the **coreos-installer install** command so that the installed system itself will use multipath beginning from the first boot.

#### Prerequisites

- You have a running OpenShift Container Platform cluster that uses version 4.8 or later.



#### NOTE

OpenShift Container Platform does not support enabling multipathing as a day-2 activity on nodes that have been upgraded from 4.6 or earlier.

- You are logged in to the cluster as a user with administrative privileges.

#### Procedure

- To enable multipath and start the **multipathd** daemon, run the following command:

```
$ mpathconf --enable && systemctl start multipathd.service
```

- Optional: If booting the PXE or ISO, you can instead enable multipath by adding **rd.multipath=default** from the kernel command line.
- Append the kernel arguments by invoking the **coreos-installer** program:
    - If there is only one multipath device connected to the machine, it should be available at path **/dev/mapper/mpatha**. For example:

```
$ coreos-installer install /dev/mapper/mpatha \ 1
--append-karg rd.multipath=default \
--append-karg root=/dev/disk/by-label/dm-mpath-root \
--append-karg rw
```

- 1 Indicates the path of the single multipathed device.



- If there are multiple multipath devices connected to the machine, or to be more explicit, instead of using `/dev/mapper/mpatha`, it is recommended to use the World Wide Name (WWN) symlink available in `/dev/disk/by-id`. For example:

```
$ coreos-installer install /dev/disk/by-id/wwn-<wwn_ID> \ 1
--append-karg rd.multipath=default \
--append-karg root=/dev/disk/by-label/dm-mpath-root \
--append-karg rw
```

- 1 Indicates the WWN ID of the target multipathed device. For example, **0xx194e957fcedb4841**.

This symlink can also be used as the `coreos.inst.install_dev` kernel argument when using special `coreos.inst.*` arguments to direct the live installer. For more information, see "Installing RHCOS and starting the OpenShift Container Platform bootstrap process".

3. Check that the kernel arguments worked by going to one of the worker nodes and listing the kernel command line arguments (in `/proc/cmdline` on the host):

```
$ oc debug node/ip-10-0-141-105.ec2.internal
```

### Example output

```
Starting pod/ip-10-0-141-105ec2internal-debug ...
To use host binaries, run `chroot /host`

sh-4.2# cat /host/proc/cmdline
...
rd.multipath=default root=/dev/disk/by-label/dm-mpath-root
...

sh-4.2# exit
```

You should see the added kernel arguments.

#### 8.4.11.5. Updating the bootloader using `bootupd`

To update the bootloader by using `bootupd`, you must either install `bootupd` on RHCOS machines manually or provide a machine config with the enabled `systemd` unit. Unlike `grubby` or other bootloader tools, `bootupd` does not manage kernel space configuration such as passing kernel arguments.

After you have installed `bootupd`, you can manage it remotely from the OpenShift Container Platform cluster.



#### NOTE

It is recommended that you use `bootupd` only on bare metal or virtualized hypervisor installations, such as for protection against the BootHole vulnerability.

#### Manual install method

You can manually install `bootupd` by using the `bootctl` command-line tool.

1. Inspect the system status:

```
# bootupctl status
```

#### Example output

```
Component EFI
  Installed: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
  Update: At latest version
```

2. RHCOS images created without **bootupd** installed on them require an explicit adoption phase. If the system status is **Adoptable**, perform the adoption:

```
# bootupctl adopt-and-update
```

#### Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

3. If an update is available, apply the update so that the changes take effect on the next reboot:

```
# bootupctl update
```

#### Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

## Machine config method

Another way to enable **bootupd** is by providing a machine config.

- Provide a machine config file with the enabled **systemd** unit, as shown in the following example:

#### Example output

```
variant: rhcos
version: 1.1.0
systemd:
  units:
    - name: custom-bootupd-auto.service
      enabled: true
      contents: |
        [Unit]
        Description=Bootupd automatic update

        [Service]
        ExecStart=/usr/bin/bootupctl update
        RemainAfterExit=yes

        [Install]
        WantedBy=multi-user.target
```

## 8.4.12. Waiting for the bootstrap process to complete

The OpenShift Container Platform bootstrap process begins after the cluster nodes first boot into the persistent RHCOS environment that has been installed to disk. The configuration information provided through the Ignition config files is used to initialize the bootstrap process and install OpenShift Container Platform on the machines. You must wait for the bootstrap process to complete.

### Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have obtained the installation program and generated the Ignition config files for your cluster.
- You installed RHCOS on your cluster machines and provided the Ignition config files that the OpenShift Container Platform installation program generated.

### Procedure

1. Monitor the bootstrap process:

```
$ ./openshift-install --dir <installation_directory> wait-for bootstrap-complete \ 1
--log-level=info 2
```

- 1 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

- 2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

### Example output

```
INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...
INFO API v1.22.1 up
INFO Waiting up to 30m0s for bootstrapping to complete...
INFO It is now safe to remove the bootstrap resources
```

The command succeeds when the Kubernetes API server signals that it has been bootstrapped on the control plane machines.

2. After bootstrap process is complete, remove the bootstrap machine from the load balancer.



### IMPORTANT

You must remove the bootstrap machine from the load balancer at this point. You can also remove or reformat the bootstrap machine itself.

### Additional resources

- See [Monitoring installation progress](#) for more information about monitoring the installation logs and retrieving diagnostic data if installation issues arise.

### 8.4.13. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

#### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

#### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

#### Example output

```
system:admin
```

### 8.4.14. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

#### Prerequisites

- You added machines to your cluster.

#### Procedure

1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

#### Example output

```
NAME      STATUS   ROLES    AGE   VERSION
master-0  Ready   master   63m   v1.22.1
master-1  Ready   master   63m   v1.22.1
master-2  Ready   master   64m   v1.22.1
```

The output lists all of the machines that you created.



## NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

- Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

### Example output

```
NAME          AGE    REQUESTOR                                     CONDITION
csr-8b2br    15m   system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper Pending
csr-8vnps    15m   system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper Pending
...
```

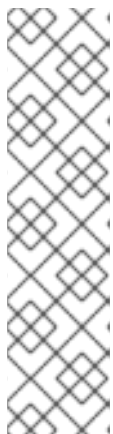
In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

- If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:



## NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.



## NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

**1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{\n"}\n{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```



#### NOTE

Some Operators might not become available until some CSRs are approved.

- Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

#### Example output

```
NAME      AGE   REQUESTOR                                     CONDITION
csr-bfd72 5m26s system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv 5m26s system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

- If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

**1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{\n"}\n{{end}}' | xargs oc adm certificate approve
```

- After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

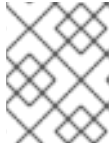
#### Example output

```
NAME      STATUS   ROLES    AGE   VERSION
master-0 Ready    master   73m   v1.22.1
```

```

master-1 Ready   master 73m v1.22.1
master-2 Ready   master 74m v1.22.1
worker-0 Ready   worker 11m v1.22.1
worker-1 Ready   worker 11m v1.22.1

```

**NOTE**

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

**Additional information**

- For more information on CSRs, see [Certificate Signing Requests](#).

**8.4.15. Initial Operator configuration**

After the control plane initializes, you must immediately configure some Operators so that they all become available.

**Prerequisites**

- Your control plane has initialized.

**Procedure**

1. Watch the cluster components come online:

```
$ watch -n5 oc get clusteroperators
```

**Example output**

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
authentication	4.9.0	True	False	False	19m
baremetal	4.9.0	True	False	False	37m
cloud-credential	4.9.0	True	False	False	40m
cluster-autoscaler	4.9.0	True	False	False	37m
config-operator	4.9.0	True	False	False	38m
console	4.9.0	True	False	False	26m
csi-snapshot-controller	4.9.0	True	False	False	37m
dns	4.9.0	True	False	False	37m
etcd	4.9.0	True	False	False	36m
image-registry	4.9.0	True	False	False	31m
ingress	4.9.0	True	False	False	30m
insights	4.9.0	True	False	False	31m
kube-apiserver	4.9.0	True	False	False	26m
kube-controller-manager	4.9.0	True	False	False	36m
kube-scheduler	4.9.0	True	False	False	36m
kube-storage-version-migrator	4.9.0	True	False	False	37m
machine-api	4.9.0	True	False	False	29m
machine-approver	4.9.0	True	False	False	37m
machine-config	4.9.0	True	False	False	36m
marketplace	4.9.0	True	False	False	37m
monitoring	4.9.0	True	False	False	29m

network	4.9.0	True	False	False	38m
node-tuning	4.9.0	True	False	False	37m
openshift-apiserver	4.9.0	True	False	False	32m
openshift-controller-manager	4.9.0	True	False	False	30m
openshift-samples	4.9.0	True	False	False	32m
operator-lifecycle-manager	4.9.0	True	False	False	37m
operator-lifecycle-manager-catalog	4.9.0	True	False	False	37m
operator-lifecycle-manager-packageserver	4.9.0	True	False	False	32m
service-ca	4.9.0	True	False	False	38m
storage	4.9.0	True	False	False	37m

2. Configure the Operators that are not available.

### Additional resources

- See [Gathering logs from a failed installation](#) for details about gathering data in the event of a failed OpenShift Container Platform installation.
- See [Troubleshooting Operator issues](#) for steps to check Operator pod health across the cluster and gather Operator logs for diagnosis.

#### 8.4.15.1. Disabling the default OperatorHub sources

Operator catalogs that source content provided by Red Hat and community projects are configured for OperatorHub by default during an OpenShift Container Platform installation. In a restricted network environment, you must disable the default catalogs as a cluster administrator.

#### Procedure

- Disable the sources for the default catalogs by adding **disableAllDefaultSources: true** to the **OperatorHub** object:

```
$ oc patch OperatorHub cluster --type json \
  -p '[{"op": "add", "path": "/spec/disableAllDefaultSources", "value": true}]'
```

#### TIP

Alternatively, you can use the web console to manage catalog sources. From the **Administration** → **Cluster Settings** → **Configuration** → **OperatorHub** page, click the **Sources** tab, where you can create, delete, disable, and enable individual sources.

#### 8.4.15.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.



### 8.4.15.2.1. Changing the image registry's management state

To start the image registry, you must change the Image Registry Operator configuration's **managementState** from **Removed** to **Managed**.

#### Procedure

- Change **managementState** Image Registry Operator configuration from **Removed** to **Managed**. For example:

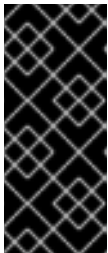
```
$ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec": {"managementState": "Managed"}}'
```

### 8.4.15.2.2. Configuring registry storage for bare metal and other manual installations

As a cluster administrator, following installation you must configure your registry to use storage.

#### Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.
- You have a cluster that uses manually-provisioned Red Hat Enterprise Linux CoreOS (RHCOS) nodes, such as bare metal.
- You have provisioned persistent storage for your cluster, such as Red Hat OpenShift Container Storage.



#### IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have 100Gi capacity.

#### Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.



#### NOTE

When using shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

#### Example output

No resources found in openshift-image-registry namespace



#### NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

#### Example output

```
storage:
  pvc:
    claim:
```

Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** PVC.

4. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

#### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
image-registry	4.9	True	False	False	6h50m

5. Ensure that your registry is set to managed to enable building and pushing of images.

- Run:

```
$ oc edit configs.imageregistry/cluster
```

Then, change the line

```
managementState: Removed
```

to

```
managementState: Managed
```

#### 8.4.15.2.3. Configuring storage for the image registry in non-production clusters

You must configure storage for the Image Registry Operator. For non-production clusters, you can set the image registry to an empty directory. If you do so, all images are lost if you restart the registry.

#### Procedure

- To set the image registry storage to an empty directory:

```
$ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec": {"storage":{"emptyDir":{}}}'
```



### WARNING

Configure this option for only non-production clusters.

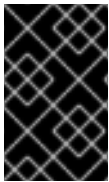
If you run this command before the Image Registry Operator initializes its components, the **oc patch** command fails with the following error:

```
Error from server (NotFound): configs.imageregistry.operator.openshift.io "cluster" not found
```

Wait a few minutes and run the command again.

#### 8.4.15.2.4. Configuring block registry storage

To allow the image registry to use block storage types during upgrades as a cluster administrator, you can use the **Recreate** rollout strategy.



### IMPORTANT

Block storage volumes are supported but not recommended for use with the image registry on production clusters. An installation where the registry is configured on block storage is not highly available because the registry cannot have more than one replica.

#### Procedure

1. To set the image registry storage as a block storage type, patch the registry so that it uses the **Recreate** rollout strategy and runs with only one ( **1** ) replica:

```
$ oc patch config.imageregistry.operator.openshift.io/cluster --type=merge -p '{"spec": {"rolloutStrategy":"Recreate","replicas":1}}'
```

2. Provision the PV for the block storage device, and create a PVC for that volume. The requested block volume uses the ReadWriteOnce (RWO) access mode.
3. Edit the registry configuration so that it references the correct PVC.

#### 8.4.16. Completing installation on user-provisioned infrastructure

After you complete the Operator configuration, you can finish installing the cluster on infrastructure that you provide.

#### Prerequisites

- Your control plane has initialized.
- You have completed the initial Operator configuration.

## Procedure

1. Confirm that all the cluster components are online with the following command:

```
$ watch -n5 oc get clusteroperators
```

### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
authentication	4.9.0	True	False	False	19m
baremetal	4.9.0	True	False	False	37m
cloud-credential	4.9.0	True	False	False	40m
cluster-autoscaler	4.9.0	True	False	False	37m
config-operator	4.9.0	True	False	False	38m
console	4.9.0	True	False	False	26m
csi-snapshot-controller	4.9.0	True	False	False	37m
dns	4.9.0	True	False	False	37m
etcd	4.9.0	True	False	False	36m
image-registry	4.9.0	True	False	False	31m
ingress	4.9.0	True	False	False	30m
insights	4.9.0	True	False	False	31m
kube-apiserver	4.9.0	True	False	False	26m
kube-controller-manager	4.9.0	True	False	False	36m
kube-scheduler	4.9.0	True	False	False	36m
kube-storage-version-migrator	4.9.0	True	False	False	37m
machine-api	4.9.0	True	False	False	29m
machine-approver	4.9.0	True	False	False	37m
machine-config	4.9.0	True	False	False	36m
marketplace	4.9.0	True	False	False	37m
monitoring	4.9.0	True	False	False	29m
network	4.9.0	True	False	False	38m
node-tuning	4.9.0	True	False	False	37m
openshift-apiserver	4.9.0	True	False	False	32m
openshift-controller-manager	4.9.0	True	False	False	30m
openshift-samples	4.9.0	True	False	False	32m
operator-lifecycle-manager	4.9.0	True	False	False	37m
operator-lifecycle-manager-catalog	4.9.0	True	False	False	37m
operator-lifecycle-manager-packageserver	4.9.0	True	False	False	32m
service-ca	4.9.0	True	False	False	38m
storage	4.9.0	True	False	False	37m

Alternatively, the following command notifies you when all of the clusters are available. It also retrieves and displays credentials:

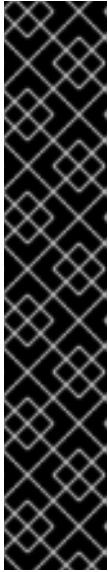
```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

### Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

The command succeeds when the Cluster Version Operator finishes deploying the OpenShift Container Platform cluster from Kubernetes API server.



## IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Confirm that the Kubernetes API server is communicating with the pods.

a. To view a list of all pods, use the following command:

```
$ oc get pods --all-namespaces
```

### Example output

```

NAMESPACE           NAME                                     READY  STATUS
RESTARTS  AGE
openshift-apiserver-operator  openshift-apiserver-operator-85cb746d55-zqhs8  1/1
Running   1    9m
openshift-apiserver          apiserver-67b9g                                1/1  Running  0
3m
openshift-apiserver          apiserver-ljcmx                                1/1  Running  0
1m
openshift-apiserver          apiserver-z25h4                                1/1  Running  0
2m
openshift-authentication-operator  authentication-operator-69d5d8bf84-vh2n8  1/1
Running   0    5m
...

```

b. View the logs for a pod that is listed in the output of the previous command by using the following command:

```
$ oc logs <pod_name> -n <namespace> 1
```

- 1** Specify the pod name and namespace, as shown in the output of the previous command.

If the pod logs display, the Kubernetes API server can communicate with the cluster machines.

3. For an installation with Fibre Channel Protocol (FCP), additional steps are required to enable multipathing. Do not enable multipathing during installation. See "Enabling multipathing with kernel arguments on RHCOS" in the *Post-installation machine configuration tasks* documentation for more information.
4. Register your cluster on the [Cluster registration](#) page.

### 8.4.17. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

#### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

### 8.4.18. Next steps

- [Validating an installation](#).
- [Customize your cluster](#).
- [Configure image streams](#) for the Cluster Samples Operator and the **must-gather** tool.
- Learn how to [use Operator Lifecycle Manager \(OLM\) on restricted networks](#).
- If the mirror registry that you used to install your cluster has a trusted CA, add it to the cluster by [configuring additional trust stores](#).
- If necessary, you can [opt out of remote health reporting](#).

## CHAPTER 9. INSTALLING ON A SINGLE NODE

### 9.1. PREPARING TO INSTALL ON A SINGLE NODE

#### 9.1.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You have read the documentation on [selecting a cluster installation method and preparing it for users](#).

#### 9.1.2. About OpenShift on a single node

You can create a single-node cluster with standard installation methods. OpenShift Container Platform on a single node is a specialized installation that requires the creation of a special ignition configuration ISO. The primary use case is for edge computing workloads, including intermittent connectivity, portable clouds, and 5G radio access networks (RAN) close to a base station. The major tradeoff with an installation on a single node is the lack of high availability.



#### IMPORTANT

The use of OpenShiftSDN with single-node OpenShift is deprecated. OVN-Kubernetes is the default networking solution for single-node OpenShift deployments.

#### 9.1.3. Requirements for installing OpenShift on a single node

Installing OpenShift Container Platform on a single node alleviates some of the requirements for high availability and large scale clusters. However, you must address the following requirements:

- **Administration host:** You must have a computer to prepare the ISO, to create the USB boot drive, and to monitor the installation.
- **Bare metal installation:** Installing OpenShift Container Platform on a single node on bare metal requires that you specify the **platform.none: {}** parameter in the **install-config.yaml** configuration file.
- **Production-grade server:** Installing OpenShift Container Platform on a single node requires a server with sufficient resources to run OpenShift Container Platform services and a production workload.

Table 9.1. Minimum resource requirements

Profile	vCPU	Memory	Storage
Minimum	8 vCPU cores	32GB of RAM	120GB

**NOTE**

One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio:

$$(\text{threads per core} \times \text{cores}) \times \text{sockets} = \text{vCPUs}$$

The server must have a Baseboard Management Controller (BMC) when booting with virtual media.

- **Networking:** The server must have access to the internet or access to a local registry if it is not connected to a routable network. The server must have a DHCP reservation or a static IP address for the Kubernetes API, Ingress route, and cluster node domain names. You must configure the DNS to resolve the IP address to each of the following fully qualified domain names (FQDN):

**Table 9.2. Required DNS records**

Usage	FQDN	Description
Kubernetes API	<b>api.&lt;cluster_name&gt;.&lt;base_domain&gt;</b>	Add a DNS A/AAAA or CNAME record. This record must be resolvable by clients external to the cluster.
Internal API	<b>api-int.&lt;cluster_name&gt;.&lt;base_domain&gt;</b>	Add a DNS A/AAAA or CNAME record when creating the ISO manually. This record must be resolvable by nodes within the cluster.
Ingress route	<b>*.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;</b>	Add a wildcard DNS A/AAAA or CNAME record that targets the node. This record must be resolvable by clients external to the cluster.

Without persistent IP addresses, communications between the **apiserver** and **etcd** might fail.

## 9.2. INSTALLING OPENSIFT ON A SINGLE NODE

### 9.2.1. Generating the discovery ISO with the Assisted Installer

Installing OpenShift Container Platform on a single node requires a discovery ISO, which the Assisted Installer (AI) can generate with the cluster name, base domain, Secure Shell (SSH) public key, and pull secret.

#### Procedure

1. On the administration node, open a browser and navigate to [Install OpenShift with the Assisted Installer](#).



2. Click **Create Cluster** to create a new cluster.
3. In the **Cluster name** field, enter a name for the cluster.
4. In the **Base domain** field, enter a base domain. For example:

```
example.com
```

All DNS records must be subdomains of this base domain and include the cluster name. You cannot change the base domain after cluster installation. For example:

```
<cluster-name>.example.com
```

5. Select **Install single node OpenShift (SNO)**.
6. Read the 4.9 release notes, which outline some of the limitations for installing OpenShift Container Platform on a single node.
7. Select the OpenShift Container Platform version.
8. Optional: Edit the pull secret.
9. Click **Next**.
10. Click **Generate Discovery ISO**.
11. Select **Full image file** to boot with a USB drive or PXE. Select **Minimal image file** to boot with virtual media.
12. Add SSH public key of the administration node to the **Public key** field.
13. Click **Generate Discovery ISO**.
14. Download the discovery ISO.
15. Make a note of the discovery ISO URL for installing with virtual media.

### 9.2.2. Generating the discovery ISO manually

Installing OpenShift Container Platform on a single node requires a discovery ISO, which you can generate with the following procedure.

#### Procedure

1. Download the OpenShift Container Platform client (**oc**) and make it available for use by entering the following command:

```
$ curl -k https://mirror.openshift.com/pub/openshift-v4/clients/ocp/latest/openshift-client-linux.tar.gz > oc.tar.gz
```

```
$ tar zxf oc.tar.gz
```

```
$ chmod +x oc
```

2. Set the OpenShift Container Platform version:

```
$ OCP_VERSION=<ocp_version> 1
```

- 1 Replace **<ocp\_version>** with the current version. For example, **latest-4.9**

3. Download the OpenShift Container Platform installer and make it available for use by entering the following commands:

```
$ curl -k https://mirror.openshift.com/pub/openshift-  
v4/clients/ocp/$OCP_VERSION/openshift-install-linux.tar.gz > openshift-install-linux.tar.gz
```

```
$ tar zxvf openshift-install-linux.tar.gz
```

```
$ chmod +x openshift-install
```

4. Retrieve the RHCOS ISO URL:

```
$ ISO_URL=$(./openshift-install coreos print-stream-json | grep location | grep x86_64 | grep  
iso | cut -d\" -f4)
```

5. Download the RHCOS ISO:

```
$ curl -L $ISO_URL > rhcos-live.x86_64.iso
```

6. Prepare the **install-config.yaml** file:

```
apiVersion: v1  
baseDomain: <domain> 1  
compute:  
- name: worker  
  replicas: 0 2  
controlPlane:  
  name: master  
  replicas: 1 3  
metadata:  
  name: <name> 4  
networking:  
  networkType: OVNKubernetes  
  clusterNetwork:  
  - cidr: <IP_address>/<prefix> 5  
    hostPrefix: <prefix> 6  
  serviceNetwork:  
  - <IP_address>/<prefix> 7  
platform:  
  none: {}  
bootstrapInPlace:  
  installationDisk: <path_to_install_drive> 8  
pullSecret: '<pull_secret>' 9  
sshKey: |  
  <ssh_key> 10
```

- 1 Add the cluster domain name.
- 2 Set the **compute** replicas to **0**. This makes the control plane node schedulable.
- 3 Set the **controlPlane** replicas to **1**. In conjunction with the previous **compute** setting, this setting ensures the cluster runs on a single node.
- 4 Set the **metadata** name to the cluster name.
- 5 Set the **clusterNetwork** CIDR.
- 6 Set the **clusterNetwork** host prefix. Pods receive their IP addresses from this pool.
- 7 Set the **serviceNetwork** CIDR. Services receive their IP addresses from this pool.
- 8 Set the path to the installation disk drive.
- 9 Copy the [pull secret from the Red Hat OpenShift Cluster Manager](#) . In step 1, click **Download pull secret** and add the contents to this configuration setting.
- 10 Add the public SSH key from the administration host so that you can log in to the cluster after installation.

7. Generate OpenShift Container Platform assets:

```
$ mkdir ocp
```

```
$ cp install-config.yaml ocp
```

```
$ ./openshift-install --dir=ocp create single-node-ignition-config
```

8. Embed the ignition data into the RHCOS ISO:

```
$ alias coreos-installer='podman run --privileged --pull always --rm \
-v /dev:/dev -v /run/udev:/run/udev -v $PWD:/data \
-w /data quay.io/coreos/coreos-installer:release'
```

```
$ cp ocp/bootstrap-in-place-for-live-iso.ign iso.ign
```

```
$ coreos-installer iso ignition embed -fi iso.ign rhcos-live.x86_64.iso
```

### 9.2.3. Installing with USB media

Installing with USB media involves creating a bootable USB drive with the discovery ISO on the administration node. Booting the server with the USB drive prepares the node for a single node installation.

#### Procedure

1. On the administration node, insert a USB drive into a USB port.
2. Create a bootable USB drive:

■

```
# dd if=<path-to-iso> of=<path/to/usb> status=progress
```

For example:

```
# dd if=discovery_image_sno.iso of=/dev/sdb status=progress
```

After the ISO is copied to the USB drive, you can use the USB drive to install OpenShift Container Platform.

3. On the server, insert the USB drive into a USB port.
4. Reboot the server and enter the BIOS settings upon reboot.
5. Change boot drive order to make the USB drive boot first.
6. Save and exit the BIOS settings. The server will boot with the discovery image.

### 9.2.4. Monitoring the installation with the Assisted Installer

If you created the ISO using the Assisted Installer, use this procedure to monitor the installation.

#### Procedure

1. On the administration host, return to the browser and refresh the page. If necessary, reload the [Install OpenShift with the Assisted Installer](#) page and select the cluster name.
2. Click **Next** until you reach step 3, **Networking**.
3. Select a subnet from the available subnets.
4. Keep **Use the same host discovery SSH key** checked. You can change the SSH public key, if necessary.
5. Click **Next** to proceed to the **Review and Create** step.
6. Click **Install cluster**.
7. Monitor the installation's progress. Watch the cluster events. After the installation process finishes writing the discovery image to the server's drive, the server will restart. Remove the USB drive and reset the BIOS to boot to the server's local media rather than the USB drive.

The server will restart several times, deploying the control plane.

### 9.2.5. Monitoring the installation manually

If you created the ISO manually, use this procedure to monitor the installation.

#### Procedure

1. Monitor the installation:

```
$ ./openshift-install --dir=ocp wait-for install-complete
```

The server will restart several times while deploying the control plane.

2. Optional: After the installation is complete, check the environment:

```
█ $ export KUBECONFIG=ocp/auth/kubeconfig
```

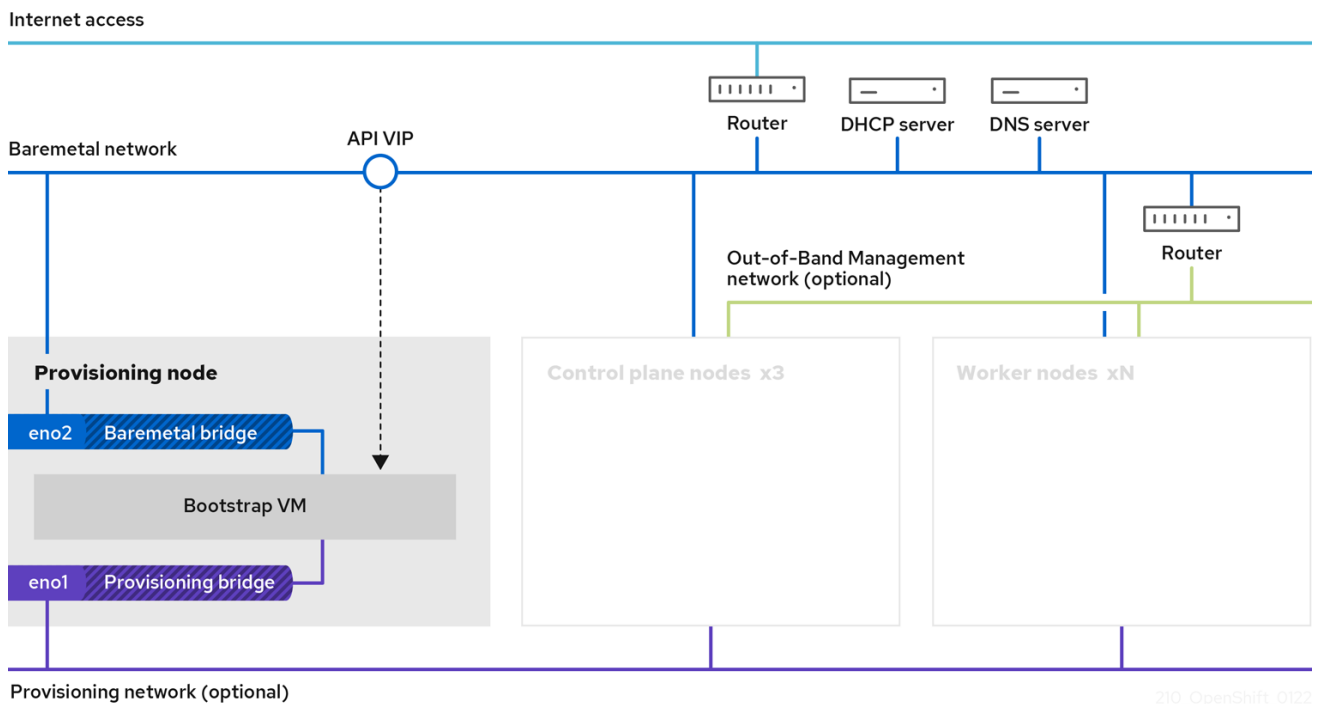
```
█ $ oc get nodes
```

```
█ $ oc get clusterversion
```

# CHAPTER 10. DEPLOYING INSTALLER-PROVISIONED CLUSTERS ON BARE METAL

## 10.1. OVERVIEW

Installer-provisioned installation on bare metal nodes deploys and configures the infrastructure that a OpenShift Container Platform cluster runs on. This guide provides a methodology to achieving a successful installer-provisioned bare-metal installation. The following diagram illustrates the installation environment in phase 1 of deployment:



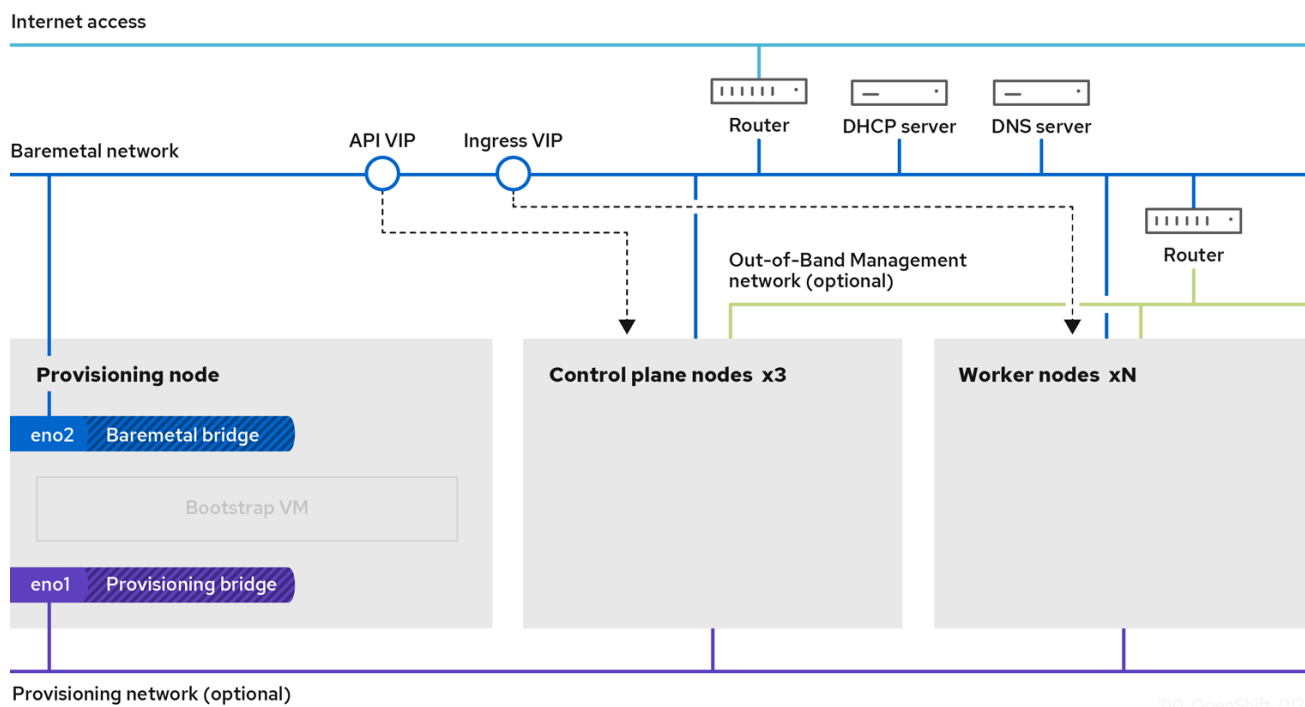
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The provisioning node can be removed after the installation.

- **Provisioner:** A physical machine that runs the installation program and hosts the bootstrap VM that deploys the controller of a new OpenShift Container Platform cluster.
- **Bootstrap VM:** A virtual machine used in the process of deploying an OpenShift Container Platform cluster.
- **Network bridges:** The bootstrap VM connects to the bare metal network and to the provisioning network, if present, via network bridges, **eno1** and **eno2**.

In phase 2 of the deployment, the provisioner destroys the bootstrap VM automatically and moves the virtual IP addresses (VIPs) to the appropriate nodes. The API VIP moves to the control plane nodes and the Ingress VIP moves to the worker nodes.

The following diagram illustrates phase 2 of deployment:



## IMPORTANT

The **provisioning** network is optional, but it is required for PXE booting. If you deploy without a **provisioning** network, you must use a virtual media BMC addressing option such as **redfish-virtualmedia** or **idrac-virtualmedia**.

## 10.2. PREREQUISITES

Installer-provisioned installation of OpenShift Container Platform requires:

1. One provisioner node with Red Hat Enterprise Linux (RHEL) 8.x installed. The provisioning node can be removed after installation.
2. Three control plane nodes.
3. Baseboard Management Controller (BMC) access to each node.
4. At least one network:
  - a. One required routable network
  - b. One optional network for provisioning nodes; and,
  - c. One optional management network.

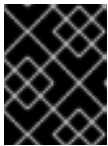
Before starting an installer-provisioned installation of OpenShift Container Platform, ensure the hardware environment meets the following requirements.

### 10.2.1. Node requirements

Installer-provisioned installation involves a number of hardware node requirements:

- **CPU architecture:** All nodes must use **x86\_64** CPU architecture.

- **Similar nodes:** Red Hat recommends nodes have an identical configuration per role. That is, Red Hat recommends nodes be the same brand and model with the same CPU, memory, and storage configuration.
- **Baseboard Management Controller:** The **provisioner** node must be able to access the baseboard management controller (BMC) of each OpenShift Container Platform cluster node. You may use IPMI, Redfish, or a proprietary protocol.
- **Latest generation:** Nodes must be of the most recent generation. Installer-provisioned installation relies on BMC protocols, which must be compatible across nodes. Additionally, RHEL 8 ships with the most recent drivers for RAID controllers. Ensure that the nodes are recent enough to support RHEL 8 for the **provisioner** node and RHCOS 8 for the control plane and worker nodes.
- **Registry node:** (Optional) If setting up a disconnected mirrored registry, it is recommended the registry reside in its own node.
- **Provisioner node:** Installer-provisioned installation requires one **provisioner** node.
- **Control plane:** Installer-provisioned installation requires three control plane nodes for high availability. You can deploy an OpenShift Container Platform cluster with only three control plane nodes, making the control plane nodes schedulable as worker nodes. Smaller clusters are more resource efficient for administrators and developers during development, production, and testing.
- **Worker nodes:** While not required, a typical production cluster has two or more worker nodes.



### IMPORTANT

Do not deploy a cluster with only one worker node, because the cluster will deploy with routers and ingress traffic in a degraded state.

- **Network interfaces:** Each node must have at least one network interface for the routable **baremetal** network. Each node must have one network interface for a **provisioning** network when using the **provisioning** network for deployment. Using the **provisioning** network is the default configuration.
- **Unified Extensible Firmware Interface (UEFI):** Installer-provisioned installation requires UEFI boot on all OpenShift Container Platform nodes when using IPv6 addressing on the **provisioning** network. In addition, UEFI Device PXE Settings must be set to use the IPv6 protocol on the **provisioning** network NIC, but omitting the **provisioning** network removes this requirement.



### IMPORTANT

When starting the installation from virtual media such as an ISO image, delete all old UEFI boot table entries. If the boot table includes entries that are not generic entries provided by the firmware, the installation might fail.

- **Secure Boot:** Many production scenarios require nodes with Secure Boot enabled to verify the node only boots with trusted software, such as UEFI firmware drivers, EFI applications, and the operating system. You may deploy with Secure Boot manually or managed.
  1. **Manually:** To deploy an OpenShift Container Platform cluster with Secure Boot manually, you must enable UEFI boot mode and Secure Boot on each control plane node and each



worker node. Red Hat supports Secure Boot with manually enabled UEFI and Secure Boot only when installer-provisioned installations use Redfish virtual media. See "Configuring nodes for Secure Boot manually" in the "Configuring nodes" section for additional details.

2. **Managed:** To deploy an OpenShift Container Platform cluster with managed Secure Boot, you must set the **bootMode** value to **UEFISecureBoot** in the **install-config.yaml** file. Red Hat only supports installer-provisioned installation with managed Secure Boot on 10th generation HPE hardware and 13th generation Dell hardware running firmware version **2.75.75.75** or greater. Deploying with managed Secure Boot does not require Redfish virtual media. See "Configuring managed Secure Boot" in the "Setting up the environment for an OpenShift installation" section for details.



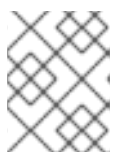
#### NOTE

Red Hat does not support Secure Boot with self-generated keys.

### 10.2.2. Planning a bare metal cluster for OpenShift Virtualization

If you will use OpenShift Virtualization, it is important to be aware of several requirements before you install your bare metal cluster.

- If you want to use live migration features, you must have multiple worker nodes *at the time of cluster installation*. This is because live migration requires the cluster-level high availability (HA) flag to be set to true. The HA flag is set when a cluster is installed and cannot be changed afterwards. If there are fewer than two worker nodes defined when you install your cluster, the HA flag is set to false for the life of the cluster.



#### NOTE

You can install OpenShift Virtualization on a single-node cluster, but single-node OpenShift does not support high availability.

- Live migration requires shared storage. Storage for OpenShift Virtualization must support and use the ReadWriteMany (RWX) access mode.
- If you plan to use Single Root I/O Virtualization (SR-IOV), ensure that your network interface controllers (NICs) are supported by OpenShift Container Platform.

#### Additional resources

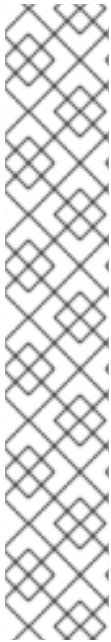
- [Preparing your cluster for OpenShift Virtualization](#)
- [About Single Root I/O Virtualization \(SR-IOV\) hardware networks](#)
- [Connecting a virtual machine to an SR-IOV network](#)

### 10.2.3. Firmware requirements for installing with virtual media

The installer for installer-provisioned OpenShift Container Platform clusters validates the hardware and firmware compatibility with Redfish virtual media. The following table lists the minimum firmware versions tested and verified to work for installer-provisioned OpenShift Container Platform clusters deployed by using Redfish virtual media.

**Table 10.1. Firmware compatibility for Redfish virtual media**

Hardware	Model	Management	Firmware versions
HP	10th Generation	iLO5	2.63 or later
Dell	14th Generation	iDRAC 9	v4.20.20.20 - v4.40.00.00 only
	13th Generation	iDRAC 8	v2.75.75.75 or later



## NOTE

Red Hat does not test every combination of firmware, hardware, or other third-party components. For further information about third-party support, see [Red Hat third-party support policy](#).

See the hardware documentation for the nodes or contact the hardware vendor for information about updating the firmware.

For HP servers, Redfish virtual media is not supported on 9th generation systems running iLO4, because Ironic does not support iLO4 with virtual media.

For Dell servers, ensure the OpenShift Container Platform cluster nodes have AutoAttach Enabled through the iDRAC console. The menu path is: **Configuration** → **Virtual Media** → **Attach Mode** → **AutoAttach** . With iDRAC 9 firmware version **04.40.00.00**, the Virtual Console plugin defaults to **eHTML5**, which causes problems with the **InsertVirtualMedia** workflow. Set the plug-in to **HTML5** to avoid this issue. The menu path is: **Configuration** → **Virtual console** → **Plug-in Type** → **HTML5** .

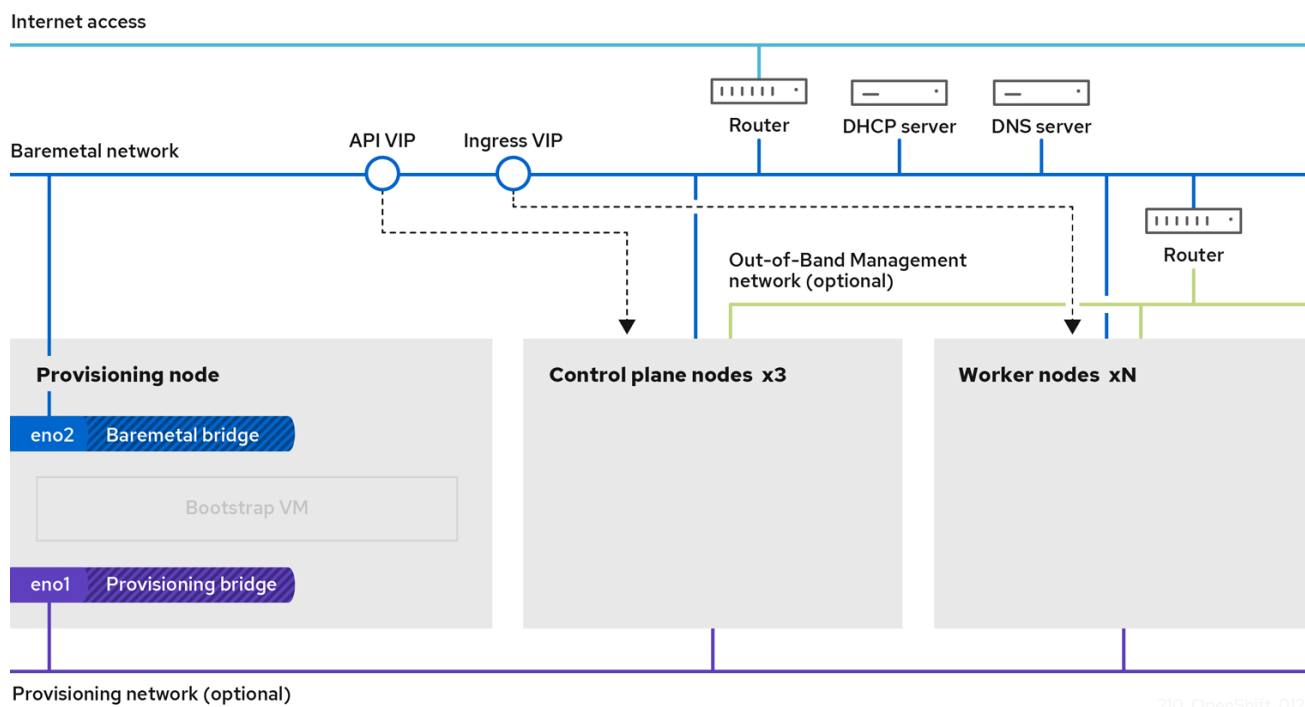


## IMPORTANT

The installer will not initiate installation on a node if the node firmware is below the foregoing versions when installing with virtual media.

### 10.2.4. Network requirements

Installer-provisioned installation of OpenShift Container Platform involves several network requirements. First, installer-provisioned installation involves an optional non-routable **provisioning** network for provisioning the operating system on each bare metal node. Second, installer-provisioned installation involves a routable **baremetal** network.



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#### 10.2.4.1. Increase the network MTU

Before deploying OpenShift Container Platform, increase the network maximum transmission unit (MTU) to 1500 or more. If the MTU is lower than 1500, the Ironic image that is used to boot the node might fail to communicate with the Ironic inspector pod, and inspection will fail. If this occurs, installation stops because the nodes are not available for installation.

#### 10.2.4.2. Configuring NICs

OpenShift Container Platform deploys with two networks:

- provisioning:** The **provisioning** network is an optional non-routable network used for provisioning the underlying operating system on each node that is a part of the OpenShift Container Platform cluster. The network interface for the **provisioning** network on each cluster node must have the BIOS or UEFI configured to PXE boot. The **provisioningNetworkInterface** configuration setting specifies the **provisioning** network NIC name on the control plane nodes, which must be identical on the control plane nodes. The **bootMACAddress** configuration setting provides a means to specify a particular NIC on each node for the **provisioning** network.
 

The **provisioning** network is optional, but it is required for PXE booting. If you deploy without a **provisioning** network, you must use a virtual media BMC addressing option such as **redfish-virtualmedia** or **idrac-virtualmedia**.
- baremetal:** The **baremetal** network is a routable network. You can use any NIC to interface with the **baremetal** network provided the NIC is not configured to use the **provisioning** network.



#### IMPORTANT

When using a VLAN, each NIC must be on a separate VLAN corresponding to the appropriate network.

### 10.2.4.3. DNS requirements

Clients access the OpenShift Container Platform cluster nodes over the **baremetal** network. A network administrator must configure a subdomain or subzone where the canonical name extension is the cluster name.

```
<cluster_name>.<base_domain>
```

For example:

```
test-cluster.example.com
```

OpenShift Container Platform includes functionality that uses cluster membership information to generate A/AAAA records. This resolves the node names to their IP addresses. After the nodes are registered with the API, the cluster can disperse node information without using CoreDNS-mDNS. This eliminates the network traffic associated with multicast DNS.

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API
- The OpenShift Container Platform application wildcard ingress API

A/AAAA records are used for name resolution and PTR records are used for reverse name resolution. Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records or DHCP to set the hostnames for all the nodes.

Installer-provisioned installation includes functionality that uses cluster membership information to generate A/AAAA records. This resolves the node names to their IP addresses. In each record, **<cluster\_name>** is the cluster name and **<base\_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster\_name>.<base\_domain>..**

Table 10.2. Required DNS records

Component	Record	Description
Kubernetes API	<b>api.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	An A/AAAA record, and a PTR record, identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
Routes	<b>*.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	The wildcard A/AAAA record refers to the application ingress load balancer. The application ingress load balancer targets the nodes that run the Ingress Controller pods. The Ingress Controller pods run on the worker nodes by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.  For example, <b>console-openshift-console.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;</b> is used as a wildcard route to the OpenShift Container Platform console.

**TIP**

You can use the **dig** command to verify DNS resolution.

**10.2.4.4. Dynamic Host Configuration Protocol (DHCP) requirements**

By default, installer-provisioned installation deploys **ironic-dnsmasq** with DHCP enabled for the **provisioning** network. No other DHCP servers should be running on the **provisioning** network when the **provisioningNetwork** configuration setting is set to **managed**, which is the default value. If you have a DHCP server running on the **provisioning** network, you must set the **provisioningNetwork** configuration setting to **unmanaged** in the **install-config.yaml** file.

Network administrators must reserve IP addresses for each node in the OpenShift Container Platform cluster for the **baremetal** network on an external DHCP server.

**10.2.4.5. Reserving IP addresses for nodes with the DHCP server**

For the **baremetal** network, a network administrator must reserve a number of IP addresses, including:

1. Two unique virtual IP addresses.
  - One virtual IP address for the API endpoint.
  - One virtual IP address for the wildcard ingress endpoint.
2. One IP address for the provisioner node.
3. One IP address for each control plane (master) node.
4. One IP address for each worker node, if applicable.

**RESERVING IP ADDRESSES SO THEY BECOME STATIC IP ADDRESSES**

Some administrators prefer to use static IP addresses so that each node's IP address remains constant in the absence of a DHCP server. To use static IP addresses in the OpenShift Container Platform cluster, reserve the IP addresses with an infinite lease. During deployment, the installer will reconfigure the NICs from DHCP assigned addresses to static IP addresses. NICs with DHCP leases that are not infinite will remain configured to use DHCP.

Setting IP addresses with an infinite lease is incompatible with network configuration deployed by using the Machine Config Operator.

**ENSURING THAT YOUR DHCP SERVER CAN PROVIDE INFINITE LEASES**

Your DHCP server must provide a DHCP expiration time of 4294967295 seconds to properly set an infinite lease as specified by [rhc2131](#). If a lesser value is returned for the DHCP infinite lease time, the node reports an error and a permanent IP is not set for the node. In RHEL 8, **dhcpcd** does not provide infinite leases. If you want to use the provisioner node to serve dynamic IP addresses with infinite lease times, use **dnsmasq** rather than **dhcpcd**.



## NETWORKING BETWEEN EXTERNAL LOAD BALANCERS AND CONTROL PLANE NODES

External load balancing services and the control plane nodes must run on the same L2 network, and on the same VLAN when using VLANs to route traffic between the load balancing services and the control plane nodes.



## DO NOT CHANGE IP ADDRESSES MANUALLY AFTER DEPLOYMENT

Do not change a worker node's IP address manually after deployment. To change the IP address of a worker node after deployment, you must mark the worker node unschedulable, evacuate the pods, delete the node, and recreate it with the new IP address. See "Working with nodes" for additional details. To change the IP address of a control plane node after deployment, contact support.

The storage interface requires a DHCP reservation.

The following table provides an exemplary embodiment of fully qualified domain names. The API and Nameserver addresses begin with canonical name extensions. The hostnames of the control plane and worker nodes are exemplary, so you can use any host naming convention you prefer.

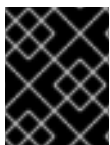
Usage	Host Name	IP
API	<b>api.&lt;cluster_name&gt;.&lt;base_domain&gt;</b>	<b>&lt;ip&gt;</b>
Ingress LB (apps)	<b>*.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;</b>	<b>&lt;ip&gt;</b>
Provisioner node	<b>provisioner.&lt;cluster_name&gt;.&lt;base_domain&gt;</b>	<b>&lt;ip&gt;</b>
Master-0	<b>openshift-master-0.&lt;cluster_name&gt;.&lt;base_domain&gt;</b>	<b>&lt;ip&gt;</b>
Master-1	<b>openshift-master-1.&lt;cluster_name&gt;.&lt;base_domain&gt;</b>	<b>&lt;ip&gt;</b>
Master-2	<b>openshift-master-2.&lt;cluster_name&gt;.&lt;base_domain&gt;</b>	<b>&lt;ip&gt;</b>
Worker-0	<b>openshift-worker-0.&lt;cluster_name&gt;.&lt;base_domain&gt;</b>	<b>&lt;ip&gt;</b>
Worker-1	<b>openshift-worker-1.&lt;cluster_name&gt;.&lt;base_domain&gt;</b>	<b>&lt;ip&gt;</b>
Worker-n	<b>openshift-worker-n.&lt;cluster_name&gt;.&lt;base_domain&gt;</b>	<b>&lt;ip&gt;</b>

**NOTE**

If you do not create DHCP reservations, the installer requires reverse DNS resolution to set the hostnames for the Kubernetes API node, the provisioner node, the control plane nodes, and the worker nodes.

**10.2.4.6. Network Time Protocol (NTP)**

Each OpenShift Container Platform node in the cluster must have access to an NTP server. OpenShift Container Platform nodes use NTP to synchronize their clocks. For example, cluster nodes use SSL certificates that require validation, which might fail if the date and time between the nodes are not in sync.

**IMPORTANT**

Define a consistent clock date and time format in each cluster node's BIOS settings, or installation might fail.

You can reconfigure the control plane nodes to act as NTP servers on disconnected clusters, and reconfigure worker nodes to retrieve time from the control plane nodes.

**10.2.4.7. State-driven network configuration requirements (Technology Preview)**

OpenShift Container Platform supports additional post-installation state-driven network configuration on the secondary network interfaces of cluster nodes using **kubernetes-nmstate**. For example, system administrators might configure a secondary network interface on cluster nodes after installation for a storage network.

**NOTE**

Configuration must occur before scheduling pods.

State-driven network configuration requires installing **kubernetes-nmstate**, and also requires Network Manager running on the cluster nodes. See **OpenShift Virtualization > Kubernetes NMState (Tech Preview)** for additional details.

**10.2.4.8. Port access for the out-of-band management IP address**

The out-of-band management IP address is on a separate network from the node. To ensure that the out-of-band management can communicate with the provisioning node during installation, the out-of-band management IP address must be granted access to port **80** on the bootstrap host and port **6180** on the OpenShift Container Platform control plane hosts.

**10.2.5. Configuring nodes****Configuring nodes when using the provisioning network**

Each node in the cluster requires the following configuration for proper installation.

**WARNING**

A mismatch between nodes will cause an installation failure.

While the cluster nodes can contain more than two NICs, the installation process only focuses on the first two NICs. In the following table, NIC1 is a non-routable network (**provisioning**) that is only used for the installation of the OpenShift Container Platform cluster.

NIC	Network	VLAN
NIC1	<b>provisioning</b>	<provisioning_vlan>
NIC2	<b>baremetal</b>	<baremetal_vlan>

The Red Hat Enterprise Linux (RHEL) 8.x installation process on the provisioner node might vary. To install Red Hat Enterprise Linux (RHEL) 8.x using a local Satellite server or a PXE server, PXE-enable NIC2.

PXE	Boot order
NIC1 PXE-enabled <b>provisioning</b> network	1
NIC2 <b>baremetal</b> network. PXE-enabled is optional.	2

**NOTE**

Ensure PXE is disabled on all other NICs.

Configure the control plane and worker nodes as follows:

PXE	Boot order
NIC1 PXE-enabled (provisioning network)	1

**Configuring nodes without the provisioning network**

The installation process requires one NIC:

NIC	Network	VLAN
NICx	<b>baremetal</b>	<baremetal_vlan>



NICx is a routable network (**baremetal**) that is used for the installation of the OpenShift Container Platform cluster, and routable to the internet.



### IMPORTANT

The **provisioning** network is optional, but it is required for PXE booting. If you deploy without a **provisioning** network, you must use a virtual media BMC addressing option such as **redfish-virtualmedia** or **idrac-virtualmedia**.

### Configuring nodes for Secure Boot manually

Secure Boot prevents a node from booting unless it verifies the node is using only trusted software, such as UEFI firmware drivers, EFI applications, and the operating system.



### NOTE

Red Hat only supports manually configured Secure Boot when deploying with Redfish virtual media.

To enable Secure Boot manually, refer to the hardware guide for the node and execute the following:

### Procedure

1. Boot the node and enter the BIOS menu.
2. Set the node's boot mode to UEFI Enabled.
3. Enable Secure Boot.



### IMPORTANT

Red Hat does not support Secure Boot with self-generated keys.

### Configuring the Compatibility Support Module for Fujitsu iRMC

The Compatibility Support Module (CSM) configuration provides support for legacy BIOS backward compatibility with UEFI systems. You must configure the CSM when you deploy a cluster with Fujitsu iRMC, otherwise the installation might fail.



### NOTE

For information about configuring the CSM for your specific node type, refer to the hardware guide for the node.

### Prerequisites

- Ensure that you have disabled Secure Boot Control. You can disable the feature under **Security** → **Secure Boot Configuration** → **Secure Boot Control**

### Procedure

1. Boot the node and select the BIOS menu.
2. Under the **Advanced** tab, select **CSM Configuration** from the list.

3. Enable the **Launch CSM** option and set the following values:

Item	Value
Boot option filter	UEFI and Legacy
Launch PXE OpROM Policy	UEFI only
Launch Storage OpROM policy	UEFI only
Other PCI device ROM priority	UEFI only

### 10.2.6. Out-of-band management

Nodes will typically have an additional NIC used by the Baseboard Management Controllers (BMCs). These BMCs must be accessible from the provisioner node.

Each node must be accessible via out-of-band management. When using an out-of-band management network, the provisioner node requires access to the out-of-band management network for a successful OpenShift Container Platform 4 installation.

The out-of-band management setup is out of scope for this document. We recommend setting up a separate management network for out-of-band management. However, using the provisioning network or the baremetal network are valid options.

### 10.2.7. Required data for installation

Prior to the installation of the OpenShift Container Platform cluster, gather the following information from all cluster nodes:

- Out-of-band management IP
  - Examples
    - Dell (iDRAC) IP
    - HP (iLO) IP
    - Fujitsu (iRMC) IP

#### When using the provisioning network

- NIC (**provisioning**) MAC address
- NIC (**baremetal**) MAC address

#### When omitting the provisioning network

- NIC (**baremetal**) MAC address

### 10.2.8. Validation checklist for nodes

#### When using the provisioning network

- NIC1 VLAN is configured for the **provisioning** network.
- NIC1 for the **provisioning** network is PXE-enabled on the provisioner, control plane (master), and worker nodes.
- NIC2 VLAN is configured for the **baremetal** network.
- PXE has been disabled on all other NICs.
- DNS is configured with API and Ingress endpoints.
- Control plane and worker nodes are configured.
- All nodes accessible via out-of-band management.
- (Optional) A separate management network has been created.
- Required data for installation.

#### When omitting the provisioning network

- NIC1 VLAN is configured for the **baremetal** network.
- DNS is configured with API and Ingress endpoints.
- Control plane and worker nodes are configured.
- All nodes accessible via out-of-band management.
- (Optional) A separate management network has been created.
- Required data for installation.

## 10.3. SETTING UP THE ENVIRONMENT FOR AN OPENSIFT INSTALLATION

### 10.3.1. Installing RHEL on the provisioner node

With the networking configuration complete, the next step is to install RHEL 8.x on the provisioner node. The installer uses the provisioner node as the orchestrator while installing the OpenShift Container Platform cluster. For the purposes of this document, installing RHEL on the provisioner node is out of scope. However, options include but are not limited to using a RHEL Satellite server, PXE, or installation media.

### 10.3.2. Preparing the provisioner node for OpenShift Container Platform installation

Perform the following steps to prepare the environment.

#### Procedure

1. Log in to the provisioner node via **ssh**.
2. Create a non-root user (**kni**) and provide that user with **sudo** privileges:

```
# useradd kni
```

```
# passwd kni
# echo "kni ALL=(root) NOPASSWD:ALL" | tee -a /etc/sudoers.d/kni
# chmod 0440 /etc/sudoers.d/kni
```

3. Create an **ssh** key for the new user:

```
# su - kni -c "ssh-keygen -t ed25519 -f /home/kni/.ssh/id_rsa -N ""
```

4. Log in as the new user on the provisioner node:

```
# su - kni
$
```

5. Use Red Hat Subscription Manager to register the provisioner node:

```
$ sudo subscription-manager register --username=<user> --password=<pass> --auto-attach
$ sudo subscription-manager repos --enable=rhel-8-for-x86_64-appstream-rpms --
enable=rhel-8-for-x86_64-baseos-rpms
```



#### NOTE

For more information about Red Hat Subscription Manager, see [Using and Configuring Red Hat Subscription Manager](#).

6. Install the following packages:

```
$ sudo dnf install -y libvirt qemu-kvm mkisofs python3-devel jq ipmitool
```

7. Modify the user to add the **libvirt** group to the newly created user:

```
$ sudo usermod --append --groups libvirt <user>
```

8. Restart **firewalld** and enable the **http** service:

```
$ sudo systemctl start firewalld
$ sudo firewall-cmd --zone=public --add-service=http --permanent
$ sudo firewall-cmd --reload
```

9. Start and enable the **libvirtd** service:

```
$ sudo systemctl enable libvirtd --now
```

10. Create the **default** storage pool and start it:

```
$ sudo virsh pool-define-as --name default --type dir --target /var/lib/libvirt/images
$ sudo virsh pool-start default
$ sudo virsh pool-autostart default
```

11. Configure networking.

**NOTE**

You can also configure networking from the web console.

Export the **baremetal** network NIC name:

```
$ export PUB_CONN=<baremetal_nic_name>
```

Configure the **baremetal** network:

```
$ sudo nohup bash -c "
  nmcli con down \"$PUB_CONN\"
  nmcli con delete \"$PUB_CONN\"
  # RHEL 8.1 appends the word \"System\" in front of the connection, delete in case it exists
  nmcli con down \"System $PUB_CONN\"
  nmcli con delete \"System $PUB_CONN\"
  nmcli connection add ifname baremetal type bridge con-name baremetal bridge.stp no
  nmcli con add type bridge-slave ifname \"$PUB_CONN\" master baremetal
  pkill dhclient;dhclient baremetal
"
```

If you are deploying with a **provisioning** network, export the **provisioning** network NIC name:

```
$ export PROV_CONN=<prov_nic_name>
```

If you are deploying with a **provisioning** network, configure the **provisioning** network:

```
$ sudo nohup bash -c "
  nmcli con down \"$PROV_CONN\"
  nmcli con delete \"$PROV_CONN\"
  nmcli connection add ifname provisioning type bridge con-name provisioning
  nmcli con add type bridge-slave ifname \"$PROV_CONN\" master provisioning
  nmcli connection modify provisioning ipv6.addresses fd00:1101::1/64 ipv6.method manual
  nmcli con down provisioning
  nmcli con up provisioning
"
```

**NOTE**

The **ssh** connection might disconnect after executing these steps.

The IPv6 address can be any address as long as it is not routable via the **baremetal** network.

Ensure that UEFI is enabled and UEFI PXE settings are set to the IPv6 protocol when using IPv6 addressing.

- Configure the IPv4 address on the **provisioning** network connection.

```
$ nmcli connection modify provisioning ipv4.addresses 172.22.0.254/24 ipv4.method manual
```

- ssh** back into the **provisioner** node (if required).

```
# ssh kni@provisioner.<cluster-name>.<domain>
```

- Verify the connection bridges have been properly created.

```
$ sudo nmcli con show
```

```
NAME                UUID                                TYPE  DEVICE
baremetal           4d5133a5-8351-4bb9-bfd4-3af264801530 bridge baremetal
provisioning        43942805-017f-4d7d-a2c2-7cb3324482ed bridge provisioning
virbr0              d9bca40f-eee1-410b-8879-a2d4bb0465e7 bridge virbr0
bridge-slave-eno1   76a8ed50-c7e5-4999-b4f6-6d9014dd0812 ethernet eno1
bridge-slave-eno2   f31c3353-54b7-48de-893a-02d2b34c4736 ethernet eno2
```

- Create a **pull-secret.txt** file.

```
$ vim pull-secret.txt
```

In a web browser, navigate to [Install OpenShift on Bare Metal with installer-provisioned infrastructure](#), and scroll down to the **Downloads** section. Click **Copy pull secret**. Paste the contents into the **pull-secret.txt** file and save the contents in the **kni** user's home directory.

### 10.3.3. Retrieving the OpenShift Container Platform installer

Use the **stable-4.x** version of the installer to deploy the generally available stable version of OpenShift Container Platform:

```
$ export VERSION=stable-4.9
export RELEASE_IMAGE=$(curl -s https://mirror.openshift.com/pub/openshift-
v4/clients/ocp/$VERSION/release.txt | grep 'Pull From: quay.io' | awk -F ' ' '{print $3}')
```

### 10.3.4. Extracting the OpenShift Container Platform installer

After retrieving the installer, the next step is to extract it.

#### Procedure

- Set the environment variables:

```
$ export cmd=openshift-baremetal-install
$ export pullsecret_file=~/.pull-secret.txt
$ export extract_dir=$(pwd)
```

- Get the **oc** binary:

```
$ curl -s https://mirror.openshift.com/pub/openshift-v4/clients/ocp/$VERSION/openshift-client-
linux.tar.gz | tar zxvf - oc
```

- Extract the installer:

```
$ sudo cp oc /usr/local/bin
$ oc adm release extract --registry-config "${pullsecret_file}" --command=$cmd --to
"${extract_dir}" ${RELEASE_IMAGE}
```

```
$ sudo cp openshift-baremetal-install /usr/local/bin
```

### 10.3.5. Creating an RHCOS images cache (optional)

To employ image caching, you must download two images: the Red Hat Enterprise Linux CoreOS (RHCOS) image used by the bootstrap VM and the RHCOS image used by the installer to provision the different nodes. Image caching is optional, but especially useful when running the installer on a network with limited bandwidth.

If you are running the installer on a network with limited bandwidth and the RHCOS images download takes more than 15 to 20 minutes, the installer will timeout. Caching images on a web server will help in such scenarios.

Install a container that contains the images.

#### Procedure

1. Install **podman**:

```
$ sudo dnf install -y podman
```

2. Open firewall port **8080** to be used for RHCOS image caching:

```
$ sudo firewall-cmd --add-port=8080/tcp --zone=public --permanent
```

```
$ sudo firewall-cmd --reload
```

3. Create a directory to store the **bootstraposimage** and **clusterosimage**:

```
$ mkdir /home/kni/rhcos_image_cache
```

4. Set the appropriate SELinux context for the newly created directory:

```
$ sudo semanage fcontext -a -t httpd_sys_content_t "/home/kni/rhcos_image_cache(/.*)?"
```

```
$ sudo restorecon -Rv /home/kni/rhcos_image_cache/
```

5. Get the URI for the RHCOS image that the installation program will deploy on the bootstrap VM:

```
$ export RHCOS_QEMU_URI=$(/usr/local/bin/openshift-baremetal-install coreos print-stream-json | jq -r --arg ARCH "$(arch)"
'.architectures[$ARCH].artifacts.qemu.formats["qcow2.gz"].disk.location')
```

6. Get the name of the image that the installation program will deploy on the bootstrap VM:

```
$ export RHCOS_QEMU_NAME=${RHCOS_QEMU_URI##*/}
```

7. Get the SHA hash for the RHCOS image that will be deployed on the nodes:

```
$ export RHCOS_QEMU_UNCOMPRESSED_SHA256=$(/usr/local/bin/openshift-baremetal-
install coreos print-stream-json | jq -r --arg ARCH "$(arch)"
'.architectures[$ARCH].artifacts.qemu.formats["qcow2.gz"].disk["uncompressed-sha256"])
```

8. Get the URI for the image that the installation program will deploy on the cluster nodes:

```
$ export RHCOS_OPENSTACK_URI=$(/usr/local/bin/openshift-baremetal-install coreos
print-stream-json | jq -r --arg ARCH "$(arch)"
'.architectures[$ARCH].artifacts.openstack.formats["qcow2.gz"].disk.location)
```

9. Get the name of the image that the installation program will deploy on the cluster nodes:

```
$ export RHCOS_OPENSTACK_NAME=${RHCOS_OPENSTACK_URI##*/}
```

10. Get the SHA hash for the image that the installation program will deploy on the cluster nodes:

```
$ export RHCOS_OPENSTACK_UNCOMPRESSED_SHA256=$(/usr/local/bin/openshift-
baremetal-install coreos print-stream-json | jq -r --arg ARCH "$(arch)"
'.architectures[$ARCH].artifacts.openstack.formats["qcow2.gz"].disk["uncompressed-
sha256"])
```

11. Download the images and place them in the **/home/kni/rhcos\_image\_cache** directory:

```
$ curl -L ${RHCOS_QEMU_URI} -o
/home/kni/rhcos_image_cache/${RHCOS_QEMU_NAME}
```

```
$ curl -L ${RHCOS_OPENSTACK_URI} -o
/home/kni/rhcos_image_cache/${RHCOS_OPENSTACK_NAME}
```

12. Confirm SELinux type is of **httpd\_sys\_content\_t** for the newly created files:

```
$ ls -Z /home/kni/rhcos_image_cache
```

13. Create the pod:

```
$ podman run -d --name rhcos_image_cache \
-v /home/kni/rhcos_image_cache:/var/www/html \
-p 8080:8080/tcp \
quay.io/centos7/httpd-24-centos7:latest
```

The above command creates a caching webserver with the name **rhcos\_image\_cache**, which serves the images for deployment. The first image **\${RHCOS\_PATH}\${RHCOS\_QEMU\_URI}?sha256=\${RHCOS\_QEMU\_SHA\_UNCOMPRESSED}** is the **bootstrapOSImage** and the second image **\${RHCOS\_PATH}\${RHCOS\_OPENSTACK\_URI}?sha256=\${RHCOS\_OPENSTACK\_SHA\_COMPRESSED}** is the **clusterOSImage** in the **install-config.yaml** file.

14. Generate the **bootstrapOSImage** and **clusterOSImage** configuration:

```
$ export BAREMETAL_IP=$(ip addr show dev baremetal | awk '/inet /{print $2}' | cut -d"/" -f1)
```



```
$ export
BOOTSTRAP_OS_IMAGE="http://${BAREMETAL_IP}:8080/${RHCOS_QEMU_NAME}?
sha256=${RHCOS_QEMU_UNCOMPRESSED_SHA256}"
```

```
$ export
CLUSTER_OS_IMAGE="http://${BAREMETAL_IP}:8080/${RHCOS_OPENSTACK_NAME}?
sha256=${RHCOS_OPENSTACK_UNCOMPRESSED_SHA256}"
```

```
$ echo " bootstrapOSImage=${BOOTSTRAP_OS_IMAGE}"
```

```
$ echo " clusterOSImage=${CLUSTER_OS_IMAGE}"
```

15. Add the required configuration to the **install-config.yaml** file under **platform.baremetal**:

```
platform:
  baremetal:
    bootstrapOSImage: <bootstrap_os_image> 1
    clusterOSImage: <cluster_os_image> 2
```

**1** Replace **<bootstrap\_os\_image>** with the value of **\$BOOTSTRAP\_OS\_IMAGE**.

**2** Replace **<cluster\_os\_image>** with the value of **\$CLUSTER\_OS\_IMAGE**.

See the "Configuration files" section for additional details.

## 10.3.6. Configuration files

### 10.3.6.1. Configuring the **install-config.yaml** file

The **install-config.yaml** file requires some additional details. Most of the information is teaching the installer and the resulting cluster enough about the available hardware so that it is able to fully manage it.

1. Configure **install-config.yaml**. Change the appropriate variables to match the environment, including **pullSecret** and **sshKey**.

```
apiVersion: v1
baseDomain: <domain>
metadata:
  name: <cluster-name>
networking:
  machineNetwork:
    - cidr: <public-cidr>
  networkType: OVNKubernetes
compute:
  - name: worker
    replicas: 2 1
controlPlane:
  name: master
  replicas: 3
platform:
  baremetal: {}
```

```

platform:
  baremetal:
    apiVIP: <api-ip>
    ingressVIP: <wildcard-ip>
    provisioningNetworkCIDR: <CIDR>
    hosts:
      - name: openshift-master-0
        role: master
        bmc:
          address: ipmi://<out-of-band-ip> 2
          username: <user>
          password: <password>
          bootMACAddress: <NIC1-mac-address>
          rootDeviceHints:
            deviceName: "/dev/disk/by-id/<disk_id>" 3
      - name: <openshift-master-1>
        role: master
        bmc:
          address: ipmi://<out-of-band-ip> 4
          username: <user>
          password: <password>
          bootMACAddress: <NIC1-mac-address>
          rootDeviceHints:
            deviceName: "/dev/disk/by-id/<disk_id>" 5
      - name: <openshift-master-2>
        role: master
        bmc:
          address: ipmi://<out-of-band-ip> 6
          username: <user>
          password: <password>
          bootMACAddress: <NIC1-mac-address>
          rootDeviceHints:
            deviceName: "/dev/disk/by-id/<disk_id>" 7
      - name: <openshift-worker-0>
        role: worker
        bmc:
          address: ipmi://<out-of-band-ip> 8
          username: <user>
          password: <password>
          bootMACAddress: <NIC1-mac-address>
      - name: <openshift-worker-1>
        role: worker
        bmc:
          address: ipmi://<out-of-band-ip>
          username: <user>
          password: <password>
          bootMACAddress: <NIC1-mac-address>
          rootDeviceHints:
            deviceName: "/dev/disk/by-id/<disk_id>" 9
    pullSecret: '<pull_secret>'
    sshKey: '<ssh_pub_key>'

```

- 1 Scale the worker machines based on the number of worker nodes that are part of the OpenShift Container Platform cluster. Valid options for the **replicas** value are **0** and integers greater than or equal to **2**. Set the number of replicas to **0** to deploy a three-node

cluster, which contains only three control plane machines. A three-node cluster is a smaller, more resource-efficient cluster that can be used for testing, development, and production. You cannot install the cluster with only one worker.

**2 4 6 8** See the BMC addressing sections for more options.

**3 5 7 9** Set the path to the installation disk drive, for example, `/dev/disk/by-id/wwn-0x64cd98f04fde100024684cf3034da5c2`.

2. Create a directory to store cluster configs.

```
$ mkdir ~/clusterconfigs
$ cp install-config.yaml ~/clusterconfigs
```

3. Ensure all bare metal nodes are powered off prior to installing the OpenShift Container Platform cluster.

```
$ ipmitool -I lanplus -U <user> -P <password> -H <management-server-ip> power off
```

4. Remove old bootstrap resources if any are left over from a previous deployment attempt.

```
for i in $(sudo virsh list | tail -n +3 | grep bootstrap | awk {'print $2'});
do
  sudo virsh destroy $i;
  sudo virsh undefine $i;
  sudo virsh vol-delete $i --pool $i;
  sudo virsh vol-delete $i.ign --pool $i;
  sudo virsh pool-destroy $i;
  sudo virsh pool-undefine $i;
done
```

### 10.3.6.2. Setting proxy settings within the `install-config.yaml` file (optional)

To deploy an OpenShift Container Platform cluster using a proxy, make the following changes to the `install-config.yaml` file.

```
apiVersion: v1
baseDomain: <domain>
proxy:
  httpProxy: http://USERNAME:PASSWORD@proxy.example.com:PORT
  httpsProxy: https://USERNAME:PASSWORD@proxy.example.com:PORT
  noProxy: <WILDCARD_OF_DOMAIN>,<PROVISIONING_NETWORK/CIDR>,
  <BMC_ADDRESS_RANGE/CIDR>
```

The following is an example of `noProxy` with values.

```
noProxy: .example.com,172.22.0.0/24,10.10.0.0/24
```

With a proxy enabled, set the appropriate values of the proxy in the corresponding key/value pair.

Key considerations:

- If the proxy does not have an HTTPS proxy, change the value of **httpsProxy** from **https://** to **http://**.
- If using a provisioning network, include it in the **noProxy** setting, otherwise the installer will fail.
- Set all of the proxy settings as environment variables within the provisioner node. For example, **HTTP\_PROXY**, **HTTPS\_PROXY**, and **NO\_PROXY**.



#### NOTE

When provisioning with IPv6, you cannot define a CIDR address block in the **noProxy** settings. You must define each address separately.

### 10.3.6.3. Modifying the `install-config.yaml` file for no provisioning network (optional)

To deploy an OpenShift Container Platform cluster without a **provisioning** network, make the following changes to the `install-config.yaml` file.

```
platform:
  baremetal:
    apiVIP: <api_VIP>
    ingressVIP: <ingress_VIP>
    provisioningNetwork: "Disabled" 1
```

- 1** Add the **provisioningNetwork** configuration setting, if needed, and set it to **Disabled**.



#### IMPORTANT

The **provisioning** network is required for PXE booting. If you deploy without a **provisioning** network, you must use a virtual media BMC addressing option such as **redfish-virtualmedia** or **idrac-virtualmedia**. See "Redfish virtual media for HPE iLO" in the "BMC addressing for HPE iLO" section or "Redfish virtual media for Dell iDRAC" in the "BMC addressing for Dell iDRAC" section for additional details.

### 10.3.6.4. Modifying the `install-config.yaml` file for dual-stack network (optional)

To deploy an OpenShift Container Platform cluster with dual-stack networking, edit the **machineNetwork**, **clusterNetwork**, and **serviceNetwork** configuration settings in the `install-config.yaml` file. Each setting must have two CIDR entries each. Ensure the first CIDR entry is the IPv4 setting and the second CIDR entry is the IPv6 setting.

```
machineNetwork:
- cidr: {{ extcidrnet }}
- cidr: {{ extcidrnet6 }}
clusterNetwork:
- cidr: 10.128.0.0/14
  hostPrefix: 23
- cidr: fd02::/48
  hostPrefix: 64
serviceNetwork:
- 172.30.0.0/16
- fd03::/112
```

**IMPORTANT**

The API VIP IP address and the Ingress VIP address must be of the primary IP address family when using dual-stack networking. Currently, Red Hat does not support dual-stack VIPs or dual-stack networking with IPv6 as the primary IP address family. However, Red Hat does support dual-stack networking with IPv4 as the primary IP address family. Therefore, the IPv4 entries must go **before** the IPv6 entries.

**10.3.6.5. Configuring managed Secure Boot in the `install-config.yaml` file (optional)**

You can enable managed Secure Boot when deploying an installer-provisioned cluster using Redfish BMC addressing, such as **redfish**, **redfish-virtualmedia**, or **idrac-virtualmedia**. To enable managed Secure Boot, add the **bootMode** configuration setting to each node:

**Example**

```
hosts:
  - name: openshift-master-0
    role: master
    bmc:
      address: redfish://<out_of_band_ip> ❶
      username: <user>
      password: <password>
      bootMACAddress: <NIC1_mac_address>
      rootDeviceHints:
        deviceName: "/dev/sda"
      bootMode: UEFISecureBoot ❷
```

- ❶ Ensure the **bmc.address** setting uses **redfish**, **redfish-virtualmedia**, or **idrac-virtualmedia** as the protocol. See "BMC addressing for HPE iLO" or "BMC addressing for Dell iDRAC" for additional details.
- ❷ The **bootMode** setting is **UEFI** by default. Change it to **UEFISecureBoot** to enable managed Secure Boot.

**NOTE**

See "Configuring nodes" in the "Prerequisites" to ensure the nodes can support managed Secure Boot. If the nodes do not support managed Secure Boot, see "Configuring nodes for Secure Boot manually" in the "Configuring nodes" section. Configuring Secure Boot manually requires Redfish virtual media.

**NOTE**

Red Hat does not support Secure Boot with IPMI, because IPMI does not provide Secure Boot management facilities.

**10.3.6.6. Additional `install-config` parameters**

See the following tables for the required parameters, the **hosts** parameter, and the **bmc** parameter for the **install-config.yaml** file.

Table 10.3. Required parameters

Parameters	Default	Description
<b>baseDomain</b>		The domain name for the cluster. For example, <b>example.com</b> .
<b>bootMode</b>	<b>UEFI</b>	The boot mode for a node. Options are <b>legacy</b> , <b>UEFI</b> , and <b>UEFISecureBoot</b> . If <b>bootMode</b> is not set, Ironic sets it while inspecting the node.
<b>sshKey</b>		The <b>sshKey</b> configuration setting contains the key in the <code>~/.ssh/id_rsa.pub</code> file required to access the control plane nodes and worker nodes. Typically, this key is from the <b>provisioner</b> node.
<b>pullSecret</b>		The <b>pullSecret</b> configuration setting contains a copy of the pull secret downloaded from the <a href="#">Install OpenShift on Bare Metal</a> page when preparing the provisioner node.
<pre> metadata:   name: </pre>		The name to be given to the OpenShift Container Platform cluster. For example, <b>openshift</b> .
<pre> networking:   machineNetwork:     - cidr: </pre>		The public CIDR (Classless Inter-Domain Routing) of the external network. For example, <b>10.0.0/24</b> .
<pre> compute:   - name: worker </pre>		The OpenShift Container Platform cluster requires a name be provided for worker (or compute) nodes even if there are zero nodes.
<pre> compute:   replicas: 2 </pre>		Replicas sets the number of worker (or compute) nodes in the OpenShift Container Platform cluster.
<pre> controlPlane:   name: master </pre>		The OpenShift Container Platform cluster requires a name for control plane (master) nodes.

Parameters	Default	Description
<b>controlPlane:</b> <b>replicas: 3</b>		Replicas sets the number of control plane (master) nodes included as part of the OpenShift Container Platform cluster.
<b>provisioningNetworkInterface</b>		The name of the network interface on nodes connected to the <b>provisioning</b> network. For OpenShift Container Platform 4.9 and later releases, use the <b>bootMACAddress</b> configuration setting to enable Ironic to identify the IP address of the NIC instead of using the <b>provisioningNetworkInterface</b> configuration setting to identify the name of the NIC.
<b>defaultMachinePlatform</b>		The default configuration used for machine pools without a platform configuration.
<b>apiVIP</b>		<p>(Optional) The virtual IP address for Kubernetes API communication.</p> <p>This setting must either be provided in the <b>install-config.yaml</b> file as a reserved IP from the MachineNetwork or pre-configured in the DNS so that the default name resolves correctly. Use the virtual IP address and not the FQDN when adding a value to the <b>apiVIP</b> configuration setting in the <b>install-config.yaml</b> file. The IP address must be from the primary IPv4 network when using dual stack networking. If not set, the installer uses <b>api.&lt;cluster_name&gt;.&lt;base_domain&gt;</b> to derive the IP address from the DNS.</p>
<b>disableCertificateVerification</b>	<b>False</b>	<b>redfish</b> and <b>redfish-virtualmedia</b> need this parameter to manage BMC addresses. The value should be <b>True</b> when using a self-signed certificate for BMC addresses.

Parameters	Default	Description
<b>ingressVIP</b>		<p>(Optional) The virtual IP address for ingress traffic.</p> <p>This setting must either be provided in the <b>install-config.yaml</b> file as a reserved IP from the MachineNetwork or pre-configured in the DNS so that the default name resolves correctly. Use the virtual IP address and not the FQDN when adding a value to the <b>ingressVIP</b> configuration setting in the <b>install-config.yaml</b> file. The IP address must be from the primary IPv4 network when using dual stack networking. If not set, the installer uses <b>test.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;</b> to derive the IP address from the DNS.</p>

Table 10.4. Optional Parameters

Parameters	Default	Description
<b>provisioningDHCPRange</b>	<b>172.22.0.10,172.22.0.100</b>	Defines the IP range for nodes on the <b>provisioning</b> network.
<b>provisioningNetworkCIDR</b>	<b>172.22.0.0/24</b>	The CIDR for the network to use for provisioning. This option is required when not using the default address range on the <b>provisioning</b> network.
<b>clusterProvisioningIP</b>	The third IP address of the <b>provisioningNetworkCIDR</b> .	The IP address within the cluster where the provisioning services run. Defaults to the third IP address of the <b>provisioning</b> subnet. For example, <b>172.22.0.3</b> .
<b>bootstrapProvisioningIP</b>	The second IP address of the <b>provisioningNetworkCIDR</b> .	The IP address on the bootstrap VM where the provisioning services run while the installer is deploying the control plane (master) nodes. Defaults to the second IP address of the <b>provisioning</b> subnet. For example, <b>172.22.0.2</b> or <b>2620:52:0:1307::2</b> .
<b>externalBridge</b>	<b>baremetal</b>	The name of the <b>baremetal</b> bridge of the hypervisor attached to the <b>baremetal</b> network.




Parameters	Default	Description
<b>provisioningBridge</b>	<b>provisioning</b>	The name of the <b>provisioning</b> bridge on the <b>provisioner</b> host attached to the <b>provisioning</b> network.
<b>defaultMachinePlatform</b>		The default configuration used for machine pools without a platform configuration.
<b>bootstrapOSImage</b>		A URL to override the default operating system image for the bootstrap node. The URL must contain a SHA-256 hash of the image. For example: <a href="https://mirror.openshift.com/rhcos-&lt;version&gt;-qemu.qcow2.gz?sha256=&lt;uncompressed_sha256&gt;">https://mirror.openshift.com/rhcos-&lt;version&gt;-qemu.qcow2.gz?sha256=&lt;uncompressed_sha256&gt;</a> .
<b>clusterOSImage</b>		A URL to override the default operating system for cluster nodes. The URL must include a SHA-256 hash of the image. For example, <a href="https://mirror.openshift.com/images/rhcos-&lt;version&gt;-openstack.qcow2.gz?sha256=&lt;compressed_sha256&gt;">https://mirror.openshift.com/images/rhcos-&lt;version&gt;-openstack.qcow2.gz?sha256=&lt;compressed_sha256&gt;</a> .
<b>provisioningNetwork</b>		<p>The <b>provisioningNetwork</b> configuration setting determines whether the cluster uses the <b>provisioning</b> network. If it does, the configuration setting also determines if the cluster manages the network.</p> <p><b>Disabled:</b> Set this parameter to <b>Disabled</b> to disable the requirement for a <b>provisioning</b> network. When set to <b>Disabled</b>, you must only use virtual media based provisioning, or bring up the cluster using the assisted installer. If <b>Disabled</b> and using power management, BMCs must be accessible from the <b>baremetal</b> network. If <b>Disabled</b>, you must provide two IP addresses on the <b>baremetal</b> network that are used for the provisioning services.</p> <p><b>Managed:</b> Set this parameter to <b>Managed</b>, which is the default, to fully manage the provisioning network, including DHCP, TFTP, and so on.</p> <p><b>Unmanaged:</b> Set this parameter to <b>Unmanaged</b> to enable the provisioning network but take care of manual configuration of DHCP. Virtual media provisioning is recommended but PXE is still available if required.</p>
<b>httpProxy</b>		Set this parameter to the appropriate HTTP proxy used within your environment.
<b>httpsProxy</b>		Set this parameter to the appropriate HTTPS proxy used within your environment.
<b>noProxy</b>		Set this parameter to the appropriate list of exclusions for proxy usage within your environment.

## Hosts

The **hosts** parameter is a list of separate bare metal assets used to build the cluster.

Table 10.5. Hosts

Name	Default	Description
<b>name</b>		The name of the <b>BareMetalHost</b> resource to associate with the details. For example, <b>openshift-master-0</b> .
<b>role</b>		The role of the bare metal node. Either <b>master</b> or <b>worker</b> .
<b>bmc</b>		Connection details for the baseboard management controller. See the BMC addressing section for additional details.
<b>bootMACAddress</b>		<p>The MAC address of the NIC that the host uses for the <b>provisioning</b> network. Ironic retrieves the IP address using the <b>bootMACAddress</b> configuration setting. Then, it binds to the host.</p> <div style="display: flex; align-items: flex-start;"> <div style="flex: 1;">  </div> <div style="flex: 2;"> <p><b>NOTE</b></p> <p>You must provide a valid MAC address from the host if you disabled the <b>provisioning</b> network.</p> </div> </div>

### 10.3.6.7. BMC addressing

Most vendors support Baseboard Management Controller (BMC) addressing with the Intelligent Platform Management Interface (IPMI). IPMI does not encrypt communications. It is suitable for use within a data center over a secured or dedicated management network. Check with your vendor to see if they support Redfish network boot. Redfish delivers simple and secure management for converged, hybrid IT and the Software Defined Data Center (SDDC). Redfish is human readable and machine capable, and leverages common internet and web services standards to expose information directly to the modern tool chain. If your hardware does not support Redfish network boot, use IPMI.

#### IPMI

Hosts using IPMI use the **ipmi://<out-of-band-ip>:<port>** address format, which defaults to port **623** if not specified. The following example demonstrates an IPMI configuration within the **install-config.yaml** file.

```
platform:
  baremetal:
    hosts:
      - name: openshift-master-0
        role: master
        bmc:
          address: ipmi://<out-of-band-ip>
          username: <user>
          password: <password>
```



## IMPORTANT

The **provisioning** network is required when PXE booting using IPMI for BMC addressing. It is not possible to PXE boot hosts without a **provisioning** network. If you deploy without a **provisioning** network, you must use a virtual media BMC addressing option such as **redfish-virtualmedia** or **idrac-virtualmedia**. See "Redfish virtual media for HPE iLO" in the "BMC addressing for HPE iLO" section or "Redfish virtual media for Dell iDRAC" in the "BMC addressing for Dell iDRAC" section for additional details.

### Redfish network boot

To enable Redfish, use **redfish://** or **redfish+http://** to disable TLS. The installer requires both the hostname or the IP address and the path to the system ID. The following example demonstrates a Redfish configuration within the **install-config.yaml** file.

```
platform:
  baremetal:
    hosts:
      - name: openshift-master-0
        role: master
    bmc:
      address: redfish://<out-of-band-ip>/redfish/v1/Systems/1
      username: <user>
      password: <password>
```

While it is recommended to have a certificate of authority for the out-of-band management addresses, you must include **disableCertificateVerification: True** in the **bmc** configuration if using self-signed certificates. The following example demonstrates a Redfish configuration using the **disableCertificateVerification: True** configuration parameter within the **install-config.yaml** file.

```
platform:
  baremetal:
    hosts:
      - name: openshift-master-0
        role: master
    bmc:
      address: redfish://<out-of-band-ip>/redfish/v1/Systems/1
      username: <user>
      password: <password>
      disableCertificateVerification: True
```

### 10.3.6.8. BMC addressing for Dell iDRAC

The **address** field for each **bmc** entry is a URL for connecting to the OpenShift Container Platform cluster nodes, including the type of controller in the URL scheme and its location on the network.

```
platform:
  baremetal:
    hosts:
      - name: <hostname>
        role: <master | worker>
    bmc:
```

```
address: <address> 1
username: <user>
password: <password>
```

- 1** The **address** configuration setting specifies the protocol.

For Dell hardware, Red Hat supports integrated Dell Remote Access Controller (iDRAC) virtual media, Redfish network boot, and IPMI.

### BMC address formats for Dell iDRAC

Protocol	Address Format
iDRAC virtual media	<b>idrac-virtualmedia://&lt;out-of-band-ip&gt;/redfish/v1/Systems/System.Embedded.1</b>
Redfish network boot	<b>redfish://&lt;out-of-band-ip&gt;/redfish/v1/Systems/System.Embedded.1</b>
IPMI	<b>ipmi://&lt;out-of-band-ip&gt;</b>



### IMPORTANT

Use **idrac-virtualmedia** as the protocol for Redfish virtual media. **redfish-virtualmedia** will not work on Dell hardware. Dell's **idrac-virtualmedia** uses the Redfish standard with Dell's OEM extensions.

See the following sections for additional details.

### Redfish virtual media for Dell iDRAC

For Redfish virtual media on Dell servers, use **idrac-virtualmedia://** in the **address** setting. Using **redfish-virtualmedia://** will not work.

The following example demonstrates using iDRAC virtual media within the **install-config.yaml** file.

```
platform:
  baremetal:
    hosts:
      - name: openshift-master-0
        role: master
    bmc:
      address: idrac-virtualmedia://<out-of-band-ip>/redfish/v1/Systems/System.Embedded.1
      username: <user>
      password: <password>
```

While it is recommended to have a certificate of authority for the out-of-band management addresses, you must include **disableCertificateVerification: True** in the **bmc** configuration if using self-signed certificates. The following example demonstrates a Redfish configuration using the **disableCertificateVerification: True** configuration parameter within the **install-config.yaml** file.

```
platform:
  baremetal:
    hosts:
```

```

- name: openshift-master-0
  role: master
  bmc:
    address: idrac-virtualmedia://<out-of-band-ip>/redfish/v1/Systems/System.Embedded.1
    username: <user>
    password: <password>
    disableCertificateVerification: True

```

## NOTE

Currently, Redfish is only supported on Dell with iDRAC firmware versions **4.20.20.20** through **04.40.00.00** for installer-provisioned installations on bare metal deployments. There is a known issue with version **04.40.00.00**. With iDRAC 9 firmware version **04.40.00.00**, the Virtual Console plugin defaults to **eHTML5**, which causes problems with the **InsertVirtualMedia** workflow. Set the plugin to **HTML5** to avoid this issue. The menu path is: **Configuration** → **Virtual console** → **Plug-in Type** → **HTML5**.

Ensure the OpenShift Container Platform cluster nodes have AutoAttach Enabled through the iDRAC console. The menu path is: **Configuration** → **Virtual Media** → **Attach Mode** → **AutoAttach**.

Use **idrac-virtualmedia://** as the protocol for Redfish virtual media. Using **redfish-virtualmedia://** will not work on Dell hardware, because the **idrac-virtualmedia://** protocol corresponds to the **idrac** hardware type and the Redfish protocol in Ironic. Dell's **idrac-virtualmedia://** protocol uses the Redfish standard with Dell's OEM extensions. Ironic also supports the **idrac** type with the WSMAN protocol. Therefore, you must specify **idrac-virtualmedia://** to avoid unexpected behavior when electing to use Redfish with virtual media on Dell hardware.

## Redfish network boot for iDRAC

To enable Redfish, use **redfish://** or **redfish+http://** to disable transport layer security (TLS). The installer requires both the hostname or the IP address and the path to the system ID. The following example demonstrates a Redfish configuration within the **install-config.yaml** file.

```

platform:
  baremetal:
    hosts:
      - name: openshift-master-0
        role: master
        bmc:
          address: redfish://<out-of-band-ip>/redfish/v1/Systems/System.Embedded.1
          username: <user>
          password: <password>

```

While it is recommended to have a certificate of authority for the out-of-band management addresses, you must include **disableCertificateVerification: True** in the **bmc** configuration if using self-signed certificates. The following example demonstrates a Redfish configuration using the **disableCertificateVerification: True** configuration parameter within the **install-config.yaml** file.

```

platform:
  baremetal:
    hosts:
      - name: openshift-master-0
        role: master

```

```

bmc:
  address: redfish://<out-of-band-ip>/redfish/v1/Systems/System.Embedded.1
  username: <user>
  password: <password>
  disableCertificateVerification: True

```

## NOTE

Currently, Redfish is only supported on Dell hardware with iDRAC firmware versions **4.20.20.20** through **04.40.00.00** for installer-provisioned installations on bare metal deployments. There is a known issue with version **04.40.00.00**. With iDRAC 9 firmware version **04.40.00.00**, the Virtual Console plugin defaults to **eHTML5**, which causes problems with the **InsertVirtualMedia** workflow. Set the plugin to **HTML5** to avoid this issue. The menu path is: **Configuration** → **Virtual console** → **Plug-in Type** → **HTML5**.

Ensure the OpenShift Container Platform cluster nodes have AutoAttach Enabled through the iDRAC console. The menu path is: **Configuration** → **Virtual Media** → **Attach Mode** → **AutoAttach**.

The **redfish://** URL protocol corresponds to the **redfish** hardware type in Ironic.

### 10.3.6.9. BMC addressing for HPE iLO

The **address** field for each **bmc** entry is a URL for connecting to the OpenShift Container Platform cluster nodes, including the type of controller in the URL scheme and its location on the network.

```

platform:
  baremetal:
    hosts:
      - name: <hostname>
        role: <master | worker>
    bmc:
      address: <address> 1
      username: <user>
      password: <password>

```

**1** The **address** configuration setting specifies the protocol.

For HPE integrated Lights Out (iLO), Red Hat supports Redfish virtual media, Redfish network boot, and IPMI.

Table 10.6. BMC address formats for HPE iLO

Protocol	Address Format
Redfish virtual media	<b>redfish-virtualmedia://&lt;out-of-band-ip&gt;/redfish/v1/Systems/1</b>
Redfish network boot	<b>redfish://&lt;out-of-band-ip&gt;/redfish/v1/Systems/1</b>
IPMI	<b>ipmi://&lt;out-of-band-ip&gt;</b>

See the following sections for additional details.

### Redfish virtual media for HPE iLO

To enable Redfish virtual media for HPE servers, use **redfish-virtualmedia://** in the **address** setting. The following example demonstrates using Redfish virtual media within the **install-config.yaml** file.

```
platform:
  baremetal:
    hosts:
      - name: openshift-master-0
        role: master
    bmc:
      address: redfish-virtualmedia://<out-of-band-ip>/redfish/v1/Systems/1
      username: <user>
      password: <password>
```

While it is recommended to have a certificate of authority for the out-of-band management addresses, you must include **disableCertificateVerification: True** in the **bmc** configuration if using self-signed certificates. The following example demonstrates a Redfish configuration using the **disableCertificateVerification: True** configuration parameter within the **install-config.yaml** file.

```
platform:
  baremetal:
    hosts:
      - name: openshift-master-0
        role: master
    bmc:
      address: redfish-virtualmedia://<out-of-band-ip>/redfish/v1/Systems/1
      username: <user>
      password: <password>
      disableCertificateVerification: True
```



#### NOTE

Redfish virtual media is not supported on 9th generation systems running iLO4, because Ironic does not support iLO4 with virtual media.

### Redfish network boot for HPE iLO

To enable Redfish, use **redfish://** or **redfish+http://** to disable TLS. The installer requires both the hostname or the IP address and the path to the system ID. The following example demonstrates a Redfish configuration within the **install-config.yaml** file.

```
platform:
  baremetal:
    hosts:
      - name: openshift-master-0
        role: master
    bmc:
      address: redfish://<out-of-band-ip>/redfish/v1/Systems/1
      username: <user>
      password: <password>
```

While it is recommended to have a certificate of authority for the out-of-band management addresses, you must include **disableCertificateVerification: True** in the **bmc** configuration if using self-signed certificates. The following example demonstrates a Redfish configuration using the **disableCertificateVerification: True** configuration parameter within the **install-config.yaml** file.

```
platform:
  baremetal:
    hosts:
      - name: openshift-master-0
        role: master
    bmc:
      address: redfish://<out-of-band-ip>/redfish/v1/Systems/1
      username: <user>
      password: <password>
      disableCertificateVerification: True
```

### 10.3.6.10. BMC addressing for Fujitsu iRMC

The **address** field for each **bmc** entry is a URL for connecting to the OpenShift Container Platform cluster nodes, including the type of controller in the URL scheme and its location on the network.

```
platform:
  baremetal:
    hosts:
      - name: <hostname>
        role: <master | worker>
    bmc:
      address: <address> 1
      username: <user>
      password: <password>
```

**1** The **address** configuration setting specifies the protocol.

For Fujitsu hardware, Red Hat supports integrated Remote Management Controller (iRMC) and IPMI.

Table 10.7. BMC address formats for Fujitsu iRMC

Protocol	Address Format
iRMC	<b>irmc://&lt;out-of-band-ip&gt;</b>
IPMI	<b>ipmi://&lt;out-of-band-ip&gt;</b>

### iRMC

Fujitsu nodes can use **irmc://<out-of-band-ip>** and defaults to port **443**. The following example demonstrates an iRMC configuration within the **install-config.yaml** file.

```
platform:
  baremetal:
    hosts:
      - name: openshift-master-0
        role: master
    bmc:
      address: irmc://<out-of-band-ip>
      username: <user>
      password: <password>
```



**NOTE**

Currently Fujitsu supports iRMC S5 firmware version 3.05P and above for installer-provisioned installation on bare metal.

**10.3.6.11. Root device hints**

The **rootDeviceHints** parameter enables the installer to provision the Red Hat Enterprise Linux CoreOS (RHCOS) image to a particular device. The installer examines the devices in the order it discovers them, and compares the discovered values with the hint values. The installer uses the first discovered device that matches the hint value. The configuration can combine multiple hints, but a device must match all hints for the installer to select it.

**Table 10.8. Subfields**

Subfield	Description
<b>deviceName</b>	A string containing a Linux device name like <b>/dev/vda</b> . The hint must match the actual value exactly.
<b>hctl</b>	A string containing a SCSI bus address like <b>0:0:0:0</b> . The hint must match the actual value exactly.
<b>model</b>	A string containing a vendor-specific device identifier. The hint can be a substring of the actual value.
<b>vendor</b>	A string containing the name of the vendor or manufacturer of the device. The hint can be a substring of the actual value.
<b>serialNumber</b>	A string containing the device serial number. The hint must match the actual value exactly.
<b>minSizeGigabytes</b>	An integer representing the minimum size of the device in gigabytes.
<b>wwn</b>	A string containing the unique storage identifier. The hint must match the actual value exactly.
<b>wwnWithExtension</b>	A string containing the unique storage identifier with the vendor extension appended. The hint must match the actual value exactly.
<b>wwnVendorExtension</b>	A string containing the unique vendor storage identifier. The hint must match the actual value exactly.
<b>rotational</b>	A boolean indicating whether the device should be a rotating disk (true) or not (false).

## Example usage

```
- name: master-0
  role: master
  bmc:
    address: ipmi://10.10.0.3:6203
    username: admin
    password: redhat
  bootMACAddress: de:ad:be:ef:00:40
  rootDeviceHints:
    deviceName: "/dev/sda"
```

### 10.3.6.12. Creating the OpenShift Container Platform manifests

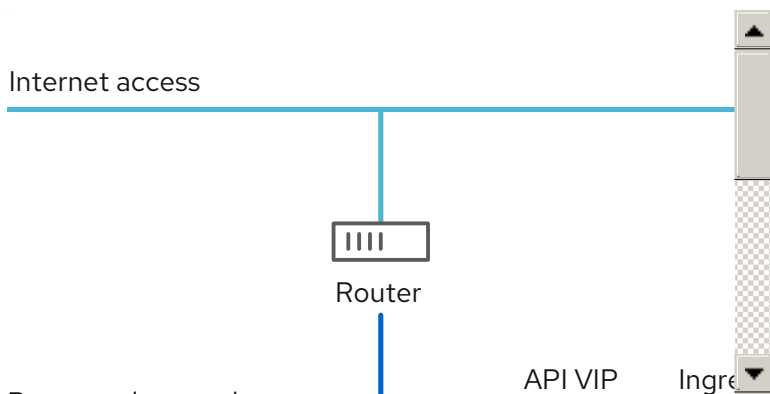
1. Create the OpenShift Container Platform manifests.

```
$ ./openshift-baremetal-install --dir ~/clusterconfigs create manifests
```

```
INFO Consuming Install Config from target directory
WARNING Making control-plane schedulable by setting MastersSchedulable to true for
Scheduler cluster settings
WARNING Discarding the OpenShift Manifest that was provided in the target directory
because its dependencies are dirty and it needs to be regenerated
```

### 10.3.6.13. Configuring NTP for disconnected clusters (optional)

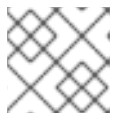
OpenShift Container Platform installs the **chrony** Network Time Protocol (NTP) service on the cluster nodes.



OpenShift Container Platform nodes must agree on a date and time to run properly. When worker nodes retrieve the date and time from the NTP servers on the control plane nodes, it enables the installation and operation of clusters that are not connected to a routable network and thereby do not have access to a higher stratum NTP server.

## Procedure

1. Create a Butane config, **99-master-chrony-conf-override.bu**, including the contents of the **chrony.conf** file for the control plane nodes.

**NOTE**

See "Creating machine configs with Butane" for information about Butane.

**Butane config example**

```
variant: openshift
version: 4.9.0
metadata:
  name: 99-master-chrony-conf-override
  labels:
    machineconfiguration.openshift.io/role: master
storage:
  files:
    - path: /etc/chrony.conf
      mode: 0644
      overwrite: true
      contents:
        inline: |
          # Use public servers from the pool.ntp.org project.
          # Please consider joining the pool (https://www.pool.ntp.org/join.html).

          # The Machine Config Operator manages this file
          server openshift-master-0.<cluster-name>.<domain> iburst 1
          server openshift-master-1.<cluster-name>.<domain> iburst
          server openshift-master-2.<cluster-name>.<domain> iburst

          stratumweight 0
          driftfile /var/lib/chrony/drift
          rtcsync
          makestep 10 3
          bindcmdaddress 127.0.0.1
          bindcmdaddress ::1
          keyfile /etc/chrony.keys
          commandkey 1
          generatecommandkey
          noclientlog
          logchange 0.5
          logdir /var/log/chrony

          # Configure the control plane nodes to serve as local NTP servers
          # for all worker nodes, even if they are not in sync with an
          # upstream NTP server.

          # Allow NTP client access from the local network.
          allow all
          # Serve time even if not synchronized to a time source.
          local stratum 3 orphan
```

1 You must replace **<cluster-name>** with the name of the cluster and replace **<domain>** with the fully qualified domain name.

2. Use Butane to generate a **MachineConfig** object file, **99-master-chrony-conf-override.yaml**, containing the configuration to be delivered to the control plane nodes:

```
$ butane 99-master-chrony-conf-override.bu -o 99-master-chrony-conf-override.yaml
```

3. Create a Butane config, **99-worker-chrony-conf-override.bu**, including the contents of the **chrony.conf** file for the worker nodes that references the NTP servers on the control plane nodes.

### Butane config example

```
variant: openshift
version: 4.9.0
metadata:
  name: 99-worker-chrony-conf-override
  labels:
    machineconfiguration.openshift.io/role: worker
storage:
  files:
    - path: /etc/chrony.conf
      mode: 0644
      overwrite: true
      contents:
        inline: |
          # The Machine Config Operator manages this file.
          server openshift-master-0.<cluster-name>.<domain> iburst 1
          server openshift-master-1.<cluster-name>.<domain> iburst
          server openshift-master-2.<cluster-name>.<domain> iburst

          stratumweight 0
          driftfile /var/lib/chrony/drift
          rtcsync
          makestep 10 3
          bindcmdaddress 127.0.0.1
          bindcmdaddress ::1
          keyfile /etc/chrony.keys
          commandkey 1
          generatecommandkey
          noclientlog
          logchange 0.5
          logdir /var/log/chrony
```

- 1 You must replace **<cluster-name>** with the name of the cluster and replace **<domain>** with the fully qualified domain name.

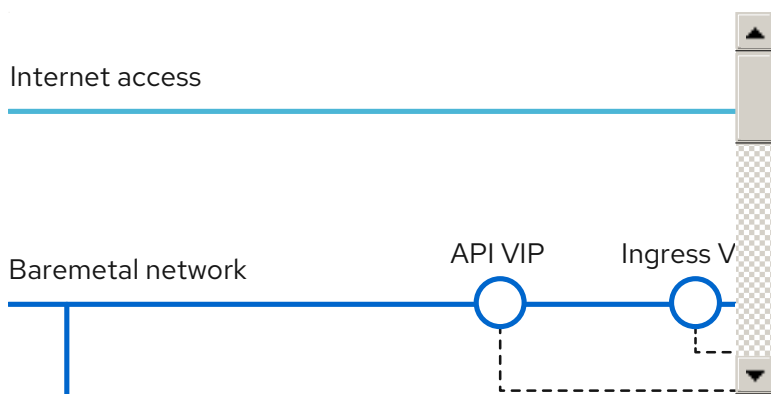
4. Use Butane to generate a **MachineConfig** object file, **99-worker-chrony-conf-override.yaml**, containing the configuration to be delivered to the worker nodes:

```
$ butane 99-worker-chrony-conf-override.bu -o 99-worker-chrony-conf-override.yaml
```

#### 10.3.6.14. (Optional) Configure network components to run on the control plane

You can configure networking components to run exclusively on the control plane nodes. By default, OpenShift Container Platform allows any node in the machine config pool to host the **ingressVIP** virtual IP address. However, some environments deploy worker nodes in separate subnets from the control

plane nodes. When deploying remote workers in separate subnets, you must place the **ingressVIP** virtual IP address exclusively with the control plane nodes.



## Procedure

1. Change to the directory storing the **install-config.yaml** file:

```
$ cd ~/clusterconfigs
```

2. Switch to the **manifests** subdirectory:

```
$ cd manifests
```

3. Create a file named **cluster-network-avoid-workers-99-config.yaml**:

```
$ touch cluster-network-avoid-workers-99-config.yaml
```

4. Open the **cluster-network-avoid-workers-99-config.yaml** file in an editor and enter a custom resource (CR) that describes the Operator configuration:

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  name: 50-worker-fix-ipi-rwn
  labels:
    machineconfiguration.openshift.io/role: worker
spec:
  config:
    ignition:
      version: 3.2.0
    storage:
      files:
        - path: /etc/kubernetes/manifests/keepalived.yaml
          mode: 0644
          contents:
            source: data:,
```

This manifest places the **ingressVIP** virtual IP address on the control plane nodes. Additionally, this manifest deploys the following processes on the control plane nodes only:

- **openshift-ingress-operator**
- **keepalived**

5. Save the **cluster-network-avoid-workers-99-config.yaml** file.
6. Create a **manifests/cluster-ingress-default-ingresscontroller.yaml** file:

```
apiVersion: operator.openshift.io/v1
kind: IngressController
metadata:
  name: default
  namespace: openshift-ingress-operator
spec:
  nodePlacement:
    nodeSelector:
      matchLabels:
        node-role.kubernetes.io/master: ""
```

7. Consider backing up the **manifests** directory. The installer deletes the **manifests/** directory when creating the cluster.
8. Modify the **cluster-scheduler-02-config.yml** manifest to make the control plane nodes schedulable by setting the **mastersSchedulable** field to **true**. Control plane nodes are not schedulable by default. For example:

```
$ sed -i "s;mastersSchedulable: false;mastersSchedulable: true;g"
clusterconfigs/manifests/cluster-scheduler-02-config.yml
```



#### NOTE

If control plane nodes are not schedulable after completing this procedure, deploying the cluster will fail.

### 10.3.6.15. Configuring BIOS for worker node

The following procedure configures BIOS for the worker node during the installation process.

#### Procedure

1. Create manifests.
2. Modify the BMH file corresponding to the worker:

```
$ vim clusterconfigs/openshift/99_openshift-cluster-api_hosts-3.yaml
```

3. Add the BIOS configuration to the **spec** section of the BMH file:

```
spec:
  firmware:
    simultaneousMultithreadingEnabled: true
    sriovEnabled: true
    virtualizationEnabled: true
```

**NOTE**

1. Red Hat supports three BIOS configurations. See the [BMH documentation](#) for details. Only servers with bmc type **irmc** are supported. Other types of servers are currently not supported.

4. Create cluster.

### 10.3.7. Creating a disconnected registry (optional)

In some cases, you might want to install an OpenShift Container Platform cluster using a local copy of the installation registry. This could be for enhancing network efficiency because the cluster nodes are on a network that does not have access to the internet.

A local, or mirrored, copy of the registry requires the following:

- A certificate for the registry node. This can be a self-signed certificate.
- A web server that a container on a system will serve.
- An updated pull secret that contains the certificate and local repository information.

**NOTE**

Creating a disconnected registry on a registry node is optional. The subsequent sections indicate that they are optional since they are steps you need to execute only when creating a disconnected registry on a registry node. You should execute all of the subsequent sub-sections labeled "(optional)" when creating a disconnected registry on a registry node.

#### 10.3.7.1. Preparing the registry node to host the mirrored registry (optional)

Make the following changes to the registry node.

**Procedure**

1. Open the firewall port on the registry node.

```
$ sudo firewall-cmd --add-port=5000/tcp --zone=libvirt --permanent
$ sudo firewall-cmd --add-port=5000/tcp --zone=public --permanent
$ sudo firewall-cmd --reload
```

2. Install the required packages for the registry node.

```
$ sudo yum -y install python3 podman httpd httpd-tools jq
```

3. Create the directory structure where the repository information will be held.

```
$ sudo mkdir -p /opt/registry/{auth,certs,data}
```

#### 10.3.7.2. Generating the self-signed certificate (optional)

Generate a self-signed certificate for the registry node and put it in the **/opt/registry/certs** directory.

## Procedure

1. Adjust the certificate information as appropriate.

```
$ host_fqdn=$( hostname --long )
$ cert_c="<Country Name>" # Country Name (C, 2 letter code)
$ cert_s="<State>"       # Certificate State (S)
$ cert_l="<Locality>"    # Certificate Locality (L)
$ cert_o="<Organization>" # Certificate Organization (O)
$ cert_ou="<Org Unit>"   # Certificate Organizational Unit (OU)
$ cert_cn="${host_fqdn}" # Certificate Common Name (CN)

$ openssl req \
  -newkey rsa:4096 \
  -nodes \
  -sha256 \
  -keyout /opt/registry/certs/domain.key \
  -x509 \
  -days 365 \
  -out /opt/registry/certs/domain.crt \
  -addext "subjectAltName = DNS:${host_fqdn}" \
  -subj "/C=${cert_c}/ST=${cert_s}/L=${cert_l}/O=${cert_o}/OU=${cert_ou}/CN=${cert_cn}"
```



### NOTE

When replacing **<Country Name>**, ensure that it only contains two letters. For example, **US**.

2. Update the registry node's **ca-trust** with the new certificate.

```
$ sudo cp /opt/registry/certs/domain.crt /etc/pki/ca-trust/source/anchors/
$ sudo update-ca-trust extract
```

### 10.3.7.3. Creating the registry podman container (optional)

The registry container uses the **/opt/registry** directory for certificates, authentication files, and to store its data files.

The registry container uses **htpasswd** and needs an **htpasswd** file for authentication.

## Procedure

1. Create an **htpasswd** file in **/opt/registry/auth** for the container to use.

```
$ htpasswd -bBc /opt/registry/auth/htpasswd <user> <passwd>
```

Replace **<user>** with the user name and **<passwd>** with the password.

2. Create and start the registry container.

```
$ podman create \
  --name ocpdiscon-registry \
  -p 5000:5000 \
  -e "REGISTRY_AUTH=htpasswd" \
```



```

-e "REGISTRY_AUTH_HTPASSWD_REALM=Registry" \
-e "REGISTRY_HTTP_SECRET=ALongRandomSecretForRegistry" \
-e "REGISTRY_AUTH_HTPASSWD_PATH=/auth/htpasswd" \
-e "REGISTRY_HTTP_TLS_CERTIFICATE=/certs/domain.crt" \
-e "REGISTRY_HTTP_TLS_KEY=/certs/domain.key" \
-e "REGISTRY_COMPATIBILITY_SCHEMA1_ENABLED=true" \
-v /opt/registry/data:/var/lib/registry:z \
-v /opt/registry/auth:/auth:z \
-v /opt/registry/certs:/certs:z \
docker.io/library/registry:2

```

```
$ podman start ocpdiscon-registry
```

#### 10.3.7.4. Copy and update the pull-secret (optional)

Copy the pull secret file from the provisioner node to the registry node and modify it to include the authentication information for the new registry node.

##### Procedure

1. Copy the **pull-secret.txt** file.

```
$ scp kni@provisioner:/home/kni/pull-secret.txt pull-secret.txt
```

2. Update the **host\_fqdn** environment variable with the fully qualified domain name of the registry node.

```
$ host_fqdn=$( hostname --long )
```

3. Update the **b64auth** environment variable with the base64 encoding of the **http** credentials used to create the **htpasswd** file.

```
$ b64auth=$( echo -n '<username>:<passwd>' | openssl base64 )
```

Replace **<username>** with the user name and **<passwd>** with the password.

4. Set the **AUTHSTRING** environment variable to use the **base64** authorization string. The **\$USER** variable is an environment variable containing the name of the current user.

```
$ AUTHSTRING="{\"$host_fqdn:5000\": {\"auth\": \"\$b64auth\", \"email\": \"\$USER@redhat.com\"}}"
```

5. Update the **pull-secret.txt** file.

```
$ jq ".auths += $AUTHSTRING" < pull-secret.txt > pull-secret-update.txt
```

#### 10.3.7.5. Mirroring the repository (optional)

##### Procedure

1. Copy the **oc** binary from the provisioner node to the registry node.

```
$ sudo scp kni@provisioner:/usr/local/bin/oc /usr/local/bin
```

2. Set the required environment variables.

- a. Set the release version:

```
$ VERSION=<release_version>
```

For **<release\_version>**, specify the tag that corresponds to the version of OpenShift Container Platform to install, such as **4.9**.

- b. Set the local registry name and host port:

```
$ LOCAL_REG='<local_registry_host_name>:<local_registry_host_port>'
```

For **<local\_registry\_host\_name>**, specify the registry domain name for your mirror repository, and for **<local\_registry\_host\_port>**, specify the port that it serves content on.

- c. Set the local repository name:

```
$ LOCAL_REPO='<local_repository_name>'
```

For **<local\_repository\_name>**, specify the name of the repository to create in your registry, such as **ocp4/openshift4**.

3. Mirror the remote install images to the local repository.

```
$ /usr/local/bin/oc adm release mirror \
-a pull-secret-update.txt \
--from=$UPSTREAM_REPO \
--to-release-image=$LOCAL_REG/$LOCAL_REPO:${VERSION} \
--to=$LOCAL_REG/$LOCAL_REPO
```

### 10.3.7.6. Modify the `install-config.yaml` file to use the disconnected registry (optional)

On the provisioner node, the `install-config.yaml` file should use the newly created pull-secret from the `pull-secret-update.txt` file. The `install-config.yaml` file must also contain the disconnected registry node's certificate and registry information.

#### Procedure

1. Add the disconnected registry node's certificate to the `install-config.yaml` file. The certificate should follow the `"additionalTrustBundle: |"` line and be properly indented, usually by two spaces.

```
$ echo "additionalTrustBundle: |" >> install-config.yaml
$ sed -e 's/^/ /' /opt/registry/certs/domain.crt >> install-config.yaml
```

2. Add the mirror information for the registry to the `install-config.yaml` file.

```
$ echo "imageContentSources:" >> install-config.yaml
$ echo "- mirrors:" >> install-config.yaml
$ echo "  - registry.example.com:5000/ocp4/openshift4" >> install-config.yaml
```

```
$ echo " source: quay.io/openshift-release-dev/ocp-release" >> install-config.yaml
$ echo "- mirrors:" >> install-config.yaml
$ echo " - registry.example.com:5000/ocp4/openshift4" >> install-config.yaml
$ echo " source: quay.io/openshift-release-dev/ocp-v4.0-art-dev" >> install-config.yaml
```

**NOTE**

Replace **registry.example.com** with the registry's fully qualified domain name.

### 10.3.8. Deploying routers on worker nodes

During installation, the installer deploys router pods on worker nodes. By default, the installer installs two router pods. If the initial cluster has only one worker node, or if a deployed cluster requires additional routers to handle external traffic loads destined for services within the OpenShift Container Platform cluster, you can create a **yaml** file to set an appropriate number of router replicas.

**NOTE**

By default, the installer deploys two routers. If the cluster has at least two worker nodes, you can skip this section.

**NOTE**

If the cluster has no worker nodes, the installer deploys the two routers on the control plane nodes by default. If the cluster has no worker nodes, you can skip this section.

#### Procedure

1. Create a **router-replicas.yaml** file.

```
apiVersion: operator.openshift.io/v1
kind: IngressController
metadata:
  name: default
  namespace: openshift-ingress-operator
spec:
  replicas: <num-of-router-pods>
  endpointPublishingStrategy:
    type: HostNetwork
  nodePlacement:
    nodeSelector:
      matchLabels:
        node-role.kubernetes.io/worker: ""
```

**NOTE**

Replace **<num-of-router-pods>** with an appropriate value. If working with just one worker node, set **replicas:** to **1**. If working with more than 3 worker nodes, you can increase **replicas:** from the default value **2** as appropriate.

2. Save and copy the **router-replicas.yaml** file to the **clusterconfigs/openshift** directory.

```
cp ~/router-replicas.yaml clusterconfigs/openshift/99_router-replicas.yaml
```

-

### 10.3.9. Validation checklist for installation

- OpenShift Container Platform installer has been retrieved.
- OpenShift Container Platform installer has been extracted.
- Required parameters for the **install-config.yaml** have been configured.
- The **hosts** parameter for the **install-config.yaml** has been configured.
- The **bmc** parameter for the **install-config.yaml** has been configured.
- Conventions for the values configured in the **bmc address** field have been applied.
- Created a disconnected registry (optional).
- (optional) Validate disconnected registry settings if in use.
- (optional) Deployed routers on worker nodes.

### 10.3.10. Deploying the cluster via the OpenShift Container Platform installer

Run the OpenShift Container Platform installer:

```
$ ./openshift-baremetal-install --dir ~/clusterconfigs --log-level debug create cluster
```

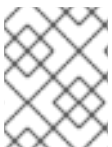
### 10.3.11. Following the installation

During the deployment process, you can check the installation's overall status by issuing the **tail** command to the **.openshift\_install.log** log file in the install directory folder.

```
$ tail -f /path/to/install-dir/.openshift_install.log
```

### 10.3.12. Verifying static IP address configuration

If the DHCP reservation for a cluster node specifies an infinite lease, after the installer successfully provisions the node, the dispatcher script checks the node's network configuration. If the script determines that the network configuration contains an infinite DHCP lease, it creates a new connection using the IP address of the DHCP lease as a static IP address.



#### NOTE

The dispatcher script might run on successfully provisioned nodes while the provisioning of other nodes in the cluster is ongoing.

Verify the network configuration is working properly.

#### Procedure

1. Check the network interface configuration on the node.

- Turn off the DHCP server and reboot the OpenShift Container Platform node and ensure that the network configuration works properly.

### Additional resources

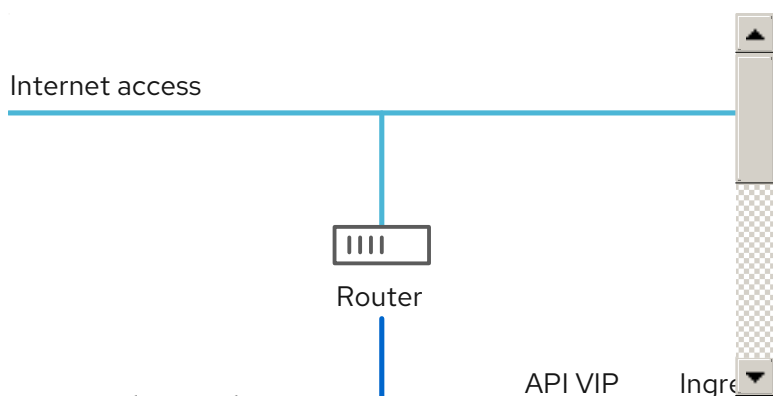
- See [OpenShift Container Platform upgrade channels and releases](#) for an explanation of the different release channels.

## 10.4. INSTALLER-PROVISIONED POST-INSTALLATION CONFIGURATION

After successfully deploying an installer-provisioned cluster, consider the following post-installation procedures.

### 10.4.1. Configuring NTP for disconnected clusters (optional)

OpenShift Container Platform installs the **chrony** Network Time Protocol (NTP) service on the cluster nodes. Use the following procedure to configure NTP servers on the control plane nodes and configure worker nodes as NTP clients of the control plane nodes after a successful deployment.



OpenShift Container Platform nodes must agree on a date and time to run properly. When worker nodes retrieve the date and time from the NTP servers on the control plane nodes, it enables the installation and operation of clusters that are not connected to a routable network and thereby do not have access to a higher stratum NTP server.

### Procedure

- Create a Butane config, **99-master-chrony-conf-override.bu**, including the contents of the **chrony.conf** file for the control plane nodes.



#### NOTE

See "Creating machine configs with Butane" for information about Butane.

### Butane config example

```
variant: openshift
version: 4.9.0
metadata:
  name: 99-master-chrony-conf-override
labels:
  machineconfiguration.openshift.io/role: master
```

```

storage:
  files:
    - path: /etc/chrony.conf
      mode: 0644
      overwrite: true
      contents:
        inline: |
          # Use public servers from the pool.ntp.org project.
          # Please consider joining the pool (https://www.pool.ntp.org/join.html).

          # The Machine Config Operator manages this file
          server openshift-master-0.<cluster-name>.<domain> iburst 1
          server openshift-master-1.<cluster-name>.<domain> iburst
          server openshift-master-2.<cluster-name>.<domain> iburst

          stratumweight 0
          driftfile /var/lib/chrony/drift
          rtcsync
          makestep 10 3
          bindcmdaddress 127.0.0.1
          bindcmdaddress ::1
          keyfile /etc/chrony.keys
          commandkey 1
          generatecommandkey
          noclientlog
          logchange 0.5
          logdir /var/log/chrony

          # Configure the control plane nodes to serve as local NTP servers
          # for all worker nodes, even if they are not in sync with an
          # upstream NTP server.

          # Allow NTP client access from the local network.
          allow all
          # Serve time even if not synchronized to a time source.
          local stratum 3 orphan

```

1 You must replace **<cluster-name>** with the name of the cluster and replace **<domain>** with the fully qualified domain name.

2. Use Butane to generate a **MachineConfig** object file, **99-master-chrony-conf-override.yaml**, containing the configuration to be delivered to the control plane nodes:

```
$ butane 99-master-chrony-conf-override.bu -o 99-master-chrony-conf-override.yaml
```

3. Create a Butane config, **99-worker-chrony-conf-override.bu**, including the contents of the **chrony.conf** file for the worker nodes that references the NTP servers on the control plane nodes.

### Butane config example

```

variant: openshift
version: 4.9.0
metadata:

```

```

name: 99-worker-chrony-conf-override
labels:
  machineconfiguration.openshift.io/role: worker
storage:
files:
  - path: /etc/chrony.conf
    mode: 0644
    overwrite: true
    contents:
      inline: |
        # The Machine Config Operator manages this file.
        server openshift-master-0.<cluster-name>.<domain> iburst 1
        server openshift-master-1.<cluster-name>.<domain> iburst
        server openshift-master-2.<cluster-name>.<domain> iburst

        stratumweight 0
        driftfile /var/lib/chrony/drift
        rtsync
        makestep 10 3
        bindcmdaddress 127.0.0.1
        bindcmdaddress ::1
        keyfile /etc/chrony.keys
        commandkey 1
        generatecommandkey
        noclientlog
        logchange 0.5
        logdir /var/log/chrony

```

1 You must replace **<cluster-name>** with the name of the cluster and replace **<domain>** with the fully qualified domain name.

- Use Butane to generate a **MachineConfig** object file, **99-worker-chrony-conf-override.yaml**, containing the configuration to be delivered to the worker nodes:

```
$ butane 99-worker-chrony-conf-override.bu -o 99-worker-chrony-conf-override.yaml
```

- Apply the **99-master-chrony-conf-override.yaml** policy to the control plane nodes.

```
$ oc apply -f 99-master-chrony-conf-override.yaml
```

### Example output

```
machineconfig.machineconfiguration.openshift.io/99-master-chrony-conf-override created
```

- Apply the **99-worker-chrony-conf-override.yaml** policy to the worker nodes.

```
$ oc apply -f 99-worker-chrony-conf-override.yaml
```

### Example output

```
machineconfig.machineconfiguration.openshift.io/99-worker-chrony-conf-override created
```

7. Check the status of the applied NTP settings.

```
$ oc describe machineconfigpool
```

### 10.4.2. Enabling a provisioning network after installation

The assisted installer and installer-provisioned installation for bare metal clusters provide the ability to deploy a cluster without a **provisioning** network. This capability is for scenarios such as proof-of-concept clusters or deploying exclusively with Redfish virtual media when each node's baseboard management controller is routable via the **baremetal** network.

You can enable a **provisioning** network after installation using the Cluster Baremetal Operator (CBO).

#### Prerequisites

- A dedicated physical network must exist, connected to all worker and control plane nodes.
- You must isolate the native, untagged physical network.
- The network cannot have a DHCP server when the **provisioningNetwork** configuration setting is set to **Managed**.
- You can omit the **provisioningInterface** setting in OpenShift Container Platform 4.9 to use the **bootMACAddress** configuration setting.

#### Procedure

1. When setting the **provisioningInterface** setting, first identify the provisioning interface name for the cluster nodes. For example, **eth0** or **eno1**.
2. Enable the Preboot eXecution Environment (PXE) on the **provisioning** network interface of the cluster nodes.
3. Retrieve the current state of the **provisioning** network and save it to a provisioning custom resource (CR) file:

```
$ oc get provisioning -o yaml > enable-provisioning-nw.yaml
```

4. Modify the provisioning CR file:

```
$ vim ~/enable-provisioning-nw.yaml
```

Scroll down to the **provisioningNetwork** configuration setting and change it from **Disabled** to **Managed**. Then, add the **provisioningOSDownloadURL**, **provisioningIP**, **provisioningNetworkCIDR**, **provisioningDHCPRange**, **provisioningInterface**, and **watchAllNameSpaces** configuration settings after the **provisioningNetwork** setting. Provide appropriate values for each setting.

```
apiVersion: v1
items:
- apiVersion: metal3.io/v1alpha1
  kind: Provisioning
  metadata:
    name: provisioning-configuration
```



```
spec:
  provisioningNetwork: 1
  provisioningOSDownloadURL: 2
  provisioningIP: 3
  provisioningNetworkCIDR: 4
  provisioningDHCPRange: 5
  provisioningInterface: 6
  watchAllNameSpaces: 7
```

- 1 The **provisioningNetwork** is one of **Managed**, **Unmanaged**, or **Disabled**. When set to **Managed**, Metal3 manages the provisioning network and the CBO deploys the Metal3 pod with a configured DHCP server. When set to **Unmanaged**, the system administrator configures the DHCP server manually.
- 2 The **provisioningOSDownloadURL** is a valid HTTPS URL with a valid sha256 checksum that enables the Metal3 pod to download a qcow2 operating system image ending in **.qcow2.gz** or **.qcow2.xz**. This field is required whether the provisioning network is **Managed**, **Unmanaged**, or **Disabled**. For example:  
**http://192.168.0.1/images/rhcos-<version>.x86\_64.qcow2.gz?sha256=<sha>**.
- 3 The **provisioningIP** is the static IP address that the DHCP server and ironic use to provision the network. This static IP address must be within the **provisioning** subnet, and outside of the DHCP range. If you configure this setting, it must have a valid IP address even if the **provisioning** network is **Disabled**. The static IP address is bound to the metal3 pod. If the metal3 pod fails and moves to another server, the static IP address also moves to the new server.
- 4 The Classless Inter-Domain Routing (CIDR) address. If you configure this setting, it must have a valid CIDR address even if the **provisioning** network is **Disabled**. For example:  
**192.168.0.1/24**.
- 5 The DHCP range. This setting is only applicable to a **Managed** provisioning network. Omit this configuration setting if the **provisioning** network is **Disabled**. For example:  
**192.168.0.64, 192.168.0.253**.
- 6 The NIC name for the **provisioning** interface on cluster nodes. The **provisioningInterface** setting is only applicable to **Managed** and **Unmanaged** provisioning networks. Omit the **provisioningInterface** configuration setting if the **provisioning** network is **Disabled**. Omit the **provisioningInterface** configuration setting to use the **bootMACAddress** configuration setting instead.
- 7 Set this setting to **true** if you want metal3 to watch namespaces other than the default **openshift-machine-api** namespace. The default value is **false**.

5. Save the changes to the provisioning CR file.
6. Apply the provisioning CR file to the cluster:

```
$ oc apply -f enable-provisioning-nw.yaml
```

### 10.4.3. Configuring an external load balancer

You can configure an OpenShift Container Platform cluster to use an external load balancer in place of the default load balancer.

## Prerequisites

- On your load balancer, TCP over ports 6443, 443, and 80 must be available to any users of your system.
- Load balance the API port, 6443, between each of the control plane nodes.
- Load balance the application ports, 443 and 80, between all of the compute nodes.
- On your load balancer, port 22623, which is used to serve ignition startup configurations to nodes, is not exposed outside of the cluster.
- Your load balancer must be able to access every machine in your cluster. Methods to allow this access include:
  - Attaching the load balancer to the cluster's machine subnet.
  - Attaching floating IP addresses to machines that use the load balancer.



### IMPORTANT

External load balancing services and the control plane nodes must run on the same L2 network, and on the same VLAN when using VLANs to route traffic between the load balancing services and the control plane nodes.

## Procedure

1. Enable access to the cluster from your load balancer on ports 6443, 443, and 80. As an example, note this HAProxy configuration:

### A section of a sample HAProxy configuration

```
...
listen my-cluster-api-6443
  bind 0.0.0.0:6443
  mode tcp
  balance roundrobin
  server my-cluster-master-2 192.0.2.2:6443 check
  server my-cluster-master-0 192.0.2.3:6443 check
  server my-cluster-master-1 192.0.2.1:6443 check
listen my-cluster-apps-443
  bind 0.0.0.0:443
  mode tcp
  balance roundrobin
  server my-cluster-worker-0 192.0.2.6:443 check
  server my-cluster-worker-1 192.0.2.5:443 check
  server my-cluster-worker-2 192.0.2.4:443 check
listen my-cluster-apps-80
  bind 0.0.0.0:80
  mode tcp
  balance roundrobin
  server my-cluster-worker-0 192.0.2.7:80 check
  server my-cluster-worker-1 192.0.2.9:80 check
  server my-cluster-worker-2 192.0.2.8:80 check
```

2. Add records to your DNS server for the cluster API and apps over the load balancer. For example:

```
<load_balancer_ip_address> api.<cluster_name>.<base_domain>
<load_balancer_ip_address> apps.<cluster_name>.<base_domain>
```

3. From a command line, use **curl** to verify that the external load balancer and DNS configuration are operational.

- a. Verify that the cluster API is accessible:

```
$ curl https://<loadbalancer_ip_address>:6443/version --insecure
```

If the configuration is correct, you receive a JSON object in response:

```
{
  "major": "1",
  "minor": "11+",
  "gitVersion": "v1.11.0+ad103ed",
  "gitCommit": "ad103ed",
  "gitTreeState": "clean",
  "buildDate": "2019-01-09T06:44:10Z",
  "goVersion": "go1.10.3",
  "compiler": "gc",
  "platform": "linux/amd64"
}
```

- b. Verify that cluster applications are accessible:



#### NOTE

You can also verify application accessibility by opening the OpenShift Container Platform console in a web browser.

```
$ curl http://console-openshift-console.apps.<cluster_name>.<base_domain> -I -L --insecure
```

If the configuration is correct, you receive an HTTP response:

```
HTTP/1.1 302 Found
content-length: 0
location: https://console-openshift-console.apps.<cluster-name>.<base domain>/
cache-control: no-cacheHTTP/1.1 200 OK
referrer-policy: strict-origin-when-cross-origin
set-cookie: csrf-
token=39HoZgztDnzjJkq/JuLJMeoKNXIfiVv2YgZc09c3TBOBU4NI6kDXaJH1LdicNhN1UsQ
Wzon4Dor9GWGfopaTEQ==; Path=/; Secure
x-content-type-options: nosniff
x-dns-prefetch-control: off
x-frame-options: DENY
x-xss-protection: 1; mode=block
date: Tue, 17 Nov 2020 08:42:10 GMT
content-type: text/html; charset=utf-8
set-cookie:
```

```
1e2670d92730b515ce3a1bb65da45062=9b714eb87e93cf34853e87a92d6894be; path=/;
HttpOnly; Secure; SameSite=None
cache-control: private
```

## 10.5. EXPANDING THE CLUSTER

After deploying an installer-provisioned OpenShift Container Platform cluster, you can use the following procedures to expand the number of worker nodes. Ensure that each prospective worker node meets the prerequisites.



### NOTE

Expanding the cluster using RedFish Virtual Media involves meeting minimum firmware requirements. See **Firmware requirements for installing with virtual media** in the **Prerequisites** section for additional details when expanding the cluster using RedFish Virtual Media.

### 10.5.1. Preparing the bare metal node

Expanding the cluster requires a DHCP server. Each node must have a DHCP reservation.



#### RESERVING IP ADDRESSES SO THEY BECOME STATIC IP ADDRESSES

Some administrators prefer to use static IP addresses so that each node's IP address remains constant in the absence of a DHCP server. To use static IP addresses in the OpenShift Container Platform cluster, **reserve the IP addresses in the DHCP server with an infinite lease**. After the installer provisions the node successfully, the dispatcher script will check the node's network configuration. If the dispatcher script finds that the network configuration contains a DHCP infinite lease, it will recreate the connection as a static IP connection using the IP address from the DHCP infinite lease. NICs without DHCP infinite leases will remain unmodified.

Setting IP addresses with an infinite lease is incompatible with network configuration deployed by using the Machine Config Operator.

Preparing the bare metal node requires executing the following procedure from the provisioner node.

#### Procedure

1. Get the **oc** binary, if needed. It should already exist on the provisioner node.

```
$ curl -s https://mirror.openshift.com/pub/openshift-v4/clients/ocp/$VERSION/openshift-
client-linux-$VERSION.tar.gz | tar zxvf - oc
```

```
$ sudo cp oc /usr/local/bin
```

2. Power off the bare metal node by using the baseboard management controller, and ensure it is off.
3. Retrieve the user name and password of the bare metal node's baseboard management controller. Then, create **base64** strings from the user name and password:

```
$ echo -ne "root" | base64
```

```
$ echo -ne "password" | base64
```

4. Create a configuration file for the bare metal node.

```
$ vim bmh.yaml
```

```
---
apiVersion: v1
kind: Secret
metadata:
  name: openshift-worker-<num>-bmc-secret
type: Opaque
data:
  username: <base64-of-uid>
  password: <base64-of-pwd>
---
apiVersion: metal3.io/v1alpha1
kind: BareMetalHost
metadata:
  name: openshift-worker-<num>
spec:
  online: true
  bootMACAddress: <NIC1-mac-address>
  bmc:
    address: <protocol>://<bmc-ip>
    credentialsName: openshift-worker-<num>-bmc-secret
```

Replace **<num>** for the worker number of the bare metal node in the two **name** fields and the **credentialsName** field. Replace **<base64-of-uid>** with the **base64** string of the user name. Replace **<base64-of-pwd>** with the **base64** string of the password. Replace **<NIC1-mac-address>** with the MAC address of the bare metal node's first NIC.

See the BMC addressing section for additional BMC configuration options. Replace **<protocol>** with the BMC protocol, such as IPMI, RedFish, or others. Replace **<bmc-ip>** with the IP address of the bare metal node's baseboard management controller.



#### NOTE

If the MAC address of an existing bare metal node matches the MAC address of a bare metal host that you are attempting to provision, then the Ironic installation will fail. If the host enrollment, inspection, cleaning, or other Ironic steps fail, the Bare Metal Operator retries the installation continuously. See [Diagnosing a host duplicate MAC address](#) for more information.

5. Create the bare metal node.

```
$ oc -n openshift-machine-api create -f bmh.yaml
```

```
secret/openshift-worker-<num>-bmc-secret created
baremetalhost.metal3.io/openshift-worker-<num> created
```

Where **<num>** will be the worker number.

- Power up and inspect the bare metal node.

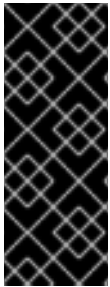
```
$ oc -n openshift-machine-api get bmh openshift-worker-<num>
```

Where **<num>** is the worker node number.

```
NAME                STATE  CONSUMER  ONLINE  ERROR
openshift-worker-<num>  ready      true
```

## 10.5.2. Replacing a bare-metal control plane node

Use the following procedure to replace an installer-provisioned OpenShift Container Platform control plane node.



### IMPORTANT

If you reuse the **BareMetalHost** object definition from an existing control plane host, do not leave the **externallyProvisioned** field set to **true**.

Existing control plane **BareMetalHost** objects may have the **externallyProvisioned** flag set to **true** if they were provisioned by the OpenShift Container Platform installation program.

### Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.
- You have taken an etcd backup.



### IMPORTANT

Take an etcd backup before performing this procedure so that you can restore your cluster if you encounter any issues. For more information about taking an etcd backup, see the *Additional resources* section.

### Procedure

- Ensure that the Bare Metal Operator is available:

```
$ oc get clusteroperator baremetal
```

#### Example output

```
NAME      VERSION  AVAILABLE  PROGRESSING  DEGRADED  SINCE  MESSAGE
baremetal  4.9.0    True       False        False     3d15h
```

- Remove the old **BareMetalHost** and **Machine** objects:

```
$ oc delete bmh -n openshift-machine-api <host_name>
$ oc delete machine -n openshift-machine-api <machine_name>
```

Replace **<host\_name>** with the name of the host and **<machine\_name>** with the name of the machine. The machine name appears under the **CONSUMER** field.

After you remove the **BareMetalHost** and **Machine** objects, then the machine controller automatically deletes the **Node** object.

3. Create the new **BareMetalHost** object and the secret to store the BMC credentials:

```
$ cat <<EOF | oc apply -f -
apiVersion: v1
kind: Secret
metadata:
  name: control-plane-<num>-bmc-secret 1
  namespace: openshift-machine-api
data:
  username: <base64_of_uid> 2
  password: <base64_of_pwd> 3
type: Opaque
---
apiVersion: metal3.io/v1alpha1
kind: BareMetalHost
metadata:
  name: control-plane-<num> 4
  namespace: openshift-machine-api
spec:
  automatedCleaningMode: disabled
  bmc:
    address: <protocol>://<bmc_ip> 5
    credentialsName: control-plane-<num>-bmc-secret 6
  bootMACAddress: <NIC1_mac_address> 7
  bootMode: UEFI
  externallyProvisioned: false
  hardwareProfile: unknown
  online: true
EOF
```

1 4 6 Replace **<num>** for the control plane number of the bare metal node in the **name** fields and the **credentialsName** field.

2 Replace **<base64\_of\_uid>** with the **base64** string of the user name.

3 Replace **<base64\_of\_pwd>** with the **base64** string of the password.

5 Replace **<protocol>** with the BMC protocol, such as **redfish**, **redfish-virtualmedia**, **idrac-virtualmedia**, or others. Replace **<bmc\_ip>** with the IP address of the bare metal node's baseboard management controller. For additional BMC configuration options, see "BMC addressing" in the *Additional resources* section.

7 Replace **<NIC1\_mac\_address>** with the MAC address of the bare metal node's first NIC.

After the inspection is complete, the **BareMetalHost** object is created and available to be provisioned.

4. View available **BareMetalHost** objects:

```
$ oc get bmh -n openshift-machine-api
```

### Example output

NAME	STATE	CONSUMER	ONLINE	ERROR	AGE
control-plane-1.example.com	available	control-plane-1	true		1h10m
control-plane-2.example.com	externally provisioned	control-plane-2		true	4h53m
control-plane-3.example.com	externally provisioned	control-plane-3		true	4h53m
compute-1.example.com	provisioned	compute-1-ktmmx		true	4h53m
compute-1.example.com	provisioned	compute-2-l2zmb		true	4h53m

There are no **MachineSet** objects for control plane nodes, so you must create a **Machine** object instead. You can copy the **providerSpec** from another control plane **Machine** object.

5. Create a **Machine** object:

```
$ cat <<EOF | oc apply -f -
apiVersion: machine.openshift.io/v1beta1
kind: Machine
metadata:
  annotations:
    metal3.io/BareMetalHost: openshift-machine-api/control-plane-<num> 1
  labels:
    machine.openshift.io/cluster-api-cluster: control-plane-<num> 2
    machine.openshift.io/cluster-api-machine-role: master
    machine.openshift.io/cluster-api-machine-type: master
  name: control-plane-<num> 3
  namespace: openshift-machine-api
spec:
  metadata: {}
  providerSpec:
    value:
      apiVersion: baremetal.cluster.k8s.io/v1alpha1
      customDeploy:
        method: install_coreos
      hostSelector: {}
      image:
        checksum: ""
        url: ""
      kind: BareMetalMachineProviderSpec
      metadata:
        creationTimestamp: null
      userData:
        name: master-user-data-managed
EOF
```

- 1
  - 2
  - 3
- Replace **<num>** for the control plane number of the bare metal node in the **name**, **labels** and **annotations** fields.



6. To view the **BareMetalHost** objects, run the following command:

```
$ oc get bmh -A
```

#### Example output

NAME	STATE	CONSUMER	ONLINE	ERROR	AGE
control-plane-1.example.com	provisioned	control-plane-1	true		2h53m
control-plane-2.example.com	externally provisioned	control-plane-2	true		5h53m
control-plane-3.example.com	externally provisioned	control-plane-3	true		5h53m
compute-1.example.com	provisioned	compute-1-ktmmx	true		5h53m
compute-2.example.com	provisioned	compute-2-l2zmb	true		5h53m

7. After the RHCOS installation, verify that the **BareMetalHost** is added to the cluster:

```
$ oc get nodes
```

#### Example output

NAME	STATUS	ROLES	AGE	VERSION
control-plane-1.example.com	available	master	4m2s	v1.18.2
control-plane-2.example.com	available	master	141m	v1.18.2
control-plane-3.example.com	available	master	141m	v1.18.2
compute-1.example.com	available	worker	87m	v1.18.2
compute-2.example.com	available	worker	87m	v1.18.2



#### NOTE

After replacement of the new control plane node, the etcd pod running in the new node is in **crashloopback** status. See "Replacing an unhealthy etcd member" in the *Additional resources* section for more information.

#### Additional resources

- [Replacing an unhealthy etcd member](#)
- [Backing up etcd](#)
- [BMC addressing](#)

### 10.5.3. Preparing to deploy with Virtual Media on the baremetal network

If the **provisioning** network is enabled and you want to expand the cluster using Virtual Media on the **baremetal** network, use the following procedure.

#### Prerequisites

- There is an existing cluster with a **baremetal** network and a **provisioning** network.

## Procedure

1. Edit the **provisioning** custom resource (CR) to enable deploying with Virtual Media on the **baremetal** network:

```
oc edit provisioning
```

```
apiVersion: metal3.io/v1alpha1
kind: Provisioning
metadata:
  creationTimestamp: "2021-08-05T18:51:50Z"
  finalizers:
  - provisioning.metal3.io
  generation: 8
  name: provisioning-configuration
  resourceVersion: "551591"
  uid: f76e956f-24c6-4361-aa5b-feaf72c5b526
spec:
  preProvisioningOSDownloadURLs: {}
  provisioningDHCPRange: 172.22.0.10,172.22.0.254
  provisioningIP: 172.22.0.3
  provisioningInterface: enp1s0
  provisioningNetwork: Managed
  provisioningNetworkCIDR: 172.22.0.0/24
  provisioningOSDownloadURL: http://192.168.111.1/images/rhcos-
<version>.x86_64.qcow2.gz?sha256=<sha256>
  virtualMediaViaExternalNetwork: true 1
status:
  generations:
  - group: apps
    hash: ""
    lastGeneration: 7
    name: metal3
    namespace: openshift-machine-api
    resource: deployments
  - group: apps
    hash: ""
    lastGeneration: 1
    name: metal3-image-cache
    namespace: openshift-machine-api
    resource: daemonsets
  observedGeneration: 8
  readyReplicas: 0
```

- 1** Add **virtualMediaViaExternalNetwork: true** to the **provisioning** CR.

2. Edit the machineset to use the API VIP address:

```
oc edit machineset
```

```
apiVersion: machine.openshift.io/v1beta1
kind: MachineSet
metadata:
  creationTimestamp: "2021-08-05T18:51:52Z"
```

```

generation: 11
labels:
  machine.openshift.io/cluster-api-cluster: ostest-hwmdt
  machine.openshift.io/cluster-api-machine-role: worker
  machine.openshift.io/cluster-api-machine-type: worker
name: ostest-hwmdt-worker-0
namespace: openshift-machine-api
resourceVersion: "551513"
uid: fad1c6e0-b9da-4d4a-8d73-286f78788931
spec:
  replicas: 2
  selector:
    matchLabels:
      machine.openshift.io/cluster-api-cluster: ostest-hwmdt
      machine.openshift.io/cluster-api-machineset: ostest-hwmdt-worker-0
  template:
    metadata:
      labels:
        machine.openshift.io/cluster-api-cluster: ostest-hwmdt
        machine.openshift.io/cluster-api-machine-role: worker
        machine.openshift.io/cluster-api-machine-type: worker
        machine.openshift.io/cluster-api-machineset: ostest-hwmdt-worker-0
    spec:
      metadata: {}
      providerSpec:
        value:
          apiVersion: baremetal.cluster.k8s.io/v1alpha1
          hostSelector: {}
          image:
            checksum: http://172.22.0.3:6181/images/rhcos-<version>.x86_64.qcow2.<md5sum>
            url: http://172.22.0.3:6181/images/rhcos-<version>.x86_64.qcow2
          kind: BareMetalMachineProviderSpec
          metadata:
            creationTimestamp: null
          userData:
            name: worker-user-data
      status:
        availableReplicas: 2
        fullyLabeledReplicas: 2
        observedGeneration: 11
        readyReplicas: 2
        replicas: 2

```

1 Edit the **checksum** URL to use the API VIP address.

2 Edit the **url** URL to use the API VIP address.

#### 10.5.4. Diagnosing a duplicate MAC address when provisioning a new host in the cluster

If the MAC address of an existing bare-metal node in the cluster matches the MAC address of a bare-metal host you are attempting to add to the cluster, the Bare Metal Operator associates the host with the existing node. If the host enrollment, inspection, cleaning, or other Ironic steps fail, the Bare Metal

Operator retries the installation continuously. A registration error is displayed for the failed bare-metal host.

You can diagnose a duplicate MAC address by examining the bare-metal hosts that are running in the **openshift-machine-api** namespace.

### Prerequisites

- Install an OpenShift Container Platform cluster on bare metal.
- Install the OpenShift Container Platform CLI **oc**.
- Log in as a user with **cluster-admin** privileges.

### Procedure

To determine whether a bare-metal host that fails provisioning has the same MAC address as an existing node, do the following:

1. Get the bare-metal hosts running in the **openshift-machine-api** namespace:

```
$ oc get bmh -n openshift-machine-api
```

#### Example output

NAME	STATUS	PROVISIONING STATUS	CONSUMER
openshift-master-0	OK	externally provisioned	openshift-zpwpq-master-0
openshift-master-1	OK	externally provisioned	openshift-zpwpq-master-1
openshift-master-2	OK	externally provisioned	openshift-zpwpq-master-2
openshift-worker-0	OK	provisioned	openshift-zpwpq-worker-0-lv84n
openshift-worker-1	OK	provisioned	openshift-zpwpq-worker-0-zd8lm
openshift-worker-2	error	registering	

2. To see more detailed information about the status of the failing host, run the following command replacing **<bare\_metal\_host\_name>** with the name of the host:

```
$ oc get -n openshift-machine-api bmh <bare_metal_host_name> -o yaml
```

#### Example output

```
...
status:
  errorCount: 12
  errorMessage: MAC address b4:96:91:1d:7c:20 conflicts with existing node openshift-
worker-1
  errorType: registration error
...
```

### 10.5.5. Provisioning the bare metal node

Provisioning the bare metal node requires executing the following procedure from the provisioner node.

#### Procedure

1. Ensure the **STATE** is **ready** before provisioning the bare metal node.

```
$ oc -n openshift-machine-api get bmh openshift-worker-<num>
```

Where **<num>** is the worker node number.

```
NAME                STATE  CONSUMER  ONLINE  ERROR
openshift-worker-<num> ready   true
```

2. Get a count of the number of worker nodes.

```
$ oc get nodes
```

```
NAME                                STATUS  ROLES  AGE  VERSION
provisioner.openshift.example.com    Ready  master  30h  v1.22.1
openshift-master-1.openshift.example.com  Ready  master  30h  v1.22.1
openshift-master-2.openshift.example.com  Ready  master  30h  v1.22.1
openshift-master-3.openshift.example.com  Ready  master  30h  v1.22.1
openshift-worker-0.openshift.example.com  Ready  master  30h  v1.22.1
openshift-worker-1.openshift.example.com  Ready  master  30h  v1.22.1
```

3. Get the machine set.

```
$ oc get machinesets -n openshift-machine-api
```

```
NAME                DESIRED  CURRENT  READY  AVAILABLE  AGE
...
openshift-worker-0.example.com  1        1        1        1        55m
openshift-worker-1.example.com  1        1        1        1        55m
```

4. Increase the number of worker nodes by one.

```
$ oc scale --replicas=<num> machineset <machineset> -n openshift-machine-api
```

Replace **<num>** with the new number of worker nodes. Replace **<machineset>** with the name of the machine set from the previous step.

5. Check the status of the bare metal node.

```
$ oc -n openshift-machine-api get bmh openshift-worker-<num>
```

Where **<num>** is the worker node number. The STATE changes from **ready** to **provisioning**.

```
NAME                STATE  CONSUMER  ONLINE  ERROR
openshift-worker-<num> provisioning  openshift-worker-<num>-65tjz  true
```

The **provisioning** status remains until the OpenShift Container Platform cluster provisions the node. This can take 30 minutes or more. After the node is provisioned, the state will change to **provisioned**.

```
NAME                STATE  CONSUMER  ONLINE  ERROR
openshift-worker-<num> provisioning  openshift-worker-<num>-65tjz  true
```

6. After provisioning completes, ensure the bare metal node is ready.

```
$ oc get nodes
```

```
NAME                                STATUS  ROLES  AGE   VERSION
provisioner.openshift.example.com    Ready  master 30h   v1.22.1
openshift-master-1.openshift.example.com  Ready  master 30h   v1.22.1
openshift-master-2.openshift.example.com  Ready  master 30h   v1.22.1
openshift-master-3.openshift.example.com  Ready  master 30h   v1.22.1
openshift-worker-0.openshift.example.com  Ready  master 30h   v1.22.1
openshift-worker-1.openshift.example.com  Ready  master 30h   v1.22.1
openshift-worker-<num>.openshift.example.com Ready  worker 3m27s v1.22.1
```

You can also check the kubelet.

```
$ ssh openshift-worker-<num>
```

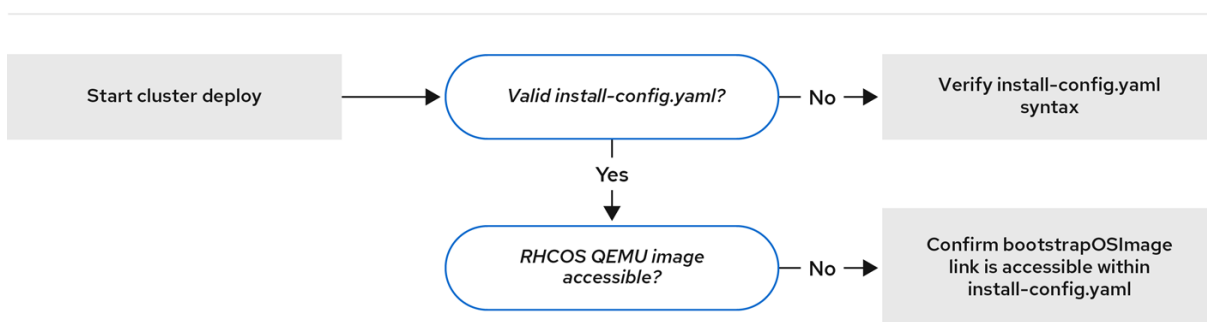
```
[kni@openshift-worker-<num>]$ journalctl -fu kubelet
```

## 10.6. TROUBLESHOOTING

### 10.6.1. Troubleshooting the installer workflow

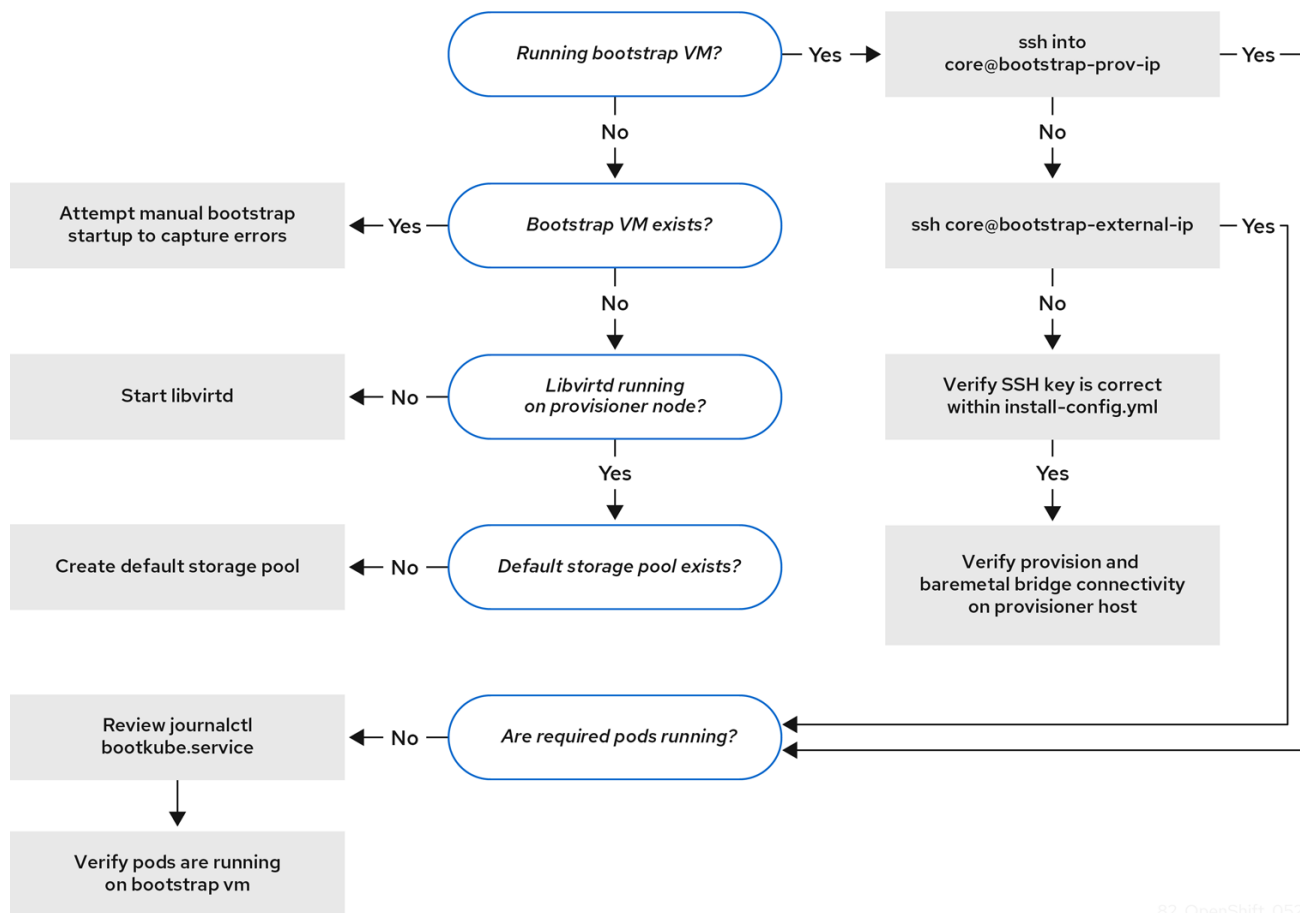
Prior to troubleshooting the installation environment, it is critical to understand the overall flow of the installer-provisioned installation on bare metal. The diagrams below provide a troubleshooting flow with a step-by-step breakdown for the environment.

Workflow 1 of 4



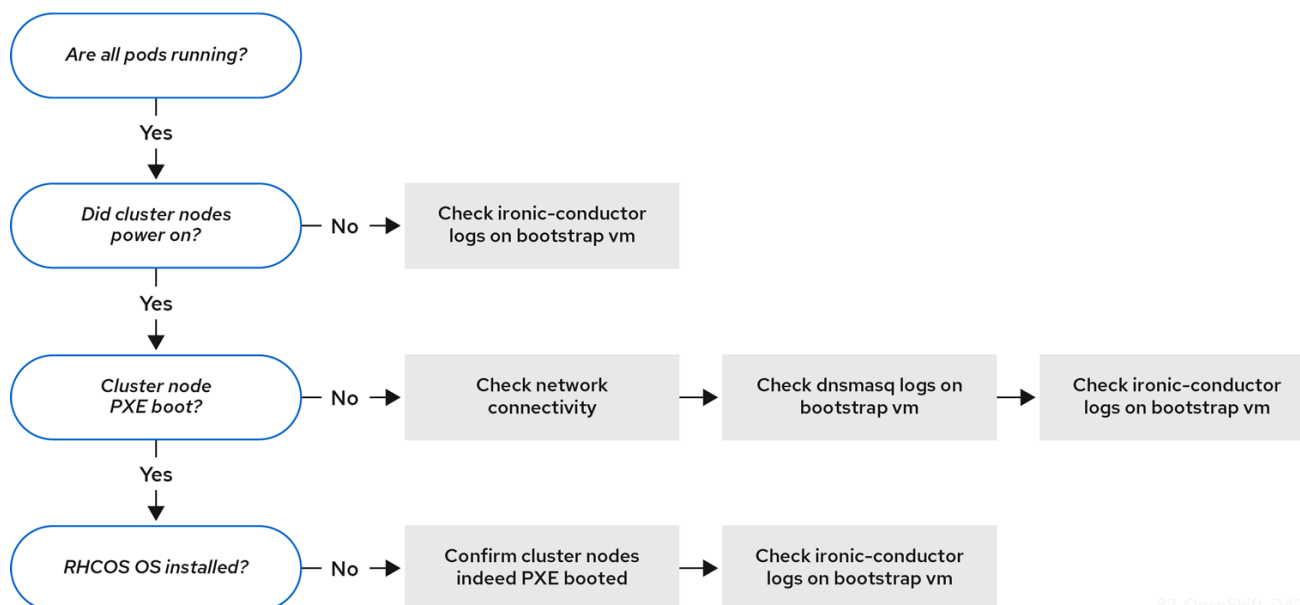
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*Workflow 1 of 4* illustrates a troubleshooting workflow when the **install-config.yaml** file has errors or the Red Hat Enterprise Linux CoreOS (RHCOS) images are inaccessible. Troubleshooting suggestions can be found at [Troubleshooting install-config.yaml](#).



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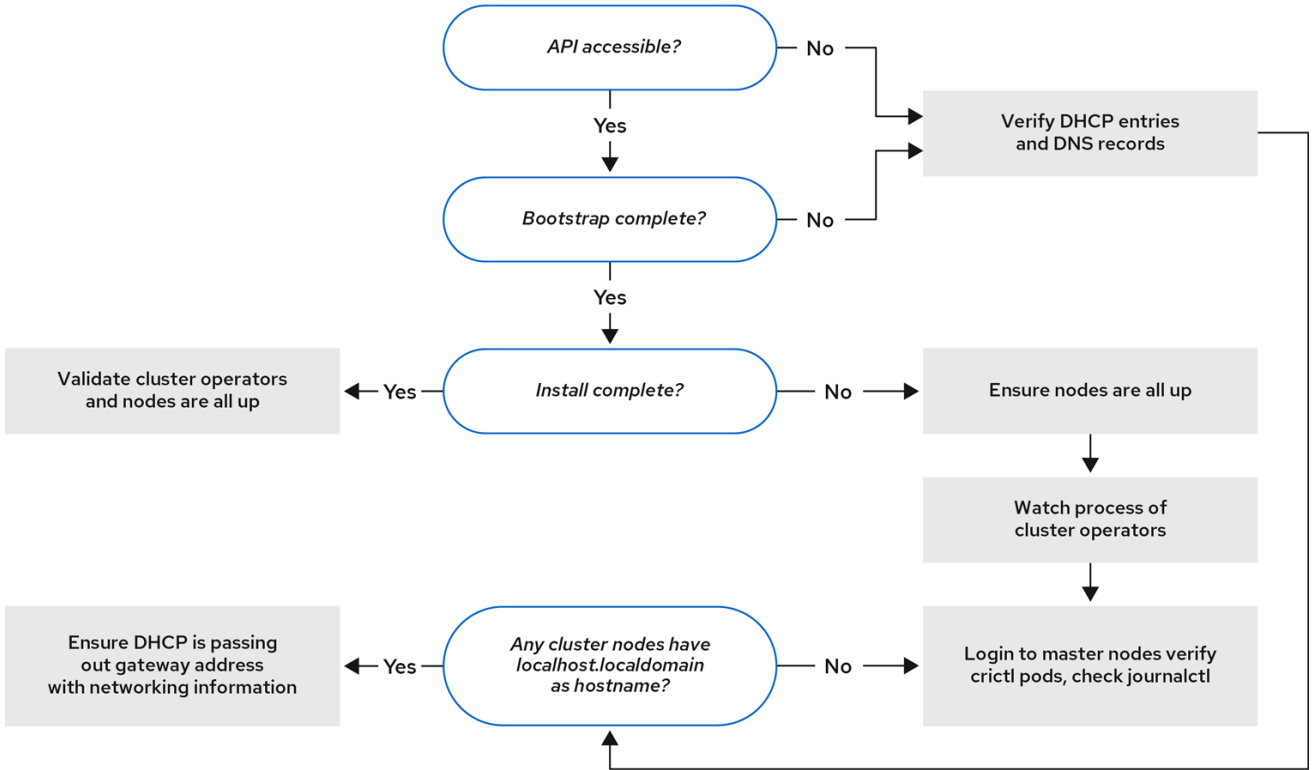
Workflow 2 of 4 illustrates a troubleshooting workflow for [bootstrap VM issues](#), [bootstrap VMs that cannot boot up the cluster nodes](#), and [inspecting logs](#). When installing an OpenShift Container Platform cluster without the **provisioning** network, this workflow does not apply.



82\_OpenShift\_0420

Workflow 3 of 4 illustrates a troubleshooting workflow for [cluster nodes that will not PXE boot](#). If installing using RedFish Virtual Media, each node must meet minimum firmware requirements for the installer to deploy the node. See **Firmware requirements for installing with virtual media** in the **Prerequisites** section for additional details.

Workflow 4 of 4



82\_OpenShift\_0420

Workflow 4 of 4 illustrates a troubleshooting workflow from [a non-accessible API](#) to a [validated installation](#).

### 10.6.2. Troubleshooting install-config.yaml

The **install-config.yaml** configuration file represents all of the nodes that are part of the OpenShift Container Platform cluster. The file contains the necessary options consisting of but not limited to **apiVersion**, **baseDomain**, **imageContentSources** and virtual IP addresses. If errors occur early in the deployment of the OpenShift Container Platform cluster, the errors are likely in the **install-config.yaml** configuration file.

#### Procedure

1. Use the guidelines in [YAML-tips](#).
2. Verify the YAML syntax is correct using [syntax-check](#).
3. Verify the Red Hat Enterprise Linux CoreOS (RHCOS) QEMU images are properly defined and accessible via the URL provided in the **install-config.yaml**. For example:



```
$ curl -s -o /dev/null -I -w "%{http_code}\n" http://webserver.example.com:8080/rhcos-44.81.202004250133-0-qemu.x86_64.qcow2.gz?sha256=7d884b46ee54fe87bbc3893bf2aa99af3b2d31f2e19ab5529c60636fbd0f1ce7
```

If the output is **200**, there is a valid response from the webserver storing the bootstrap VM image.

### 10.6.3. Bootstrap VM issues

The OpenShift Container Platform installation program spawns a bootstrap node virtual machine, which handles provisioning the OpenShift Container Platform cluster nodes.

#### Procedure

1. About 10 to 15 minutes after triggering the installation program, check to ensure the bootstrap VM is operational using the **virsh** command:

```
$ sudo virsh list
```

```
Id Name State
-----
12 openshift-xf6fq-bootstrap running
```



#### NOTE

The name of the bootstrap VM is always the cluster name followed by a random set of characters and ending in the word "bootstrap."

If the bootstrap VM is not running after 10–15 minutes, troubleshoot why it is not running. Possible issues include:

2. Verify **libvirtd** is running on the system:

```
$ systemctl status libvirtd
```

```
● libvirtd.service - Virtualization daemon
   Loaded: loaded (/usr/lib/systemd/system/libvirtd.service; enabled; vendor preset: enabled)
   Active: active (running) since Tue 2020-03-03 21:21:07 UTC; 3 weeks 5 days ago
     Docs: man:libvirtd(8)
           https://libvirt.org
   Main PID: 9850 (libvirtd)
    Tasks: 20 (limit: 32768)
   Memory: 74.8M
   CGroup: /system.slice/libvirtd.service
           └─ 9850 /usr/sbin/libvirtd
```

If the bootstrap VM is operational, log in to it.

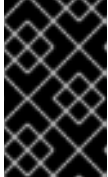
3. Use the **virsh console** command to find the IP address of the bootstrap VM:

```
$ sudo virsh console example.com
```

```

Connected to domain example.com
Escape character is ^]
Red Hat Enterprise Linux CoreOS 43.81.202001142154.0 (Ootpa) 4.3
SSH host key: SHA256:BRWJktXZgQQRY5zjuAV0IKZ4WM7i4TiUyMVAnqu9Pqg (ED25519)
SSH host key: SHA256:7+iKGA7VtG5szmk2jB5gl/5EZ+SNcJ3a2g23o0Inlio (ECDSA)
SSH host key: SHA256:DH5VWhvhvagOTaLsYiVNse9ca+ZSW/30OOMed8rIGOc (RSA)
ens3: fd35:919d:4042:2:c7ed:9a9f:a9ec:7
ens4: 172.22.0.2 fe80::1d05:e52e:be5d:263f
localhost login:

```



### IMPORTANT

When deploying an OpenShift Container Platform cluster without the **provisioning** network, you must use a public IP address and not a private IP address like **172.22.0.2**.

- After you obtain the IP address, log in to the bootstrap VM using the **ssh** command:



### NOTE

In the console output of the previous step, you can use the IPv6 IP address provided by **ens3** or the IPv4 IP provided by **ens4**.

```
$ ssh core@172.22.0.2
```

If you are not successful logging in to the bootstrap VM, you have likely encountered one of the following scenarios:

- You cannot reach the **172.22.0.0/24** network. Verify the network connectivity between the provisioner and the **provisioning** network bridge. This issue might occur if you are using a **provisioning** network.
- You cannot reach the bootstrap VM through the public network. When attempting to SSH via **baremetal** network, verify connectivity on the **provisioner** host specifically around the **baremetal** network bridge.
- You encountered **Permission denied (publickey,password,keyboard-interactive)**. When attempting to access the bootstrap VM, a **Permission denied** error might occur. Verify that the SSH key for the user attempting to log into the VM is set within the **install-config.yaml** file.

#### 10.6.3.1. Bootstrap VM cannot boot up the cluster nodes

During the deployment, it is possible for the bootstrap VM to fail to boot the cluster nodes, which prevents the VM from provisioning the nodes with the RHCOS image. This scenario can arise due to:

- A problem with the **install-config.yaml** file.
- Issues with out-of-band network access when using the baremetal network.

To verify the issue, there are three containers related to **ironic**:

- ironic-api**
- ironic-conductor**

- **ironic-inspector**

### Procedure

1. Log in to the bootstrap VM:

```
$ ssh core@172.22.0.2
```

2. To check the container logs, execute the following:

```
[core@localhost ~]$ sudo podman logs -f <container-name>
```

Replace **<container-name>** with one of **ironic-api**, **ironic-conductor**, or **ironic-inspector**. If you encounter an issue where the control plane nodes are not booting up via PXE, check the **ironic-conductor** pod. The **ironic-conductor** pod contains the most detail about the attempt to boot the cluster nodes, because it attempts to log in to the node over IPMI.

### Potential reason

The cluster nodes might be in the **ON** state when deployment started.

### Solution

Power off the OpenShift Container Platform cluster nodes before you begin the installation over IPMI:

```
$ ipmitool -I lanplus -U root -P <password> -H <out-of-band-ip> power off
```

### 10.6.3.2. Inspecting logs

When experiencing issues downloading or accessing the RHCOS images, first verify that the URL is correct in the **install-config.yaml** configuration file.

### Example of internal webserver hosting RHCOS images

```
bootstrapOSImage: http://<ip:port>/rhcos-43.81.202001142154.0-qemu.x86_64.qcow2.gz?
sha256=9d999f55ff1d44f7ed7c106508e5deecd04dc3c06095d34d36bf1cd127837e0c
clusterOSImage: http://<ip:port>/rhcos-43.81.202001142154.0-openstack.x86_64.qcow2.gz?
sha256=a1bda656fa0892f7b936fdc6b6a6086bddaed5dafacedcd7a1e811abb78fe3b0
```

The **ipa-downloader** and **coreos-downloader** containers download resources from a webserver or the external [quay.io](https://quay.io) registry, whichever the **install-config.yaml** configuration file specifies. Verify the following two containers are up and running and inspect their logs as needed:

- **ipa-downloader**
- **coreos-downloader**

### Procedure

1. Log in to the bootstrap VM:

```
$ ssh core@172.22.0.2
```

2. Check the status of the **ipa-downloader** and **coreos-downloader** containers within the bootstrap VM:

```
[core@localhost ~]$ sudo podman logs -f ipa-downloader
```

```
[core@localhost ~]$ sudo podman logs -f coreos-downloader
```

If the bootstrap VM cannot access the URL to the images, use the **curl** command to verify that the VM can access the images.

3. To inspect the **bootkube** logs that indicate if all the containers launched during the deployment phase, execute the following:

```
[core@localhost ~]$ journalctl -xe
```

```
[core@localhost ~]$ journalctl -b -f -u bootkube.service
```

4. Verify all the pods, including **dnsmasq**, **mariadb**, **httpd**, and **ironic**, are running:

```
[core@localhost ~]$ sudo podman ps
```

5. If there are issues with the pods, check the logs of the containers with issues. To check the log of the **ironic-api**, execute the following:

```
[core@localhost ~]$ sudo podman logs <ironic-api>
```

#### 10.6.4. Cluster nodes will not PXE boot

When OpenShift Container Platform cluster nodes will not PXE boot, execute the following checks on the cluster nodes that will not PXE boot. This procedure does not apply when installing an OpenShift Container Platform cluster without the **provisioning** network.

##### Procedure

1. Check the network connectivity to the **provisioning** network.
2. Ensure PXE is enabled on the NIC for the **provisioning** network and PXE is disabled for all other NICs.
3. Verify that the **install-config.yaml** configuration file has the proper hardware profile and boot MAC address for the NIC connected to the **provisioning** network. For example:

##### control plane node settings

```
bootMACAddress: 24:6E:96:1B:96:90 # MAC of bootable provisioning NIC
hardwareProfile: default          #control plane node settings
```

##### Worker node settings

```
bootMACAddress: 24:6E:96:1B:96:90 # MAC of bootable provisioning NIC
hardwareProfile: unknown          #worker node settings
```

## 10.6.5. The API is not accessible

When the cluster is running and clients cannot access the API, domain name resolution issues might impede access to the API.

### Procedure

1. **Hostname Resolution:** Check the cluster nodes to ensure they have a fully qualified domain name, and not just **localhost.localdomain**. For example:

```
$ hostname
```

If a hostname is not set, set the correct hostname. For example:

```
$ hostnamectl set-hostname <hostname>
```

2. **Incorrect Name Resolution:** Ensure that each node has the correct name resolution in the DNS server using **dig** and **nslookup**. For example:

```
$ dig api.<cluster-name>.example.com
```

```
;; <<>> DiG 9.11.4-P2-RedHat-9.11.4-26.P2.el8 <<>> api.<cluster-name>.example.com
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 37551
;; flags: qr aa rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 1, ADDITIONAL: 2

;; OPT PSEUDOSECTION:
;; EDNS: version: 0, flags:; udp: 4096
;; COOKIE: 866929d2f8e8563582af23f05ec44203d313e50948d43f60 (good)
;; QUESTION SECTION:
;api.<cluster-name>.example.com. IN A

;; ANSWER SECTION:
api.<cluster-name>.example.com. 10800 IN A 10.19.13.86

;; AUTHORITY SECTION:
<cluster-name>.example.com. 10800 IN NS <cluster-name>.example.com.

;; ADDITIONAL SECTION:
<cluster-name>.example.com. 10800 IN A 10.19.14.247

;; Query time: 0 msec
;; SERVER: 10.19.14.247#53(10.19.14.247)
;; WHEN: Tue May 19 20:30:59 UTC 2020
;; MSG SIZE rcvd: 140
```

The output in the foregoing example indicates that the appropriate IP address for the **api.<cluster-name>.example.com** VIP is **10.19.13.86**. This IP address should reside on the **baremetal** network.

## 10.6.6. Cleaning up previous installations

In the event of a previous failed deployment, remove the artifacts from the failed attempt before attempting to deploy OpenShift Container Platform again.

## Procedure

1. Power off all bare metal nodes prior to installing the OpenShift Container Platform cluster:

```
$ ipmitool -I lanplus -U <user> -P <password> -H <management-server-ip> power off
```

2. Remove all old bootstrap resources if any are left over from a previous deployment attempt:

```
for i in $(sudo virsh list | tail -n +3 | grep bootstrap | awk {'print $2'});
do
  sudo virsh destroy $i;
  sudo virsh undefine $i;
  sudo virsh vol-delete $i --pool $i;
  sudo virsh vol-delete $i.ign --pool $i;
  sudo virsh pool-destroy $i;
  sudo virsh pool-undefine $i;
done
```

3. Remove the following from the **clusterconfigs** directory to prevent Terraform from failing:

```
$ rm -rf ~/clusterconfigs/auth ~/clusterconfigs/terraform* ~/clusterconfigs/tls
~/clusterconfigs/metadata.json
```

### 10.6.7. Issues with creating the registry

When creating a disconnected registry, you might encounter a "User Not Authorized" error when attempting to mirror the registry. This error might occur if you fail to append the new authentication to the existing **pull-secret.txt** file.

## Procedure

1. Check to ensure authentication is successful:

```
$ /usr/local/bin/oc adm release mirror \
-a pull-secret-update.json
--from=$UPSTREAM_REPO \
--to-release-image=$LOCAL_REG/$LOCAL_REPO:${VERSION} \
--to=$LOCAL_REG/$LOCAL_REPO
```

## NOTE

Example output of the variables used to mirror the install images:

```
UPSTREAM_REPO=${RELEASE_IMAGE}
LOCAL_REG=<registry_FQDN>:<registry_port>
LOCAL_REPO='ocp4/openshift4'
```

The values of **RELEASE\_IMAGE** and **VERSION** were set during the **Retrieving OpenShift Installer** step of the **Setting up the environment for an OpenShift installation** section.

2. After mirroring the registry, confirm that you can access it in your disconnected environment:

```
$ curl -k -u <user>:<password> https://registry.example.com:<registry-port>/v2/_catalog
{"repositories":["<Repo-Name>"]}
```

## 10.6.8. Miscellaneous issues

### 10.6.8.1. Addressing the runtime network not ready error

After the deployment of a cluster you might receive the following error:

```
`runtime network not ready: NetworkReady=false reason:NetworkPluginNotReady message:Network
plugin returns error: Missing CNI default network`
```

The Cluster Network Operator is responsible for deploying the networking components in response to a special object created by the installer. It runs very early in the installation process, after the control plane (master) nodes have come up, but before the bootstrap control plane has been torn down. It can be indicative of more subtle installer issues, such as long delays in bringing up control plane (master) nodes or issues with **apiserver** communication.

#### Procedure

1. Inspect the pods in the **openshift-network-operator** namespace:

```
$ oc get all -n openshift-network-operator
```

```
NAME                                READY STATUS           RESTARTS  AGE
pod/network-operator-69dfd7b577-bg89v 0/1   ContainerCreating 0      149m
```

2. On the **provisioner** node, determine that the network configuration exists:

```
$ kubectl get network.config.openshift.io cluster -oyaml
```

```
apiVersion: config.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  serviceNetwork:
  - 172.30.0.0/16
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  networkType: OpenShiftSDN
```

If it does not exist, the installer did not create it. To determine why the installer did not create it, execute the following:

```
$ openshift-install create manifests
```

3. Check that the **network-operator** is running:

```
$ kubectl -n openshift-network-operator get pods
```

4. Retrieve the logs:

```
$ kubectl -n openshift-network-operator logs -l "name=network-operator"
```

On high availability clusters with three or more control plane (master) nodes, the Operator will perform leader election and all other Operators will sleep. For additional details, see [Troubleshooting](#).

### 10.6.8.2. Cluster nodes not getting the correct IPv6 address over DHCP

If the cluster nodes are not getting the correct IPv6 address over DHCP, check the following:

1. Ensure the reserved IPv6 addresses reside outside the DHCP range.
2. In the IP address reservation on the DHCP server, ensure the reservation specifies the correct DHCP Unique Identifier (DUID). For example:

```
# This is a dnsmasq dhcp reservation, 'id:00:03:00:01' is the client id and '18:db:f2:8c:d5:9f' is
the MAC Address for the NIC
id:00:03:00:01:18:db:f2:8c:d5:9f,openshift-master-1,[2620:52:0:1302::6]
```

3. Ensure that route announcements are working.
4. Ensure that the DHCP server is listening on the required interfaces serving the IP address ranges.

### 10.6.8.3. Cluster nodes not getting the correct hostname over DHCP

During IPv6 deployment, cluster nodes must get their hostname over DHCP. Sometimes the **NetworkManager** does not assign the hostname immediately. A control plane (master) node might report an error such as:

```
Failed Units: 2
NetworkManager-wait-online.service
nodeip-configuration.service
```

This error indicates that the cluster node likely booted without first receiving a hostname from the DHCP server, which causes **kubelet** to boot with a **localhost.localdomain** hostname. To address the error, force the node to renew the hostname.

#### Procedure

1. Retrieve the **hostname**:

```
[core@master-X ~]$ hostname
```

If the hostname is **localhost**, proceed with the following steps.



#### NOTE

Where **X** is the control plane node number.



- Force the cluster node to renew the DHCP lease:

```
[core@master-X ~]$ sudo nmcli con up "<bare-metal-nic>"
```

Replace **<bare-metal-nic>** with the wired connection corresponding to the **baremetal** network.

- Check **hostname** again:

```
[core@master-X ~]$ hostname
```

- If the hostname is still **localhost.localdomain**, restart **NetworkManager**:

```
[core@master-X ~]$ sudo systemctl restart NetworkManager
```

- If the hostname is still **localhost.localdomain**, wait a few minutes and check again. If the hostname remains **localhost.localdomain**, repeat the previous steps.

- Restart the **nodeip-configuration** service:

```
[core@master-X ~]$ sudo systemctl restart nodeip-configuration.service
```

This service will reconfigure the **kubelet** service with the correct hostname references.

- Reload the unit files definition since the kubelet changed in the previous step:

```
[core@master-X ~]$ sudo systemctl daemon-reload
```

- Restart the **kubelet** service:

```
[core@master-X ~]$ sudo systemctl restart kubelet.service
```

- Ensure **kubelet** booted with the correct hostname:

```
[core@master-X ~]$ sudo journalctl -fu kubelet.service
```

If the cluster node is not getting the correct hostname over DHCP after the cluster is up and running, such as during a reboot, the cluster will have a pending **csr**. **Do not** approve a **csr**, or other issues might arise.

### Addressing a csr

- Get CSRs on the cluster:

```
$ oc get csr
```

- Verify if a pending **csr** contains **Subject Name: localhost.localdomain**:

```
$ oc get csr <pending_csr> -o jsonpath='{.spec.request}' | base64 --decode | openssl req -noout -text
```

- Remove any **csr** that contains **Subject Name: localhost.localdomain**:

```
$ oc delete csr <wrong_csr>
```

#### 10.6.8.4. Routes do not reach endpoints

During the installation process, it is possible to encounter a Virtual Router Redundancy Protocol (VRRP) conflict. This conflict might occur if a previously used OpenShift Container Platform node that was once part of a cluster deployment using a specific cluster name is still running but not part of the current OpenShift Container Platform cluster deployment using that same cluster name. For example, a cluster was deployed using the cluster name **openshift**, deploying three control plane (master) nodes and three worker nodes. Later, a separate install uses the same cluster name **openshift**, but this redeployment only installed three control plane (master) nodes, leaving the three worker nodes from a previous deployment in an **ON** state. This might cause a Virtual Router Identifier (VRID) conflict and a VRRP conflict.

1. Get the route:

```
$ oc get route oauth-openshift
```

2. Check the service endpoint:

```
$ oc get svc oauth-openshift
```

```
NAME          TYPE      CLUSTER-IP   EXTERNAL-IP  PORT(S)  AGE
oauth-openshift ClusterIP  172.30.19.162 <none>      443/TCP  59m
```

3. Attempt to reach the service from a control plane (master) node:

```
[core@master0 ~]$ curl -k https://172.30.19.162
```

```
{
  "kind": "Status",
  "apiVersion": "v1",
  "metadata": {
  },
  "status": "Failure",
  "message": "forbidden: User \"system:anonymous\" cannot get path \"/\"",
  "reason": "Forbidden",
  "details": {
  },
  "code": 403
```

4. Identify the **authentication-operator** errors from the **provisioner** node:

```
$ oc logs deployment/authentication-operator -n openshift-authentication-operator
```

```
Event(v1.ObjectReference{Kind:"Deployment", Namespace:"openshift-authentication-operator", Name:"authentication-operator", UID:"225c5bd5-b368-439b-9155-5fd3c0459d98", APIVersion:"apps/v1", ResourceVersion:"", FieldPath:""}): type: 'Normal' reason: 'OperatorStatusChanged' Status for clusteroperator/authentication changed: Degraded message changed from "IngressStateEndpointsDegraded: All 2 endpoints for oauth-server are reporting"
```

## Solution

1. Ensure that the cluster name for every deployment is unique, ensuring no conflict.
2. Turn off all the rogue nodes which are not part of the cluster deployment that are using the same cluster name. Otherwise, the authentication pod of the OpenShift Container Platform cluster might never start successfully.

### 10.6.8.5. Failed Ignition during Firstboot

During the Firstboot, the Ignition configuration may fail.

#### Procedure

1. Connect to the node where the Ignition configuration failed:

```
Failed Units: 1
machine-config-daemon-firstboot.service
```

2. Restart the **machine-config-daemon-firstboot** service:

```
[core@worker-X ~]$ sudo systemctl restart machine-config-daemon-firstboot.service
```

### 10.6.8.6. NTP out of sync

The deployment of OpenShift Container Platform clusters depends on NTP synchronized clocks among the cluster nodes. Without synchronized clocks, the deployment may fail due to clock drift if the time difference is greater than two seconds.

#### Procedure

1. Check for differences in the **AGE** of the cluster nodes. For example:

```
$ oc get nodes
```

```
NAME                                STATUS  ROLES  AGE  VERSION
master-0.cloud.example.com  Ready  master  145m  v1.22.1
master-1.cloud.example.com  Ready  master  135m  v1.22.1
master-2.cloud.example.com  Ready  master  145m  v1.22.1
worker-2.cloud.example.com  Ready  worker  100m  v1.22.1
```

2. Check for inconsistent timing delays due to clock drift. For example:

```
$ oc get bmh -n openshift-machine-api
```

```
master-1  error registering master-1 ipmi://<out-of-band-ip>
```

```
$ sudo timedatectl
```

```
Local time: Tue 2020-03-10 18:20:02 UTC
Universal time: Tue 2020-03-10 18:20:02 UTC
RTC time: Tue 2020-03-10 18:36:53
```

```

Time zone: UTC (UTC, +0000)
System clock synchronized: no
NTP service: active
RTC in local TZ: no

```

### Addressing clock drift in existing clusters

1. Create a Butane config file including the contents of the **chrony.conf** file to be delivered to the nodes. In the following example, create **99-master-chrony.bu** to add the file to the control plane nodes. You can modify the file for worker nodes or repeat this procedure for the worker role.



#### NOTE

See "Creating machine configs with Butane" for information about Butane.

```

variant: openshift
version: 4.9.0
metadata:
  name: 99-master-chrony
  labels:
    machineconfiguration.openshift.io/role: master
storage:
  files:
  - path: /etc/chrony.conf
    mode: 0644
    overwrite: true
    contents:
      inline: |
        server <NTP-server> iburst 1
        stratumweight 0
        driftfile /var/lib/chrony/drift
        rtcsync
        makestep 10 3
        bindcmdaddress 127.0.0.1
        bindcmdaddress ::1
        keyfile /etc/chrony.keys
        commandkey 1
        generatecommandkey
        noclientlog
        logchange 0.5
        logdir /var/log/chrony

```

- 1** Replace **<NTP-server>** with the IP address of the NTP server.

2. Use Butane to generate a **MachineConfig** object file, **99-master-chrony.yaml**, containing the configuration to be delivered to the nodes:

```
$ butane 99-master-chrony.bu -o 99-master-chrony.yaml
```

3. Apply the **MachineConfig** object file:

```
$ oc apply -f 99-master-chrony.yaml
```

4. Ensure the **System clock synchronized** value is **yes**:

```
$ sudo timedatectl
```

```
Local time: Tue 2020-03-10 19:10:02 UTC
Universal time: Tue 2020-03-10 19:10:02 UTC
RTC time: Tue 2020-03-10 19:36:53
Time zone: UTC (UTC, +0000)
System clock synchronized: yes
NTP service: active
RTC in local TZ: no
```

To setup clock synchronization prior to deployment, generate the manifest files and add this file to the **openshift** directory. For example:

```
$ cp chrony-masters.yaml ~/clusterconfigs/openshift/99_masters-chrony-configuration.yaml
```

Then, continue to create the cluster.

### 10.6.9. Reviewing the installation

After installation, ensure the installer deployed the nodes and pods successfully.

#### Procedure

1. When the OpenShift Container Platform cluster nodes are installed appropriately, the following **Ready** state is seen within the **STATUS** column:

```
$ oc get nodes
```

```
NAME                STATUS  ROLES    AGE  VERSION
master-0.example.com Ready  master,worker  4h  v1.22.1
master-1.example.com Ready  master,worker  4h  v1.22.1
master-2.example.com Ready  master,worker  4h  v1.22.1
```

2. Confirm the installer deployed all pods successfully. The following command removes any pods that are still running or have completed as part of the output.

```
$ oc get pods --all-namespaces | grep -iv running | grep -iv complete
```

# CHAPTER 11. DEPLOYING INSTALLER-PROVISIONED CLUSTERS ON IBM CLOUD

## 11.1. PREREQUISITES

You can use installer-provisioned installation to install OpenShift Container Platform on IBM Cloud® nodes. This document describes the prerequisites and procedures when installing OpenShift Container Platform on IBM Cloud nodes.



### IMPORTANT

Red Hat supports IPMI and PXE on the **provisioning** network only. Red Hat has not tested Red Fish, virtual media, or other complementary technologies such as Secure Boot on IBM Cloud deployments. The **provisioning** network is required.

Installer-provisioned installation of OpenShift Container Platform requires:

- One provisioner node with Red Hat Enterprise Linux CoreOS (RHCOS) 8.x installed
- Three control plane nodes
- One routable network
- One network for provisioning nodes

Before starting an installer-provisioned installation of OpenShift Container Platform on IBM Cloud, address the following prerequisites and requirements.

### 11.1.1. Setting up IBM Cloud infrastructure

To deploy an OpenShift Container Platform cluster on IBM Cloud®, you must first provision the IBM Cloud nodes.



### IMPORTANT

Red Hat supports IPMI and PXE on the **provisioning** network only. Red Hat has not tested Red Fish, virtual media, or other complementary technologies such as Secure Boot on IBM Cloud deployments. The **provisioning** network is required.

You can customize IBM Cloud nodes using the IBM Cloud API. When creating IBM Cloud nodes, you must consider the following requirements.

#### Use one data center per cluster

All nodes in the OpenShift Container Platform cluster must run in the same IBM Cloud data center.

#### Create public and private VLANs

Create all nodes with a single public VLAN and a single private VLAN.

#### Ensure subnets have sufficient IP addresses

IBM Cloud public VLAN subnets use a /28 prefix by default, which provides 16 IP addresses. That is sufficient for a cluster consisting of three control plane nodes, four worker nodes, and two IP addresses for the API VIP and Ingress VIP on the **baremetal** network. For larger clusters, you might need a smaller prefix.

IBM Cloud private VLAN subnets use a **/26** prefix by default, which provides 64 IP addresses. IBM Cloud will use private network IP addresses to access the Baseboard Management Controller (BMC) of each node. OpenShift Container Platform creates an additional subnet for the **provisioning** network. Network traffic for the **provisioning** network subnet routes through the private VLAN. For larger clusters, you might need a smaller prefix.

**Table 11.1. IP addresses per prefix**

IP addresses	Prefix
32	<b>/27</b>
64	<b>/26</b>
128	<b>/25</b>
256	<b>/24</b>

### Configuring NICs

OpenShift Container Platform deploys with two networks:

- **provisioning**: The **provisioning** network is a non-routable network used for provisioning the underlying operating system on each node that is a part of the OpenShift Container Platform cluster.
- **baremetal**: The **baremetal** network is a routable network. You can use any NIC order to interface with the **baremetal** network, provided it is not the NIC specified in the **provisioningNetworkInterface** configuration setting or the NIC associated to a node's **bootMACAddress** configuration setting for the **provisioning** network.

While the cluster nodes can contain more than two NICs, the installation process only focuses on the first two NICs. For example:

NIC	Network	VLAN
NIC1	<b>provisioning</b>	<provisioning_vlan>
NIC2	<b>baremetal</b>	<baremetal_vlan>

In the previous example, NIC1 on all control plane and worker nodes connects to the non-routable network (**provisioning**) that is only used for the installation of the OpenShift Container Platform cluster. NIC2 on all control plane and worker nodes connects to the routable **baremetal** network.

PXE	Boot order
NIC1 PXE-enabled <b>provisioning</b> network	1
NIC2 <b>baremetal</b> network.	2

**NOTE**

Ensure PXE is enabled on the NIC used for the **provisioning** network and is disabled on all other NICs.

**Configuring canonical names**

Clients access the OpenShift Container Platform cluster nodes over the **baremetal** network. Configure IBM Cloud subdomains or subzones where the canonical name extension is the cluster name.

```
<cluster_name>.<domain>
```

For example:

```
test-cluster.example.com
```

**Creating DNS entries**

You must create DNS **A** record entries resolving to unused IP addresses on the public subnet for the following:

Usage	Host Name	IP
API	api.<cluster_name>.<domain>	<ip>
Ingress LB (apps)	*.apps.<cluster_name>.<domain>	<ip>

Control plane and worker nodes already have DNS entries after provisioning.

The following table provides an example of fully qualified domain names. The API and Nameserver addresses begin with canonical name extensions. The host names of the control plane and worker nodes are examples, so you can use any host naming convention you prefer.

Usage	Host Name	IP
API	api.<cluster_name>.<domain>	<ip>
Ingress LB (apps)	*.apps.<cluster_name>.<domain>	<ip>
Provisioner node	provisioner.<cluster_name>.<domain>	<ip>
Master-0	openshift-master-0.<cluster_name>.<domain>	<ip>
Master-1	openshift-master-1.<cluster_name>.<domain>	<ip>
Master-2	openshift-master-2.<cluster_name>.<domain>	<ip>



Usage	Host Name	IP
Worker-0	openshift-worker-0. <cluster_name>.<domain>	<ip>
Worker-1	openshift-worker-1. <cluster_name>.<domain>	<ip>
Worker-n	openshift-worker-n. <cluster_name>.<domain>	<ip>

OpenShift Container Platform includes functionality that uses cluster membership information to generate **A** records. This resolves the node names to their IP addresses. After the nodes are registered with the API, the cluster can disperse node information without using CoreDNS-mDNS. This eliminates the network traffic associated with multicast DNS.



### IMPORTANT

After provisioning the IBM Cloud nodes, you must create a DNS entry for the **api.** **<cluster\_name>.<domain>** domain name on the external DNS because removing CoreDNS causes the local entry to disappear. Failure to create a DNS record for the **api.** **<cluster\_name>.<domain>** domain name in the external DNS server prevents worker nodes from joining the cluster.

### Network Time Protocol (NTP)

Each OpenShift Container Platform node in the cluster must have access to an NTP server. OpenShift Container Platform nodes use NTP to synchronize their clocks. For example, cluster nodes use SSL certificates that require validation, which might fail if the date and time between the nodes are not in sync.



### IMPORTANT

Define a consistent clock date and time format in each cluster node's BIOS settings, or installation might fail.

### Configure a DHCP server

IBM Cloud does not run DHCP on the public or private VLANs. After provisioning IBM Cloud nodes, you must set up a DHCP server for the public VLAN, which corresponds to OpenShift Container Platform's **baremetal** network.



### NOTE

The IP addresses allocated to each node do not need to match the IP addresses allocated by the IBM Cloud provisioning system.

See the "Configuring the public subnet" section for details.

### Ensure BMC access privileges

The "Remote management" page for each node on the dashboard contains the node's intelligent platform management interface (IPMI) credentials. The default IPMI privileges prevent the user from

making certain boot target changes. You must change the privilege level to **OPERATOR** so that Ironic can make those changes.

In the `install-config.yaml` file, add the `privilegelevel` parameter to the URLs used to configure each BMC. See the "Configuring the `install-config.yaml` file" section for additional details. For example:

```
ipmi://<IP>:<port>?privilegelevel=OPERATOR
```

Alternatively, contact IBM Cloud support and request that they increase the IPMI privileges to **ADMINISTRATOR** for each node.

### Create bare metal servers

Create bare metal servers in the [IBM Cloud dashboard](#) by navigating to **Create resource** → **Bare Metal Server**.

Alternatively, you can create bare metal servers with the `ibmcloud` CLI utility. For example:

```
$ ibmcloud sl hardware create --hostname <SERVERNAME> \
    --domain <DOMAIN> \
    --size <SIZE> \
    --os <OS-TYPE> \
    --datacenter <DC-NAME> \
    --port-speed <SPEED> \
    --billing <BILLING>
```

See [Installing the stand-alone IBM Cloud CLI](#) for details on installing the IBM Cloud CLI.



#### NOTE

IBM Cloud servers might take 3-5 hours to become available.

## 11.2. SETTING UP THE ENVIRONMENT FOR AN OPENSIFT CONTAINER PLATFORM INSTALLATION

### 11.2.1. Preparing the provisioner node for OpenShift Container Platform installation on IBM Cloud

Perform the following steps to prepare the provisioner node.

#### Procedure

1. Log in to the provisioner node via `ssh`.
2. Create a non-root user (`kni`) and provide that user with `sudo` privileges:

```
# useradd kni
```

```
# passwd kni
```

```
# echo "kni ALL=(root) NOPASSWD:ALL" | tee -a /etc/sudoers.d/kni
```

```
# chmod 0440 /etc/sudoers.d/kni
```

- 
- 3. Create an **ssh** key for the new user:

```
# su - kni -c "ssh-keygen -f /home/kni/.ssh/id_rsa -N ""
```

- 4. Log in as the new user on the provisioner node:

```
# su - kni
```

- 5. Use Red Hat Subscription Manager to register the provisioner node:

```
$ sudo subscription-manager register --username=<user> --password=<pass> --auto-attach
```

```
$ sudo subscription-manager repos --enable=rhel-8-for-x86_64-appstream-rpms \
--enable=rhel-8-for-x86_64-baseos-rpms
```



#### NOTE

For more information about Red Hat Subscription Manager, see [Using and Configuring Red Hat Subscription Manager](#).

- 6. Install the following packages:

```
$ sudo dnf install -y libvirt qemu-kvm mkisofs python3-devel jq ipmitool
```

- 7. Modify the user to add the **libvirt** group to the newly created user:

```
$ sudo usermod --append --groups libvirt kni
```

- 8. Start **firewalld**:

```
$ sudo systemctl start firewalld
```

- 9. Enable **firewalld**:

```
$ sudo systemctl enable firewalld
```

- 10. Start the **http** service:

```
$ sudo firewall-cmd --zone=public --add-service=http --permanent
```

```
$ sudo firewall-cmd --reload
```

- 11. Start and enable the **libvirtd** service:

```
$ sudo systemctl enable libvirtd --now
```

- 12. Set the ID of the provisioner node:

```
$ PRVN_HOST_ID=<ID>
```

You can view the ID with the following **ibmcloud** command:

```
$ ibmcloud sl hardware list
```

13. Set the ID of the public subnet:

```
$ PUBLICSUBNETID=<ID>
```

You can view the ID with the following **ibmcloud** command:

```
$ ibmcloud sl subnet list
```

14. Set the ID of the private subnet:

```
$ PRIVSUBNETID=<ID>
```

You can view the ID with the following **ibmcloud** command:

```
$ ibmcloud sl subnet list
```

15. Set the provisioner node public IP address:

```
$ PRVN_PUB_IP=$(ibmcloud sl hardware detail $PRVN_HOST_ID --output JSON | jq  
.primaryIpAddress -r)
```

16. Set the CIDR for the public network:

```
$ PUBLICCIDR=$(ibmcloud sl subnet detail $PUBLICSUBNETID --output JSON | jq .cidr)
```

17. Set the IP address and CIDR for the public network:

```
$ PUB_IP_CIDR=$PRVN_PUB_IP/$PUBLICCIDR
```

18. Set the gateway for the public network:

```
$ PUB_GATEWAY=$(ibmcloud sl subnet detail $PUBLICSUBNETID --output JSON | jq  
.gateway -r)
```

19. Set the private IP address of the provisioner node:

```
$ PRVN_PRIV_IP=$(ibmcloud sl hardware detail $PRVN_HOST_ID --output JSON | \  
jq .primaryBackendIpAddress -r)
```

20. Set the CIDR for the private network:

```
$ PRIVCIDR=$(ibmcloud sl subnet detail $PRIVSUBNETID --output JSON | jq .cidr)
```

21. Set the IP address and CIDR for the private network:

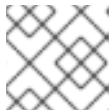
```
$ PRIV_IP_CIDR=$PRVN_PRIV_IP/$PRIVCIDR
```

22. Set the gateway for the private network:

```
$ PRIV_GATEWAY=$(ibmcloud sl subnet detail $PRIVSUBNETID --output JSON | jq
.gateway -r)
```

23. Set up the bridges for the **baremetal** and **provisioning** networks:

```
$ sudo nohup bash -c "
  nmcli --get-values UUID con show | xargs -n 1 nmcli con delete
  nmcli connection add ifname provisioning type bridge con-name provisioning
  nmcli con add type bridge-slave ifname eth1 master provisioning
  nmcli connection add ifname baremetal type bridge con-name baremetal
  nmcli con add type bridge-slave ifname eth2 master baremetal
  nmcli connection modify baremetal ipv4.addresses $PUB_IP_CIDR ipv4.method manual
  ipv4.gateway $PUB_GATEWAY
  nmcli connection modify provisioning ipv4.addresses 172.22.0.1/24,$PRIV_IP_CIDR
  ipv4.method manual
  nmcli connection modify provisioning +ipv4.routes \"10.0.0.0/8 $PRIV_GATEWAY\"
  nmcli con down baremetal
  nmcli con up baremetal
  nmcli con down provisioning
  nmcli con up provisioning
  init 6
"
```



#### NOTE

For **eth1** and **eth2**, substitute the appropriate interface name, as needed.

24. If required, SSH back into the **provisioner** node:

```
# ssh kni@provisioner.<cluster-name>.<domain>
```

25. Verify the connection bridges have been properly created:

```
$ sudo nmcli con show
```

#### Example output

```
NAME          UUID                                TYPE  DEVICE
baremetal     4d5133a5-8351-4bb9-bfd4-3af264801530 bridge baremetal
provisioning  43942805-017f-4d7d-a2c2-7cb3324482ed bridge provisioning
virbr0       d9bca40f-eee1-410b-8879-a2d4bb0465e7 bridge virbr0
bridge-slave-eth1 76a8ed50-c7e5-4999-b4f6-6d9014dd0812 ethernet eth1
bridge-slave-eth2 f31c3353-54b7-48de-893a-02d2b34c4736 ethernet eth2
```

26. Create a **pull-secret.txt** file:

```
$ vim pull-secret.txt
```

In a web browser, navigate to [Install on Bare Metal with user-provisioned infrastructure](#). In step 1, click **Download pull secret**. Paste the contents into the **pull-secret.txt** file and save the contents in the **kni** user's home directory.

## 11.2.2. Configuring the public subnet

All of the OpenShift Container Platform cluster nodes must be on the public subnet. IBM Cloud® does not provide a DHCP server on the subnet. Set it up separately on the provisioner node.

You must reset the BASH variables defined when preparing the provisioner node. Rebooting the provisioner node after preparing it will delete the BASH variables previously set.

### Procedure

1. Install **dnsmasq**:

```
$ sudo dnf install dnsmasq
```

2. Open the **dnsmasq** configuration file:

```
$ sudo vi /etc/dnsmasq.conf
```

3. Add the following configuration to the **dnsmasq** configuration file:

```
interface=baremetal
except-interface=lo
bind-dynamic
log-dhcp

dhcp-range=<ip_addr>,<ip_addr>,<pub_cidr> 1
dhcp-option=baremetal,121,0.0.0.0/0,<pub_gateway>,<prvn_priv_ip>,<prvn_pub_ip> 2

dhcp-hostsfile=/var/lib/dnsmasq/dnsmasq.hostsfile
```

- 1 Set the DHCP range. Replace both instances of **<ip\_addr>** with one unused IP address from the public subnet so that the **dhcp-range** for the **baremetal** network begins and ends with the same the IP address. Replace **<pub\_cidr>** with the CIDR of the public subnet.
- 2 Set the DHCP option. Replace **<pub\_gateway>** with the IP address of the gateway for the **baremetal** network. Replace **<prvn\_priv\_ip>** with the IP address of the provisioner node's private IP address on the **provisioning** network. Replace **<prvn\_pub\_ip>** with the IP address of the provisioner node's public IP address on the **baremetal** network.

To retrieve the value for **<pub\_cidr>**, execute:

```
$ ibmcloud sl subnet detail <publicsubnetid> --output JSON | jq .cidr
```

Replace **<publicsubnetid>** with the ID of the public subnet.

To retrieve the value for **<pub\_gateway>**, execute:

```
$ ibmcloud sl subnet detail <publicsubnetid> --output JSON | jq .gateway -r
```

Replace **<publicsubnetid>** with the ID of the public subnet.

To retrieve the value for **<prvn\_priv\_ip>**, execute:

```
$ ibmcloud sl hardware detail <id> --output JSON | \
jq .primaryBackendIpAddress -r
```

Replace **<id>** with the ID of the provisioner node.

To retrieve the value for **<prvn\_pub\_ip>**, execute:

```
$ ibmcloud sl hardware detail <id> --output JSON | jq .primaryIpAddress -r
```

Replace **<id>** with the ID of the provisioner node.

- Obtain the list of hardware for the cluster:

```
$ ibmcloud sl hardware list
```

- Obtain the MAC addresses and IP addresses for each node:

```
$ ibmcloud sl hardware detail <id> --output JSON | \
jq '.networkComponents[] | \
"\(.primaryIpAddress) \(.macAddress)" | grep -v null
```

Replace **<id>** with the ID of the node.

### Example output

```
"10.196.130.144 00:e0:ed:6a:ca:b4"
"141.125.65.215 00:e0:ed:6a:ca:b5"
```

Make a note of the MAC address and IP address of the public network. Make a separate note of the MAC address of the private network, which you will use later in the **install-config.yaml** file. Repeat this procedure for each node until you have all the public MAC and IP addresses for the public **baremetal** network, and the MAC addresses of the private **provisioning** network.

- Add the MAC and IP address pair of the public **baremetal** network for each node into the **dnsmasq.hostsfile** file:

```
$ sudo vim /var/lib/dnsmasq/dnsmasq.hostsfile
```

### Example input

```
00:e0:ed:6a:ca:b5,141.125.65.215,master-0
<mac>,<ip>,master-1
<mac>,<ip>,master-2
<mac>,<ip>,worker-0
<mac>,<ip>,worker-1
...
```

Replace **<mac>**,**<ip>** with the public MAC address and public IP address of the corresponding node name.

- Start **dnsmasq**:

```
$ sudo systemctl start dnsmasq
```

8. Enable **dnsmasq** so that it starts when booting the node:

```
$ sudo systemctl enable dnsmasq
```

9. Verify **dnsmasq** is running:

```
$ sudo systemctl status dnsmasq
```

#### Example output

```
• dnsmasq.service - DNS caching server.  
Loaded: loaded (/usr/lib/systemd/system/dnsmasq.service; enabled; vendor preset: disabled)  
Active: active (running) since Tue 2021-10-05 05:04:14 CDT; 49s ago  
Main PID: 3101 (dnsmasq)  
Tasks: 1 (limit: 204038)  
Memory: 732.0K  
CGroup: /system.slice/dnsmasq.service  
└─3101 /usr/sbin/dnsmasq -k
```

10. Open ports **53** and **67** with UDP protocol:

```
$ sudo firewall-cmd --add-port 53/udp --permanent
```

```
$ sudo firewall-cmd --add-port 67/udp --permanent
```

11. Add **provisioning** to the external zone with masquerade:

```
$ sudo firewall-cmd --change-zone=provisioning --zone=external --permanent
```

This step ensures network address translation for IPMI calls to the management subnet.

12. Reload the **firewalld** configuration:

```
$ sudo firewall-cmd --reload
```

### 11.2.3. Retrieving the OpenShift Container Platform installer

Use the **stable-4.x** version of the installer to deploy the generally available stable version of OpenShift Container Platform:

```
$ export VERSION=stable-4.9  
export RELEASE_IMAGE=$(curl -s https://mirror.openshift.com/pub/openshift-  
v4/clients/ocp/$VERSION/release.txt | grep 'Pull From: quay.io' | awk -F ' ' '{print $3}')
```

### 11.2.4. Extracting the OpenShift Container Platform installer

After retrieving the installer, the next step is to extract it.

#### Procedure

1. Set the environment variables:

-



```
$ export cmd=openshift-baremetal-install
$ export pullsecret_file=~/.pull-secret.txt
$ export extract_dir=$(pwd)
```

2. Get the **oc** binary:

```
$ curl -s https://mirror.openshift.com/pub/openshift-v4/clients/ocp/$VERSION/openshift-client-linux.tar.gz | tar zxvf - oc
```

3. Extract the installer:

```
$ sudo cp oc /usr/local/bin
$ oc adm release extract --registry-config "${pullsecret_file}" --command=$cmd --to "${extract_dir}" ${RELEASE_IMAGE}
$ sudo cp openshift-baremetal-install /usr/local/bin
```

### 11.2.5. Configuring the install-config.yaml file

The **install-config.yaml** file requires some additional details. Most of the information is teaching the installer and the resulting cluster enough about the available IBM Cloud® hardware so that it is able to fully manage it. The material difference between installing on bare metal and installing on IBM Cloud is that you must explicitly set the privilege level for IPMI in the BMC section of the **install-config.yaml** file.

#### Procedure

1. Configure **install-config.yaml**. Change the appropriate variables to match the environment, including **pullSecret** and **sshKey**.

```
apiVersion: v1
baseDomain: <domain>
metadata:
  name: <cluster_name>
networking:
  machineNetwork:
    - cidr: <public-cidr>
  networkType: OVNKubernetes
compute:
  - name: worker
    replicas: 2
controlPlane:
  name: master
  replicas: 3
  platform:
    baremetal: {}
platform:
  baremetal:
    apiVIP: <api_ip>
    ingressVIP: <wildcard_ip>
    provisioningNetworkInterface: <NIC1>
    provisioningNetworkCIDR: <CIDR>
  hosts:
    - name: openshift-master-0
      role: master
  bmc:
```

```

address: ipmi://10.196.130.145?privilegelevel=OPERATOR 1
username: root
password: <password>
bootMACAddress: 00:e0:ed:6a:ca:b4 2
rootDeviceHints:
  deviceName: "/dev/sda"
- name: openshift-worker-0
  role: worker
  bmc:
    address: ipmi://<out-of-band-ip>?privilegelevel=OPERATOR 3
    username: <user>
    password: <password>
    bootMACAddress: <NIC1_mac_address> 4
    rootDeviceHints:
      deviceName: "/dev/sda"
pullSecret: '<pull_secret>'
sshKey: '<ssh_pub_key>'

```

1 3 The **bmc.address** provides a **privilegelevel** configuration setting with the value set to **OPERATOR**. This is required for IBM Cloud.

2 4 Add the MAC address of the private **provisioning** network NIC for the corresponding node.



#### NOTE

You can use the **ibmcloud** command-line utility to retrieve the password.

```

$ ibmcloud sl hardware detail <id> --output JSON | \
jq ""(.networkManagementIpAddress)
(.remoteManagementAccounts[0].password)""

```

Replace **<id>** with the ID of the node.

2. Create a directory to store the cluster configuration:

```
$ mkdir ~/clusterconfigs
```

3. Copy the **install-config.yaml** file into the directory:

```
$ cp install-config.yaml ~/clusterconfig
```

4. Ensure all bare metal nodes are powered off prior to installing the OpenShift Container Platform cluster:

```
$ ipmitool -I lanplus -U <user> -P <password> -H <management_server_ip> power off
```

5. Remove old bootstrap resources if any are left over from a previous deployment attempt:

```

for i in $(sudo virsh list | tail -n +3 | grep bootstrap | awk {'print $2'});
do
  sudo virsh destroy $i;

```

```

sudo virsh undefine $i;
sudo virsh vol-delete $i --pool $i;
sudo virsh vol-delete $i.ign --pool $i;
sudo virsh pool-destroy $i;
sudo virsh pool-undefine $i;
done

```

### 11.2.6. Additional install-config parameters

See the following tables for the required parameters, the **hosts** parameter, and the **bmc** parameter for the **install-config.yaml** file.

Table 11.2. Required parameters

Parameters	Default	Description
<b>baseDomain</b>		The domain name for the cluster. For example, <b>example.com</b> .
<b>bootMode</b>	<b>UEFI</b>	The boot mode for a node. Options are <b>legacy</b> , <b>UEFI</b> , and <b>UEFISecureBoot</b> . If <b>bootMode</b> is not set, Ironic sets it while inspecting the node.
<b>sshKey</b>		The <b>sshKey</b> configuration setting contains the key in the <code>~/.ssh/id_rsa.pub</code> file required to access the control plane nodes and worker nodes. Typically, this key is from the <b>provisioner</b> node.
<b>pullSecret</b>		The <b>pullSecret</b> configuration setting contains a copy of the pull secret downloaded from the <a href="#">Install OpenShift on Bare Metal</a> page when preparing the provisioner node.
<pre> metadata:   name: </pre>		The name to be given to the OpenShift Container Platform cluster. For example, <b>openshift</b> .
<pre> networking:   machineNetwork:     - cidr: </pre>		The public CIDR (Classless Inter-Domain Routing) of the external network. For example, <b>10.0.0.0/24</b> .

Parameters	Default	Description
<code>compute:</code> <code>- name: worker</code>		The OpenShift Container Platform cluster requires a name be provided for worker (or compute) nodes even if there are zero nodes.
<code>compute:</code> <code>replicas: 2</code>		Replicas sets the number of worker (or compute) nodes in the OpenShift Container Platform cluster.
<code>controlPlane:</code> <code>name: master</code>		The OpenShift Container Platform cluster requires a name for control plane (master) nodes.
<code>controlPlane:</code> <code>replicas: 3</code>		Replicas sets the number of control plane (master) nodes included as part of the OpenShift Container Platform cluster.
<code>provisioningNetworkInterface</code>		The name of the network interface on nodes connected to the <b>provisioning</b> network. For OpenShift Container Platform 4.9 and later releases, use the <b>bootMACAddress</b> configuration setting to enable Ironic to identify the IP address of the NIC instead of using the <b>provisioningNetworkInterface</b> configuration setting to identify the name of the NIC.
<code>defaultMachinePlatform</code>		The default configuration used for machine pools without a platform configuration.

Parameters	Default	Description
<b>apiVIP</b>		<p>(Optional) The virtual IP address for Kubernetes API communication.</p> <p>This setting must either be provided in the <b>install-config.yaml</b> file as a reserved IP from the MachineNetwork or pre-configured in the DNS so that the default name resolves correctly. Use the virtual IP address and not the FQDN when adding a value to the <b>apiVIP</b> configuration setting in the <b>install-config.yaml</b> file. The IP address must be from the primary IPv4 network when using dual stack networking. If not set, the installer uses <b>api.&lt;cluster_name&gt;.&lt;base_domain&gt;</b> to derive the IP address from the DNS.</p>
<b>disableCertificateVerification</b>	<b>False</b>	<p><b>redfish</b> and <b>redfish-virtualmedia</b> need this parameter to manage BMC addresses. The value should be <b>True</b> when using a self-signed certificate for BMC addresses.</p>

Parameters	Default	Description
<b>ingressVIP</b>		<p>(Optional) The virtual IP address for ingress traffic.</p> <p>This setting must either be provided in the <b>install-config.yaml</b> file as a reserved IP from the MachineNetwork or pre-configured in the DNS so that the default name resolves correctly. Use the virtual IP address and not the FQDN when adding a value to the <b>ingressVIP</b> configuration setting in the <b>install-config.yaml</b> file. The IP address must be from the primary IPv4 network when using dual stack networking. If not set, the installer uses <b>test.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;</b> to derive the IP address from the DNS.</p>

Table 11.3. Optional Parameters


Parameters	Default	Description
<b>provisioningDHCPRange</b>	<b>172.22.0.10,172.22.0.100</b>	Defines the IP range for nodes on the <b>provisioning</b> network.
<b>provisioningNetworkCIDR</b>	<b>172.22.0.0/24</b>	The CIDR for the network to use for provisioning. This option is required when not using the default address range on the <b>provisioning</b> network.
<b>clusterProvisioningIP</b>	The third IP address of the <b>provisioningNetworkCIDR</b> .	The IP address within the cluster where the provisioning services run. Defaults to the third IP address of the <b>provisioning</b> subnet. For example, <b>172.22.0.3</b> .
<b>bootstrapProvisioningIP</b>	The second IP address of the <b>provisioningNetworkCIDR</b> .	The IP address on the bootstrap VM where the provisioning services run while the installer is deploying the control plane (master) nodes. Defaults to the second IP address of the <b>provisioning</b> subnet. For example, <b>172.22.0.2</b> or <b>2620:52:0:1307::2</b> .
<b>externalBridge</b>	<b>baremetal</b>	The name of the <b>baremetal</b> bridge of the hypervisor attached to the <b>baremetal</b> network.
<b>provisioningBridge</b>	<b>provisioning</b>	The name of the <b>provisioning</b> bridge on the <b>provisioner</b> host attached to the <b>provisioning</b> network.

Parameters	Default	Description
<b>defaultMachinePlatform</b>		The default configuration used for machine pools without a platform configuration.
<b>bootstrapOSImage</b>		A URL to override the default operating system image for the bootstrap node. The URL must contain a SHA-256 hash of the image. For example: <a href="https://mirror.openshift.com/rhcos-&lt;version&gt;-qemu.qcow2.gz?sha256=&lt;uncompressed_sha256&gt;">https://mirror.openshift.com/rhcos-&lt;version&gt;-qemu.qcow2.gz?sha256=&lt;uncompressed_sha256&gt;</a> .
<b>clusterOSImage</b>		A URL to override the default operating system for cluster nodes. The URL must include a SHA-256 hash of the image. For example, <a href="https://mirror.openshift.com/images/rhcos-&lt;version&gt;-openstack.qcow2.gz?sha256=&lt;compressed_sha256&gt;">https://mirror.openshift.com/images/rhcos-&lt;version&gt;-openstack.qcow2.gz?sha256=&lt;compressed_sha256&gt;</a> .
<b>provisioningNetwork</b>		<p>The <b>provisioningNetwork</b> configuration setting determines whether the cluster uses the <b>provisioning</b> network. If it does, the configuration setting also determines if the cluster manages the network.</p> <p><b>Disabled:</b> Set this parameter to <b>Disabled</b> to disable the requirement for a <b>provisioning</b> network. When set to <b>Disabled</b>, you must only use virtual media based provisioning, or bring up the cluster using the assisted installer. If <b>Disabled</b> and using power management, BMCs must be accessible from the <b>baremetal</b> network. If <b>Disabled</b>, you must provide two IP addresses on the <b>baremetal</b> network that are used for the provisioning services.</p> <p><b>Managed:</b> Set this parameter to <b>Managed</b>, which is the default, to fully manage the provisioning network, including DHCP, TFTP, and so on.</p> <p><b>Unmanaged:</b> Set this parameter to <b>Unmanaged</b> to enable the provisioning network but take care of manual configuration of DHCP. Virtual media provisioning is recommended but PXE is still available if required.</p>
<b>httpProxy</b>		Set this parameter to the appropriate HTTP proxy used within your environment.
<b>httpsProxy</b>		Set this parameter to the appropriate HTTPS proxy used within your environment.
<b>noProxy</b>		Set this parameter to the appropriate list of exclusions for proxy usage within your environment.

## Hosts

The **hosts** parameter is a list of separate bare metal assets used to build the cluster.

Table 11.4. Hosts

Name	Default	Description
<b>name</b>		The name of the <b>BareMetalHost</b> resource to associate with the details. For example, <b>openshift-master-0</b> .
<b>role</b>		The role of the bare metal node. Either <b>master</b> or <b>worker</b> .
<b>bmc</b>		Connection details for the baseboard management controller. See the BMC addressing section for additional details.
<b>bootMACAddress</b>		<p>The MAC address of the NIC that the host uses for the <b>provisioning</b> network. Ironic retrieves the IP address using the <b>bootMACAddress</b> configuration setting. Then, it binds to the host.</p> <div style="display: flex; align-items: flex-start;"> <div style="flex: 1;">  </div> <div style="flex: 2;"> <p><b>NOTE</b></p> <p>You must provide a valid MAC address from the host if you disabled the <b>provisioning</b> network.</p> </div> </div>

### 11.2.7. Root device hints

The **rootDeviceHints** parameter enables the installer to provision the Red Hat Enterprise Linux CoreOS (RHCOS) image to a particular device. The installer examines the devices in the order it discovers them, and compares the discovered values with the hint values. The installer uses the first discovered device that matches the hint value. The configuration can combine multiple hints, but a device must match all hints for the installer to select it.

Table 11.5. Subfields

Subfield	Description
<b>deviceName</b>	A string containing a Linux device name like <b>/dev/vda</b> . The hint must match the actual value exactly.
<b>hctl</b>	A string containing a SCSI bus address like <b>0:0:0:0</b> . The hint must match the actual value exactly.
<b>model</b>	A string containing a vendor-specific device identifier. The hint can be a substring of the actual value.



Subfield	Description
<b>vendor</b>	A string containing the name of the vendor or manufacturer of the device. The hint can be a substring of the actual value.
<b>serialNumber</b>	A string containing the device serial number. The hint must match the actual value exactly.
<b>minSizeGigabytes</b>	An integer representing the minimum size of the device in gigabytes.
<b>wwn</b>	A string containing the unique storage identifier. The hint must match the actual value exactly.
<b>wwnWithExtension</b>	A string containing the unique storage identifier with the vendor extension appended. The hint must match the actual value exactly.
<b>wwnVendorExtension</b>	A string containing the unique vendor storage identifier. The hint must match the actual value exactly.
<b>rotational</b>	A boolean indicating whether the device should be a rotating disk (true) or not (false).

### Example usage

```
- name: master-0
  role: master
  bmc:
    address: ipmi://10.10.0.3:6203
    username: admin
    password: redhat
  bootMACAddress: de:ad:be:ef:00:40
  rootDeviceHints:
    deviceName: "/dev/sda"
```

### 11.2.8. Creating the OpenShift Container Platform manifests

1. Create the OpenShift Container Platform manifests.

```
$ ./openshift-baremetal-install --dir ~/clusterconfigs create manifests
```

```
INFO Consuming Install Config from target directory
WARNING Making control-plane schedulable by setting MastersSchedulable to true for
Scheduler cluster settings
```

```
WARNING Discarding the OpenShift Manifest that was provided in the target directory
because its dependencies are dirty and it needs to be regenerated
```

### 11.2.9. Deploying the cluster via the OpenShift Container Platform installer

Run the OpenShift Container Platform installer:

```
$. /openshift-baremetal-install --dir ~/clusterconfigs --log-level debug create cluster
```

### 11.2.10. Following the installation

During the deployment process, you can check the installation's overall status by issuing the **tail** command to the **.openshift\_install.log** log file in the install directory folder.

```
$. tail -f /path/to/install-dir/.openshift_install.log
```

## CHAPTER 12. INSTALLING WITH Z/VM ON IBM Z AND LINUXONE

### 12.1. PREPARING TO INSTALL WITH Z/VM ON IBM Z AND LINUXONE

#### 12.1.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).

#### 12.1.2. Choosing a method to install OpenShift Container Platform with z/VM on IBM Z or LinuxONE

You can install a cluster with z/VM on IBM Z or LinuxONE infrastructure that you provision, by using one of the following methods:

- **Installing a cluster with z/VM on IBM Z and LinuxONE** You can install OpenShift Container Platform with z/VM on IBM Z or LinuxONE infrastructure that you provision.
- **Installing a cluster with z/VM on IBM Z and LinuxONE in a restricted network** You can install OpenShift Container Platform with z/VM on IBM Z or LinuxONE infrastructure that you provision in a restricted or disconnected network, by using an internal mirror of the installation release content. You can use this method to install a cluster that does not require an active internet connection to obtain the software components. You can also use this installation method to ensure that your clusters only use container images that satisfy your organizational controls on external content.

### 12.2. INSTALLING A CLUSTER WITH Z/VM ON IBM Z AND LINUXONE

In OpenShift Container Platform version 4.9, you can install a cluster on IBM Z or LinuxONE infrastructure that you provision.



#### NOTE

While this document refers only to IBM Z, all information in it also applies to LinuxONE.



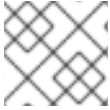
#### IMPORTANT

Additional considerations exist for non-bare metal platforms. Review the information in the [guidelines for deploying OpenShift Container Platform on non-tested platforms](#) before you install an OpenShift Container Platform cluster.

#### 12.2.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).

- Before you begin the installation process, you must clean the installation directory. This ensures that the required installation files are created and updated during the installation process.
- You provisioned [persistent storage using NFS](#) for your cluster. To deploy a private image registry, your storage must provide **ReadWriteMany** access modes.
- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.



#### NOTE

Be sure to also review this site list if you are configuring a proxy.

### 12.2.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



#### IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

### 12.2.3. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

#### 12.2.3.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

**Table 12.1. Minimum required hosts**

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.

Hosts	Description
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.



### IMPORTANT

To improve high availability of your cluster, distribute the control plane machines over different z/VM instances on at least two physical machines.

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 7.9, or RHEL 8.4.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See [Red Hat Enterprise Linux technology capabilities and limits](#) .

#### 12.2.3.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

**Table 12.2. Minimum resource requirements**

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS
Bootstrap	RHCOS	4	16 GB	100 GB	N/A
Control plane	RHCOS	4	16 GB	100 GB	N/A
Compute	RHCOS	2	8 GB	100 GB	N/A

1. One physical core (IFL) provides two logical cores (threads) when SMT-2 is enabled. The hypervisor can provide two or more vCPUs.

#### 12.2.3.3. Minimum IBM Z system environment

You can install OpenShift Container Platform version 4.9 on the following IBM hardware:

- IBM z15 (all models), IBM z14 (all models), IBM z13, and IBM z13s
- LinuxONE, any version

#### Hardware requirements

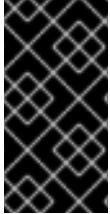
- The equivalent of 6 IFLs, which are SMT2 enabled, for each cluster.

- At least one network connection to both connect to the **LoadBalancer** service and to serve data for traffic outside the cluster.



### NOTE

You can use dedicated or shared IFLs to assign sufficient compute resources. Resource sharing is one of the key strengths of IBM Z. However, you must adjust capacity correctly on each hypervisor layer and ensure sufficient resources for every OpenShift Container Platform cluster.



### IMPORTANT

Since the overall performance of the cluster can be impacted, the LPARs that are used to setup the OpenShift Container Platform clusters must provide sufficient compute capacity. In this context, LPAR weight management, entitlements, and CPU shares on the hypervisor level play an important role.

## Operating system requirements

- One instance of z/VM 7.1 or later

On your z/VM instance, set up:

- 3 guest virtual machines for OpenShift Container Platform control plane machines
- 2 guest virtual machines for OpenShift Container Platform compute machines
- 1 guest virtual machine for the temporary OpenShift Container Platform bootstrap machine

## IBM Z network connectivity requirements

To install on IBM Z under z/VM, you require a single z/VM virtual NIC in layer 2 mode. You also need:

- A direct-attached OSA or RoCE network adapter
- A z/VM VSwitch set up. For a preferred setup, use OSA link aggregation.

## Disk storage for the z/VM guest virtual machines

- FICON attached disk storage (DASDs). These can be z/VM minidisks, fullpack minidisks, or dedicated DASDs, all of which must be formatted as CDL, which is the default. To reach the minimum required DASD size for Red Hat Enterprise Linux CoreOS (RHCOS) installations, you need extended address volumes (EAV). If available, use HyperPAV to ensure optimal performance.
- FCP attached disk storage

## Storage / Main Memory

- 16 GB for OpenShift Container Platform control plane machines
- 8 GB for OpenShift Container Platform compute machines
- 16 GB for the temporary OpenShift Container Platform bootstrap machine

### 12.2.3.4. Preferred IBM Z system environment

## Hardware requirements

- Three LPARS that each have the equivalent of six IFLs, which are SMT2 enabled, for each cluster.
- Two network connections to both connect to the **LoadBalancer** service and to serve data for traffic outside the cluster.
- HiperSockets, which are attached to a node either directly as a device or by bridging with one z/VM VSWITCH to be transparent to the z/VM guest. To directly connect HiperSockets to a node, you must set up a gateway to the external network via a RHEL 8 guest to bridge to the HiperSockets network.

## Operating system requirements

- Two or three instances of z/VM 7.1 or later for high availability

On your z/VM instances, set up:

- Three guest virtual machines for OpenShift Container Platform control plane machines, one per z/VM instance.
- At least six guest virtual machines for OpenShift Container Platform compute machines, distributed across the z/VM instances.
- One guest virtual machine for the temporary OpenShift Container Platform bootstrap machine.
- To ensure the availability of integral components in an overcommitted environment, increase the priority of the control plane by using the CP command **SET SHARE**. Do the same for infrastructure nodes, if they exist. See [SET SHARE](#) in IBM Documentation.

## IBM Z network connectivity requirements

To install on IBM Z under z/VM, you require a single z/VM virtual NIC in layer 2 mode. You also need:

- A direct-attached OSA or RoCE network adapter
- A z/VM VSwitch set up. For a preferred setup, use OSA link aggregation.

## Disk storage for the z/VM guest virtual machines

- FICON attached disk storage (DASDs). These can be z/VM minidisks, fullpack minidisks, or dedicated DASDs, all of which must be formatted as CDL, which is the default. To reach the minimum required DASD size for Red Hat Enterprise Linux CoreOS (RHCOS) installations, you need extended address volumes (EAV). If available, use HyperPAV and High Performance FICON (zHPF) to ensure optimal performance.
- FCP attached disk storage

## Storage / Main Memory

- 16 GB for OpenShift Container Platform control plane machines
- 8 GB for OpenShift Container Platform compute machines
- 16 GB for the temporary OpenShift Container Platform bootstrap machine

### 12.2.3.5. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

### Additional resources

- See [Bridging a HyperSockets LAN with a z/VM Virtual Switch](#) in IBM Documentation.
- See [Scaling HyperPAV alias devices on Linux guests on z/VM](#) for performance optimization.
- See [Topics in LPAR performance](#) for LPAR weight management and entitlements.
- [Recommended host practices for IBM Z & LinuxONE environments](#)

### 12.2.3.6. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an HTTP or HTTPS server to establish a network connection to download their Ignition config files.

The machines are configured with static IP addresses. No DHCP server is required. Ensure that the machines have persistent IP addresses and hostnames.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

#### 12.2.3.6.1. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.



### IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

Table 12.3. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests



Protocol	Port	Description
TCP	<b>1936</b>	Metrics
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> and the Cluster Version Operator on port <b>9099</b> .
	<b>10250-10259</b>	The default ports that Kubernetes reserves
	<b>10256</b>	openshift-sdn
UDP	<b>4789</b>	VXLAN and Geneve
	<b>6081</b>	VXLAN and Geneve
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> .
	<b>500</b>	IPsec IKE packets
	<b>4500</b>	IPsec NAT-T packets
TCP/UDP	<b>30000-32767</b>	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 12.4. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	<b>6443</b>	Kubernetes API

Table 12.5. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	<b>2379-2380</b>	etcd server and peer ports

### NTP configuration for user-provisioned infrastructure

OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service*.

### Additional resources

- [Configuring chrony time service](#)

### 12.2.3.7. User-provisioned DNS requirements

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:


- The Kubernetes API
- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines

Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, **<cluster\_name>** is the cluster name and **<base\_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster\_name>.<base\_domain>..**

**Table 12.6. Required DNS records**

Component	Record	Description
Kubernetes API	<b>api.&lt;cluster_name&gt;.&lt;base_domain&gt;..</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
	<b>api-int.&lt;cluster_name&gt;.&lt;base_domain&gt;..</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster.
		 <p><b>IMPORTANT</b></p> <p>The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.</p>

Component	Record	Description
Routes	<b>*.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.  For example, <b>console-openshift-console.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;</b> is used as a wildcard route to the OpenShift Container Platform console.
Bootstrap machine	<b>bootstrap.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.
Control plane machines	<b>&lt;master&gt;&lt;n&gt;.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.
Compute machines	<b>&lt;worker&gt;&lt;n&gt;.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.



## NOTE

In OpenShift Container Platform 4.4 and later, you do not need to specify etcd host and SRV records in your DNS configuration.

## TIP

You can use the **dig** command to verify name and reverse name resolution. See the section on *Validating DNS resolution for user-provisioned infrastructure* for detailed validation steps.

### 12.2.3.7.1. Example DNS configuration for user-provisioned clusters

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is **ocp4** and the base domain is **example.com**.

#### Example DNS A record configuration for a user-provisioned cluster

The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

#### Example 12.1. Sample DNS zone database

```

$TTL 1W
@ IN SOA ns1.example.com. root (
    2019070700 ; serial
    3H ; refresh (3 hours)
    30M ; retry (30 minutes)
    2W ; expiry (2 weeks)
    1W ) ; minimum (1 week)
IN NS ns1.example.com.
IN MX 10 smtp.example.com.
;
;
ns1.example.com. IN A 192.168.1.5
smtp.example.com. IN A 192.168.1.5
;
helper.example.com. IN A 192.168.1.5
helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com. IN A 192.168.1.5 1
api-int.ocp4.example.com. IN A 192.168.1.5 2
;
*.apps.ocp4.example.com. IN A 192.168.1.5 3
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 4
;
master0.ocp4.example.com. IN A 192.168.1.97 5
master1.ocp4.example.com. IN A 192.168.1.98 6
master2.ocp4.example.com. IN A 192.168.1.99 7
;
worker0.ocp4.example.com. IN A 192.168.1.11 8
worker1.ocp4.example.com. IN A 192.168.1.7 9
;
;EOF

```

- 1 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.
- 2 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.
- 3 Provides name resolution for the wildcard routes. The record refers to the IP address of the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



#### NOTE

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

- 4 Provides name resolution for the bootstrap machine.
- 5 6 7 Provides name resolution for the control plane machines.

**8 9** Provides name resolution for the compute machines.

### Example DNS PTR record configuration for a user-provisioned cluster

The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

#### Example 12.2. Sample DNS zone database for reverse records

```
$TTL 1W
@ IN SOA ns1.example.com. root (
    2019070700 ; serial
    3H ; refresh (3 hours)
    30M ; retry (30 minutes)
    2W ; expiry (2 weeks)
    1W ) ; minimum (1 week)
IN NS ns1.example.com.
;
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. 2
;
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. 3
;
97.1.168.192.in-addr.arpa. IN PTR master0.ocp4.example.com. 4
98.1.168.192.in-addr.arpa. IN PTR master1.ocp4.example.com. 5
99.1.168.192.in-addr.arpa. IN PTR master2.ocp4.example.com. 6
;
11.1.168.192.in-addr.arpa. IN PTR worker0.ocp4.example.com. 7
7.1.168.192.in-addr.arpa. IN PTR worker1.ocp4.example.com. 8
;
;EOF
```

- 1** Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.
- 2** Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.
- 3** Provides reverse DNS resolution for the bootstrap machine.
- 4 5 6** Provides reverse DNS resolution for the control plane machines.
- 7 8** Provides reverse DNS resolution for the compute machines.



#### NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard.

### 12.2.3.8. Load balancing requirements for user-provisioned infrastructure

Before you install OpenShift Container Platform, you must provision the API and application ingress load balancing infrastructure. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.



## NOTE

If you want to deploy the API and application ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer.** Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:
  - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the API routes.
  - A stateless load balancing algorithm. The options vary based on the load balancer implementation.



## NOTE

Session persistence is not required for the API load balancer to function properly.

Configure the following ports on both the front and back of the load balancers:

**Table 12.7. API load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
<b>6443</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the <b>/readyz</b> endpoint for the API server health check probe.	X	X	Kubernetes API server
<b>22623</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server



## NOTE

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the **/readyz** endpoint to the removal of the API server instance from the pool. Within the time frame after **/readyz** returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application ingress load balancer.** Provides an ingress point for application traffic flowing in from outside the cluster. Configure the following conditions:
  - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the ingress routes.
  - A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

### TIP

If the true IP address of the client can be seen by the application ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

Configure the following ports on both the front and back of the load balancers:

**Table 12.8. Application ingress load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
<b>443</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic
<b>80</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic
<b>1936</b>	The worker nodes that run the Ingress Controller pods, by default. You must configure the <b>/healthz/ready</b> endpoint for the ingress health check probe.	X	X	HTTP traffic



### NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.



### NOTE

A working configuration for the Ingress router is required for an OpenShift Container Platform cluster. You must configure the Ingress router after the control plane initializes.

#### 12.2.3.8.1. Example load balancer configuration for user-provisioned clusters

This section provides an example API and application ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an **/etc/haproxy/haproxy.cfg** configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing

one load balancing solution over another.



## NOTE

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

### Example 12.3. Sample API and application ingress load balancer configuration

```

global
log      127.0.0.1 local2
pidfile  /var/run/haproxy.pid
maxconn  4000
daemon

defaults
mode            http
log             global
option          dontlognull
option http-server-close
option          redispatch
retries         3
timeout http-request 10s
timeout queue   1m
timeout connect 10s
timeout client  1m
timeout server  1m
timeout http-keep-alive 10s
timeout check   10s
maxconn         3000

frontend stats
bind *:1936
mode            http
log             global
maxconn 10
stats enable
stats hide-version
stats refresh 30s
stats show-node
stats show-desc Stats for ocp4 cluster 1
stats auth admin:ocp4
stats uri /stats

listen api-server-6443 2
bind *:6443
mode tcp
server bootstrap bootstrap.ocp4.example.com:6443 check inter 1s backup 3
server master0 master0.ocp4.example.com:6443 check inter 1s
server master1 master1.ocp4.example.com:6443 check inter 1s
server master2 master2.ocp4.example.com:6443 check inter 1s

listen machine-config-server-22623 4
bind *:22623
mode tcp
server bootstrap bootstrap.ocp4.example.com:22623 check inter 1s backup 5

```



```

server master0 master0.ocp4.example.com:22623 check inter 1s
server master1 master1.ocp4.example.com:22623 check inter 1s
server master2 master2.ocp4.example.com:22623 check inter 1s
listen ingress-router-443 6
bind *:443
mode tcp
balance source
server worker0 worker0.ocp4.example.com:443 check inter 1s
server worker1 worker1.ocp4.example.com:443 check inter 1s
listen ingress-router-80 7
bind *:80
mode tcp
balance source
server worker0 worker0.ocp4.example.com:80 check inter 1s
server worker1 worker1.ocp4.example.com:80 check inter 1s

```

- 1 In the example, the cluster name is **ocp4**.
- 2 Port **6443** handles the Kubernetes API traffic and points to the control plane machines.
- 3 5 The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.
- 4 Port **22623** handles the machine config server traffic and points to the control plane machines.
- 6 Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.
- 7 Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



#### NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

#### TIP

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltupe** on the HAProxy node.



#### NOTE

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running **setsebool -P haproxy\_connect\_any=1**.

### 12.2.4. Preparing the user-provisioned infrastructure

Before you install OpenShift Container Platform on user-provisioned infrastructure, you must prepare the underlying infrastructure.

This section provides details about the high-level steps required to set up your cluster infrastructure in preparation for an OpenShift Container Platform installation. This includes configuring IP networking and network connectivity for your cluster nodes, preparing a web server for the Ignition files, enabling the required ports through your firewall, and setting up the required DNS and load balancing infrastructure.

After preparation, your cluster infrastructure must meet the requirements outlined in the *Requirements for a cluster with user-provisioned infrastructure* section.

## Prerequisites

- You have reviewed the [OpenShift Container Platform 4.x Tested Integrations](#) page.
- You have reviewed the infrastructure requirements detailed in the *Requirements for a cluster with user-provisioned infrastructure* section.

## Procedure

1. Set up static IP addresses.
2. Set up an HTTP or HTTPS server to provide Ignition files to the cluster nodes.
3. Ensure that your network infrastructure provides the required network connectivity between the cluster components. See the *Networking requirements for user-provisioned infrastructure* section for details about the requirements.
4. Configure your firewall to enable the ports required for the OpenShift Container Platform cluster components to communicate. See *Networking requirements for user-provisioned infrastructure* section for details about the ports that are required.
5. Setup the required DNS infrastructure for your cluster.
  - a. Configure DNS name resolution for the Kubernetes API, the application wildcard, the bootstrap machine, the control plane machines, and the compute machines.
  - b. Configure reverse DNS resolution for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.  
See the *User-provisioned DNS requirements* section for more information about the OpenShift Container Platform DNS requirements.
6. Validate your DNS configuration.
  - a. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses in the responses correspond to the correct components.
  - b. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names in the responses correspond to the correct components.  
See the *Validating DNS resolution for user-provisioned infrastructure* section for detailed DNS validation steps.

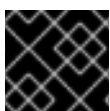
7. Provision the required API and application ingress load balancing infrastructure. See the *Load balancing requirements for user-provisioned infrastructure* section for more information about the requirements.

**NOTE**

Some load balancing solutions require the DNS name resolution for the cluster nodes to be in place before the load balancing is initialized.

### 12.2.5. Validating DNS resolution for user-provisioned infrastructure

You can validate your DNS configuration before installing OpenShift Container Platform on user-provisioned infrastructure.

**IMPORTANT**

The validation steps detailed in this section must succeed before you install your cluster.

**Prerequisites**

- You have configured the required DNS records for your user-provisioned infrastructure.

**Procedure**

1. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses contained in the responses correspond to the correct components.
  - a. Perform a lookup against the Kubernetes API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api.<cluster_name>.<base_domain> 1
```

- 1** Replace **<nameserver\_ip>** with the IP address of the nameserver, **<cluster\_name>** with your cluster name, and **<base\_domain>** with your base domain name.

**Example output**

```
api.ocp4.example.com. 0 IN A 192.168.1.5
```

- b. Perform a lookup against the Kubernetes internal API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api-int.<cluster_name>.<base_domain>
```

**Example output**

```
api-int.ocp4.example.com. 0 IN A 192.168.1.5
```

- c. Test an example **\*.apps.<cluster\_name>.<base\_domain>** DNS wildcard lookup. All of the application wildcard lookups must resolve to the IP address of the application ingress load balancer:

```
$ dig +noall +answer @<nameserver_ip> random.apps.<cluster_name>.<base_domain>
```

### Example output

```
random.apps.ocp4.example.com. 0 IN A 192.168.1.5
```



### NOTE

In the example outputs, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

You can replace **random** with another wildcard value. For example, you can query the route to the OpenShift Container Platform console:

```
$ dig +noall +answer @<nameserver_ip> console-openshift-console.apps.<cluster_name>.<base_domain>
```

### Example output

```
console-openshift-console.apps.ocp4.example.com. 0 IN A 192.168.1.5
```

- d. Run a lookup against the bootstrap DNS record name. Check that the result points to the IP address of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> bootstrap.<cluster_name>.<base_domain>
```

### Example output

```
bootstrap.ocp4.example.com. 0 IN A 192.168.1.96
```

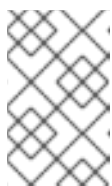
- e. Use this method to perform lookups against the DNS record names for the control plane and compute nodes. Check that the results correspond to the IP addresses of each node.
2. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names contained in the responses correspond to the correct components.
    - a. Perform a reverse lookup against the IP address of the API load balancer. Check that the response includes the record names for the Kubernetes API and the Kubernetes internal API:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.5
```

### Example output

```
5.1.168.192.in-addr.arpa. 0 IN PTR api-int.ocp4.example.com. 1  
5.1.168.192.in-addr.arpa. 0 IN PTR api.ocp4.example.com. 2
```

- 1 Provides the record name for the Kubernetes internal API.
- 2 Provides the record name for the Kubernetes API.



#### NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard. No validation step is needed for reverse DNS resolution against the IP address of the application ingress load balancer.

- b. Perform a reverse lookup against the IP address of the bootstrap node. Check that the result points to the DNS record name of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.96
```

#### Example output

```
96.1.168.192.in-addr.arpa. 0 IN PTR bootstrap.ocp4.example.com.
```

- c. Use this method to perform reverse lookups against the IP addresses for the control plane and compute nodes. Check that the results correspond to the DNS record names of each node.

### 12.2.6. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **`./openshift-install gather`** command also requires the SSH public key to be in place on the cluster nodes.



#### IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

#### Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.

**NOTE**

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.

**NOTE**

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

**Example output**

```
Agent pid 31874
```

**NOTE**

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1 Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

**Example output**

Identity added: /home/<you>/<path>/<file\_name> (<computer\_name>)

### Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

## 12.2.7. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on your provisioning machine.

### Prerequisites

- You have a machine that runs Linux, for example Red Hat Enterprise Linux 8, with 500 MB of local disk space

### Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



#### IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



#### IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#) . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

## 12.2.8. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



### IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

### Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

```
$ tar xvf <file>
```

5. Place the **oc** binary in a directory that is on your **PATH**.  
To check your **PATH**, execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```



After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

### Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.

To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### 12.2.9. Manually creating the installation configuration file

For user-provisioned installations of OpenShift Container Platform, you manually generate your installation configuration file.

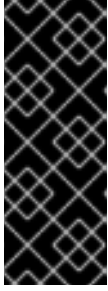
#### Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

#### Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```

**IMPORTANT**

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation\_directory>**.

**NOTE**

You must name this configuration file **install-config.yaml**.

**NOTE**

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation\_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

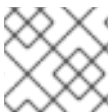
3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

**IMPORTANT**

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

**12.2.9.1. Installation configuration parameters**

Before you deploy an OpenShift Container Platform cluster, you provide a customized **install-config.yaml** installation configuration file that describes the details for your environment.

**NOTE**

After installation, you cannot modify these parameters in the **install-config.yaml** file.

**IMPORTANT**

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

**12.2.9.1.1. Required configuration parameters**

Required installation configuration parameters are described in the following table:

**Table 12.9. Required parameters**

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;</b> . <b>&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}</b> . <b>{{.baseDomain}}</b> .	String of lowercase letters, hyphens (-), and periods (.), such as <b>dev</b> .
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws</b> , <b>baremetal</b> , <b>azure</b> , <b>gcp</b> , <b>openstack</b> , <b>ovirt</b> , <b>vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object


Parameter	Description	Values
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } }</pre>

### 12.2.9.1.2. Network configuration parameters


You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

Table 12.10. Network parameters

Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	Object    <b>NOTE</b> You cannot modify parameters specified by the <b>networking</b> object after installation.
<b>networking.networkType</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .

Parameter	Description	Values
<b>networking.clusterNetwork</b>	<p>The IP address blocks for pods.</p> <p>The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b>.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   clusterNetwork:     - cidr: 10.128.0.0/14       hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	<p>Required if you use <b>networking.clusterNetwork</b>. An IP address block.</p> <p>An IPv4 network.</p>	<p>An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b>.</p>
<b>networking.clusterNetwork.hostPrefix</b>	<p>The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b>. A <b>hostPrefix</b> value of <b>23</b> provides 510 (<math>2^{(32 - 23)} - 2</math>) pod IP addresses.</p>	<p>A subnet prefix.</p> <p>The default value is <b>23</b>.</p>
<b>networking.serviceNetwork</b>	<p>The IP address block for services. The default value is <b>172.30.0.0/16</b>.</p> <p>The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.</p>	<p>An array with an IP address block in CIDR format. For example:</p> <pre>networking:   serviceNetwork:     - 172.30.0.0/16</pre>
<b>networking.machineNetwork</b>	<p>The IP address blocks for machines.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p> <p>If you specify multiple IP kernel arguments, the <b>machineNetwork.cidr</b> value must be the CIDR of the primary network.</p>	<p>An array of objects. For example:</p> <pre>networking:   machineNetwork:     - cidr: 10.0.0.0/16</pre>


Parameter	Description	Values
<b>networking.machineNetwork.cidr</b>	Required if you use <b>networking.machineNetwork</b> . An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b> .	An IP network block in CIDR notation. For example, <b>10.0.0.0/16</b> .  <b>NOTE</b> Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.

### 12.2.9.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

Table 12.11. Optional parameters

Parameter	Description	Values
<b>additionalTrustBundle</b>	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
<b>compute</b>	The configuration for the machines that comprise the compute nodes.	Array of <b>MachinePool</b> objects.
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>s390x</b> (the default).	String


Parameter	Description	Values
<b>compute.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b>
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>s390x</b> (the default).	String

Parameter	Description	Values
<b>controlPlane.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platform</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>controlPlane.replicas</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.



Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.</p> <div data-bbox="485 512 595 862" style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p><b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators</i> reference content.</p> </div> <div data-bbox="485 909 595 1258" style="border: 1px solid black; padding: 5px;"> <p><b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p> </div>	<b>Mint, Passthrough, Manual</b> or an empty string ("").

Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start;"> <div style="width: 30px; height: 30px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 30px; height: 30px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings

Parameter	Description	Values
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<b>Internal</b> or <b>External</b> . The default value is <b>External</b> .  Setting this field to <b>Internal</b> is not supported on non-cloud platforms.
<b>sshKey</b>	The SSH key or keys to authenticate access your cluster machines.   <b>NOTE</b>  For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.	One or more keys. For example:  sshKey: <key1> <key2> <key3>

### 12.2.9.2. Sample install-config.yaml file for IBM Z

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```

apiVersion: v1
baseDomain: example.com 1
compute: 2
- hyperthreading: Enabled 3
  name: worker
  replicas: 0 4
  architecture : s390x
controlPlane: 5
  hyperthreading: Enabled 6
  name: master
  replicas: 3 7
  architecture : s390x
metadata:
  name: test 8
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14 9
    hostPrefix: 23 10
  networkType: OpenShiftSDN
  serviceNetwork: 11
  - 172.30.0.0/16
platform:
  none: {} 12

```

```
fips: false 13
pullSecret: '{"auths": ...}' 14
sshKey: 'ssh-ed25519 AAAA...' 15
```

- 1** The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.
- 2 5** The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. Only one control plane pool is used.
- 3 6** Specifies whether to enable or disable simultaneous multithreading (SMT), or hyperthreading. By default, SMT is enabled to increase the performance of the cores in your machines. You can disable it by setting the parameter value to **Disabled**. If you disable SMT, you must disable it in all cluster machines; this includes both control plane and compute machines.

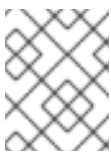
**NOTE**

Simultaneous multithreading (SMT) is enabled by default. If SMT is not available on your OpenShift Container Platform nodes, the **hyperthreading** parameter has no effect.

**IMPORTANT**

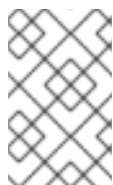
If you disable **hyperthreading**, whether on your OpenShift Container Platform nodes or in the **install-config.yaml** file, ensure that your capacity planning accounts for the dramatically decreased machine performance.

- 4** You must set this value to **0** when you install OpenShift Container Platform on user-provisioned infrastructure. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. In user-provisioned installations, you must manually deploy the compute machines before you finish installing the cluster.

**NOTE**

If you are installing a three-node cluster, do not deploy any compute machines when you install the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

- 7** The number of control plane machines that you add to the cluster. Because the cluster uses these values as the number of etcd endpoints in the cluster, the value must match the number of control plane machines that you deploy.
- 8** The cluster name that you specified in your DNS records.
- 9** A block of IP addresses from which pod IP addresses are allocated. This block must not overlap with existing physical networks. These IP addresses are used for the pod network. If you need to access the pods from an external network, you must configure load balancers and routers to manage the traffic.

**NOTE**

Class E CIDR range is reserved for a future use. To use the Class E CIDR range, you must ensure your networking environment accepts the IP addresses within the Class E CIDR range.

- 10 The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23**, then each node is assigned a **/23** subnet out of the given **cidr**, which allows for 510 ( $2^{(32 - 23)} - 2$ ) pod IP addresses. If you are required to provide access to nodes from an external network, configure load balancers and routers to manage the traffic.
- 11 The IP address pool to use for service IP addresses. You can enter only one IP address pool. This block must not overlap with existing physical networks. If you need to access the services from an external network, configure load balancers and routers to manage the traffic.
- 12 You must set the platform to **none**. You cannot provide additional platform configuration variables for IBM Z infrastructure.

**IMPORTANT**

Clusters that are installed with the platform type **none** are unable to use some features, such as managing compute machines with the Machine API. This limitation applies even if the compute machines that are attached to the cluster are installed on a platform that would normally support the feature. This parameter cannot be changed after installation.

- 13 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

**IMPORTANT**

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

- 14 The [pull secret from the Red Hat OpenShift Cluster Manager](#) . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.
- 15 The SSH public key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).

**NOTE**

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

**12.2.9.3. Configuring the cluster-wide proxy during installation**

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

## Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



### NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

## Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
  additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
  ...
```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations.
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents

specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.



#### NOTE

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



#### NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

### 12.2.9.4. Configuring a three-node cluster

You can optionally deploy zero compute machines in a bare metal cluster that consists of three control plane machines only. This provides smaller, more resource efficient clusters for cluster administrators and developers to use for testing, development, and production.

In three-node OpenShift Container Platform environments, the three control plane machines are schedulable, which means that your application workloads are scheduled to run on them.

#### Prerequisites

- You have an existing **install-config.yaml** file.

#### Procedure

- Ensure that the number of compute replicas is set to **0** in your **install-config.yaml** file, as shown in the following **compute** stanza:

```
compute:
- name: worker
  platform: {}
  replicas: 0
```



#### NOTE

You must set the value of the **replicas** parameter for the compute machines to **0** when you install OpenShift Container Platform on user-provisioned infrastructure, regardless of the number of compute machines you are deploying. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. This does not apply to user-provisioned installations, where the compute machines are deployed manually.

**NOTE**

The preferred resource for control plane nodes is six vCPUs and 21 GB. For three control plane nodes this is the memory + vCPU equivalent of a minimum five-node cluster. You should back the three nodes, each installed on a 120 GB disk, with three IFLs that are SMT2 enabled. The minimum tested setup is three vCPUs and 10 GB on a 120 GB disk for each control plane node.

For three-node cluster installations, follow these next steps:

- If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes. See the *Load balancing requirements for user-provisioned infrastructure* section for more information.
- When you create the Kubernetes manifest files in the following procedure, ensure that the **mastersSchedulable** parameter in the `<installation_directory>/manifests/cluster-scheduler-02-config.yml` file is set to **true**. This enables your application workloads to run on the control plane nodes.
- Do not deploy any compute nodes when you create the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

### 12.2.10. Cluster Network Operator configuration

The configuration for the cluster network is specified as part of the Cluster Network Operator (CNO) configuration and stored in a custom resource (CR) object that is named **cluster**. The CR specifies the fields for the **Network** API in the **operator.openshift.io** API group.

The CNO configuration inherits the following fields during cluster installation from the **Network** API in the **Network.config.openshift.io** API group and these fields cannot be changed:

#### **clusterNetwork**

IP address pools from which pod IP addresses are allocated.

#### **serviceNetwork**

IP address pool for services.

#### **defaultNetwork.type**

Cluster network provider, such as OpenShift SDN or OVN-Kubernetes.

You can specify the cluster network provider configuration for your cluster by setting the fields for the **defaultNetwork** object in the CNO object named **cluster**.

#### 12.2.10.1. Cluster Network Operator configuration object

The fields for the Cluster Network Operator (CNO) are described in the following table:

**Table 12.12. Cluster Network Operator configuration object**

Field	Type	Description
<b>metadata.name</b>	<b>string</b>	The name of the CNO object. This name is always <b>cluster</b> .




Field	Type	Description
<b>spec.clusterNetwork</b>	<b>array</b>	<p>A list specifying the blocks of IP addresses from which pod IP addresses are allocated and the subnet prefix length assigned to each individual node in the cluster. For example:</p> <pre>spec:   clusterNetwork:   - cidr: 10.128.0.0/19     hostPrefix: 23   - cidr: 10.128.32.0/19     hostPrefix: 23</pre> <p>You can customize this field only in the <b>install-config.yaml</b> file before you create the manifests. The value is read-only in the manifest file.</p>
<b>spec.serviceNetwork</b>	<b>array</b>	<p>A block of IP addresses for services. The OpenShift SDN and OVN-Kubernetes Container Network Interface (CNI) network providers support only a single IP address block for the service network. For example:</p> <pre>spec:   serviceNetwork:   - 172.30.0.0/14</pre> <p>You can customize this field only in the <b>install-config.yaml</b> file before you create the manifests. The value is read-only in the manifest file.</p>
<b>spec.defaultNetwork</b>	<b>object</b>	Configures the Container Network Interface (CNI) cluster network provider for the cluster network.
<b>spec.kubeProxyConfig</b>	<b>object</b>	The fields for this object specify the kube-proxy configuration. If you are using the OVN-Kubernetes cluster network provider, the kube-proxy configuration has no effect.

### defaultNetwork object configuration

The values for the **defaultNetwork** object are defined in the following table:

Table 12.13. **defaultNetwork** object

Field	Type	Description
-------	------	-------------

Field	Type	Description
<b>type</b>	<b>string</b>	<p>Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b>. The cluster network provider is selected during installation. This value cannot be changed after cluster installation.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>OpenShift Container Platform uses the OpenShift SDN Container Network Interface (CNI) cluster network provider by default.</p> </div> </div>
<b>openshiftSDNConfig</b>	<b>object</b>	This object is only valid for the OpenShift SDN cluster network provider.
<b>ovnKubernetesConfig</b>	<b>object</b>	This object is only valid for the OVN-Kubernetes cluster network provider.

#### Configuration for the OpenShift SDN CNI cluster network provider

The following table describes the configuration fields for the OpenShift SDN Container Network Interface (CNI) cluster network provider.

**Table 12.14. openshiftSDNConfig object**

Field	Type	Description
<b>mode</b>	<b>string</b>	<p>Configures the network isolation mode for OpenShift SDN. The default value is <b>NetworkPolicy</b>.</p> <p>The values <b>Multitenant</b> and <b>Subnet</b> are available for backwards compatibility with OpenShift Container Platform 3.x but are not recommended. This value cannot be changed after cluster installation.</p>

Field	Type	Description
<b>mtu</b>	<b>integer</b>	<p>The maximum transmission unit (MTU) for the VXLAN overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU.</p> <p>If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes.</p> <p>If your cluster requires different MTU values for different nodes, you must set this value to <b>50</b> less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of <b>9001</b>, and some have an MTU of <b>1500</b>, you must set this value to <b>1450</b>.</p> <p>This value cannot be changed after cluster installation.</p>
<b>vxlanPort</b>	<b>integer</b>	<p>The port to use for all VXLAN packets. The default value is <b>4789</b>. This value cannot be changed after cluster installation.</p> <p>If you are running in a virtualized environment with existing nodes that are part of another VXLAN network, then you might be required to change this. For example, when running an OpenShift SDN overlay on top of VMware NSX-T, you must select an alternate port for the VXLAN, because both SDNs use the same default VXLAN port number.</p> <p>On Amazon Web Services (AWS), you can select an alternate port for the VXLAN between port <b>9000</b> and port <b>9999</b>.</p>

### Example OpenShift SDN configuration

```
defaultNetwork:
  type: OpenShiftSDN
  openshiftSDNConfig:
    mode: NetworkPolicy
    mtu: 1450
    vxlanPort: 4789
```

### Configuration for the OVN-Kubernetes CNI cluster network provider

The following table describes the configuration fields for the OVN-Kubernetes CNI cluster network provider.

Table 12.15. `ovnKubernetesConfig` object

Field	Type	Description
-------	------	-------------

Field	Type	Description
<b>mtu</b>	<b>integer</b>	<p>The maximum transmission unit (MTU) for the Geneve (Generic Network Virtualization Encapsulation) overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU.</p> <p>If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes.</p> <p>If your cluster requires different MTU values for different nodes, you must set this value to <b>100</b> less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of <b>9001</b>, and some have an MTU of <b>1500</b>, you must set this value to <b>1400</b>.</p> <p>This value cannot be changed after cluster installation.</p>
<b>genevePort</b>	<b>integer</b>	The port to use for all Geneve packets. The default value is <b>6081</b> . This value cannot be changed after cluster installation.
<b>policyAuditConfig</b>	<b>object</b>	Specify a configuration object for customizing network policy audit logging. If unset, the defaults audit log settings are used.

Table 12.16. **policyAuditConfig** object

Field	Type	Description
<b>rateLimit</b>	integer	The maximum number of messages to generate every second per node. The default value is <b>20</b> messages per second.
<b>maxFileSize</b>	integer	The maximum size for the audit log in bytes. The default value is <b>50000000</b> or 50 MB.
<b>destination</b>	string	<p>One of the following additional audit log targets:</p> <p><b>libc</b> The libc <b>syslog()</b> function of the journald process on the host.</p> <p><b>udp:&lt;host&gt;:&lt;port&gt;</b> A syslog server. Replace <b>&lt;host&gt;:&lt;port&gt;</b> with the host and port of the syslog server.</p> <p><b>unix:&lt;file&gt;</b> A Unix Domain Socket file specified by <b>&lt;file&gt;</b>.</p> <p><b>null</b> Do not send the audit logs to any additional target.</p>

Field	Type	Description
<b>syslogFacility</b>	string	The syslog facility, such as <b>kern</b> , as defined by RFC5424. The default value is <b>local0</b> .


### Example OVN-Kubernetes configuration

```
defaultNetwork:
  type: OVNKubernetes
  ovnKubernetesConfig:
    mtu: 1400
    genevePort: 6081
```

### kubeProxyConfig object configuration

The values for the **kubeProxyConfig** object are defined in the following table:

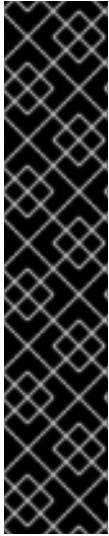
Table 12.17. **kubeProxyConfig** object

Field	Type	Description
<b>iptablesSyncPeriod</b>	<b>string</b>	<p>The refresh period for <b>iptables</b> rules. The default value is <b>30s</b>. Valid suffixes include <b>s</b>, <b>m</b>, and <b>h</b> and are described in the <a href="#">Go time package</a> documentation.</p> <div style="display: flex; align-items: flex-start;"> <div style="flex: 1;">  </div> <div style="flex: 2;"> <p><b>NOTE</b></p> <p>Because of performance improvements introduced in OpenShift Container Platform 4.3 and greater, adjusting the <b>iptablesSyncPeriod</b> parameter is no longer necessary.</p> </div> </div>
<b>proxyArguments.iptables-min-sync-period</b>	<b>array</b>	<p>The minimum duration before refreshing <b>iptables</b> rules. This field ensures that the refresh does not happen too frequently. Valid suffixes include <b>s</b>, <b>m</b>, and <b>h</b> and are described in the <a href="#">Go time package</a>. The default value is:</p> <pre>kubeProxyConfig:   proxyArguments:     iptables-min-sync-period:       - 0s</pre>

### 12.2.11. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.



### IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.



### NOTE

The installation program that generates the manifest and Ignition files is architecture specific and can be obtained from the [client image mirror](#). The Linux version of the installation program runs on s390x only. This installer program is also available as a Mac OS version.

### Prerequisites

- You obtained the OpenShift Container Platform installation program.
- You created the **install-config.yaml** installation configuration file.

### Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

- 1** For **<installation\_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.



### WARNING

If you are installing a three-node cluster, skip the following step to allow the control plane nodes to be schedulable.



## IMPORTANT

When you configure control plane nodes from the default unschedulable to schedulable, additional subscriptions are required. This is because control plane nodes then become worker nodes.

2. Check that the **mastersSchedulable** parameter in the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:
  - a. Open the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** file.
  - b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.
  - c. Save and exit the file.
3. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

- 1** For **<installation\_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation\_directory>/auth** directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

### 12.2.12. Installing RHCOS and starting the OpenShift Container Platform bootstrap process

To install OpenShift Container Platform on IBM Z infrastructure that you provision, you must install Red Hat Enterprise Linux CoreOS (RHCOS) on z/VM guest virtual machines. When you install RHCOS, you must provide the Ignition config file that was generated by the OpenShift Container Platform installation program for the type of machine you are installing. If you have configured suitable networking, DNS, and load balancing infrastructure, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS z/VM guest virtual machines have rebooted.

Complete the following steps to create the machines.

#### Prerequisites

- An HTTP or HTTPS server running on your provisioning machine that is accessible to the machines you create.

## Procedure

1. Log in to Linux on your provisioning machine.
2. Obtain the Red Hat Enterprise Linux CoreOS (RHCOS) kernel, initramfs, and rootfs files from the [RHCOS image mirror](#).



### IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Only use the appropriate kernel, initramfs, and rootfs artifacts described in the following procedure.

The file names contain the OpenShift Container Platform version number. They resemble the following examples:

- kernel: **rhcos-`<version>`-live-kernel-`<architecture>`**
- initramfs: **rhcos-`<version>`-live-initramfs.`<architecture>`.img**
- rootfs: **rhcos-`<version>`-live-rootfs.`<architecture>`.img**



### NOTE

The rootfs image is the same for FCP and DASD.

3. Create parameter files. The following parameters are specific for a particular virtual machine:
  - For **ip=**, specify the following seven entries:
    - i. The IP address for the machine.
    - ii. An empty string.
    - iii. The gateway.
    - iv. The netmask.
    - v. The machine host and domain name in the form **hostname.domainname**. Omit this value to let RHCOS decide.
    - vi. The network interface name. Omit this value to let RHCOS decide.
    - vii. If you use static IP addresses, specify **none**.
  - For **coreos.inst.ignition\_url=**, specify the Ignition file for the machine role. Use **bootstrap.ign**, **master.ign**, or **worker.ign**. Only HTTP and HTTPS protocols are supported.
  - For **coreos.live.rootfs\_url=**, specify the matching rootfs artifact for the kernel and initramfs you are booting. Only HTTP and HTTPS protocols are supported.
  - For installations on DASD-type disks, complete the following tasks:
    - i. For **coreos.inst.install\_dev=**, specify **dasda**.



- ii. Use **rd.dasd=** to specify the DASD where RHCOS is to be installed.
- iii. Leave all other parameters unchanged.  
Example parameter file, **bootstrap-0.parm**, for the bootstrap machine:

```
rd.neednet=1 \
console=ttysclp0 \
coreos.inst.install_dev=dasda \
coreos.live.rootfs_url=http://cl1.provide.example.com:8080/assets/rhcos-live-
rootfs.s390x.img \
coreos.inst.ignition_url=http://cl1.provide.example.com:8080/ignition/bootstrap.ign \
ip=172.18.78.2::172.18.78.1:255.255.255.0:::none nameserver=172.18.78.1 \
rd.znet=qeth,0.0.bdf0,0.0.bdf1,0.0.bdf2,layer2=1,portno=0 \
zfcp.allow_lun_scan=0 \
rd.dasd=0.0.3490
```

Write all options in the parameter file as a single line and make sure you have no newline characters.

- For installations on FCP-type disks, complete the following tasks:
  - i. Use **rd.zfcp=<adapter>,<wwpn>,<lun>** to specify the FCP disk where RHCOS is to be installed. For multipathing repeat this step for each additional path.



#### NOTE

When you install with multiple paths, you must enable multipathing directly after the installation, not at a later point in time, as this can cause problems.

- ii. Set the install device as: **coreos.inst.install\_dev=sda**.



#### NOTE

If additional LUNs are configured with NPIV, FCP requires **zfcp.allow\_lun\_scan=0**. If you must enable **zfcp.allow\_lun\_scan=1** because you use a CSI driver, for example, you must configure your NPIV so that each node cannot access the boot partition of another node.

- iii. Leave all other parameters unchanged.



#### IMPORTANT

Additional post-installation steps are required to fully enable multipathing. For more information, see "Enabling multipathing with kernel arguments on RHCOS" in *Post-installation machine configuration tasks*.

The following is an example parameter file **worker-1.parm** for a worker node with multipathing:

```
rd.neednet=1 \
console=ttysclp0 \
```

```

coreos.inst.install_dev=sda \
coreos.live.rootfs_url=http://cl1.provide.example.com:8080/assets/rhcos-live-
rootfs.s390x.img \
coreos.inst.ignition_url=http://cl1.provide.example.com:8080/ignition/worker.ign \
ip=172.18.78.2::172.18.78.1:255.255.255.0:::none nameserver=172.18.78.1 \
rd.znet=qeth,0.0.bdf0,0.0.bdf1,0.0.bdf2,layer2=1,portno=0 \
zfcp.allow_lun_scan=0 \
rd.zfcp=0.0.1987,0x50050763070bc5e3,0x4008400B00000000 \
rd.zfcp=0.0.19C7,0x50050763070bc5e3,0x4008400B00000000 \
rd.zfcp=0.0.1987,0x50050763071bc5e3,0x4008400B00000000 \
rd.zfcp=0.0.19C7,0x50050763071bc5e3,0x4008400B00000000

```

Write all options in the parameter file as a single line and make sure you have no newline characters.

4. Transfer the initramfs, kernel, parameter files, and RHCOS images to z/VM, for example with FTP. For details about how to transfer the files with FTP and boot from the virtual reader, see [Installing under Z/VM](#).
5. Punch the files to the virtual reader of the z/VM guest virtual machine that is to become your bootstrap node.  
See [PUNCH](#) in IBM Documentation.

### TIP

You can use the CP PUNCH command or, if you use Linux, the **vmur** command to transfer files between two z/VM guest virtual machines.

6. Log in to CMS on the bootstrap machine.
7. IPL the bootstrap machine from the reader:

```
$ ipl c
```

See [IPL](#) in IBM Documentation.

8. Repeat this procedure for the other machines in the cluster.

## 12.2.12.1. Advanced RHCOS installation reference

This section illustrates the networking configuration and other advanced options that allow you to modify the Red Hat Enterprise Linux CoreOS (RHCOS) manual installation process. The following tables describe the kernel arguments and command-line options you can use with the RHCOS live installer and the **coreos-installer** command.

### 12.2.12.1.1. Networking and bonding options for ISO installations

If you install RHCOS from an ISO image, you can add kernel arguments manually when you boot the image to configure networking for a node. If no networking arguments are specified, DHCP is activated in the initramfs when RHCOS detects that networking is required to fetch the Ignition config file.

**IMPORTANT**

When adding networking arguments manually, you must also add the **rd.neednet=1** kernel argument to bring the network up in the initramfs.

The following table provides examples for configuring networking and bonding on your RHCOS nodes for ISO installations. The examples describe how to use the **ip=**, **nameserver=**, and **bond=** kernel arguments.

**NOTE**

Ordering is important when adding the kernel arguments: **ip=**, **nameserver=**, and then **bond=**.

The networking options are passed to the **dracut** tool during system boot. For more information about the networking options supported by **dracut**, see the **dracut.cmdline** manual page.

The following information provides examples for configuring networking on your RHCOS nodes for ISO installations. The examples describe how to use the **ip=** and **nameserver=** kernel arguments.

**NOTE**

Ordering is important when adding the kernel arguments: **ip=** and **nameserver=**.

The networking options are passed to the **dracut** tool during system boot. For more information about the networking options supported by **dracut**, see the **dracut.cmdline** manual page.

The following examples are the networking options for ISO installation.

**Configuring DHCP or static IP addresses**

To configure an IP address, either use DHCP (**ip=dhcp**) or set an individual static IP address (**ip=<host\_ip>**). If setting a static IP, you must then identify the DNS server IP address (**nameserver=<dns\_ip>**) on each node. The following example sets:

- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The hostname to **core0.example.com**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
nameserver=4.4.4.41
```

**NOTE**

When you use DHCP to configure IP addressing for the RHCOS machines, the machines also obtain the DNS server information through DHCP. For DHCP-based deployments, you can define the DNS server address that is used by the RHCOS nodes through your DHCP server configuration.

**Configuring an IP address without a static hostname**

You can configure an IP address without assigning a static hostname. If a static hostname is not set by the user, it will be picked up and automatically set by a reverse DNS lookup. To configure an IP address without a static hostname refer to the following example:

- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0::enp1s0:none
nameserver=4.4.4.41
```

**Specifying multiple network interfaces**

You can specify multiple network interfaces by setting multiple **ip=** entries.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=10.10.10.3::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

**Configuring default gateway and route**

Optional: You can configure routes to additional networks by setting an **rd.route=** value.

**NOTE**

When you configure one or multiple networks, one default gateway is required. If the additional network gateway is different from the primary network gateway, the default gateway must be the primary network gateway.

- Run the following command to configure the default gateway:

```
ip=::10.10.10.254:::
```

- Enter the following command to configure the route for the additional network:

```
rd.route=20.20.20.0/24:20.20.20.254:enp2s0
```

**Disabling DHCP on a single interface**

You can disable DHCP on a single interface, such as when there are two or more network interfaces and only one interface is being used. In the example, the **enp1s0** interface has a static networking configuration and DHCP is disabled for **enp2s0**, which is not used:

■

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=:::core0.example.com:enp2s0:none
```

### Combining DHCP and static IP configurations

You can combine DHCP and static IP configurations on systems with multiple network interfaces, for example:

```
ip=enp1s0:dhcp
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

### Configuring VLANs on individual interfaces

Optional: You can configure VLANs on individual interfaces by using the **vlan=** parameter.

- To configure a VLAN on a network interface and use a static IP address, run the following command:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0.100:none
vlan=enp2s0.100:enp2s0
```

- To configure a VLAN on a network interface and to use DHCP, run the following command:

```
ip=enp2s0.100:dhcp
vlan=enp2s0.100:enp2s0
```

### Providing multiple DNS servers

You can provide multiple DNS servers by adding a **nameserver=** entry for each server, for example:

```
nameserver=1.1.1.1
nameserver=8.8.8.8
```

### Bonding multiple network interfaces to a single interface

Optional: You can bond multiple network interfaces to a single interface by using the **bond=** option.

Refer to the following examples:

- The syntax for configuring a bonded interface is: **bond=name[:network\_interfaces][:options]** *name* is the bonding device name (**bond0**), *network\_interfaces* represents a comma-separated list of physical (ethernet) interfaces (**em1,em2**), and *options* is a comma-separated list of bonding options. Enter **modinfo bonding** to see available options.
- When you create a bonded interface using **bond=**, you must specify how the IP address is assigned and other information for the bonded interface.
- To configure the bonded interface to use DHCP, set the bond's IP address to **dhcp**. For example:

```
bond=bond0:em1,em2:mode=active-backup
ip=bond0:dhcp
```

- To configure the bonded interface to use a static IP address, enter the specific IP address you want and related information. For example:

```
bond=bond0:em1,em2:mode=active-backup,fail_over_mac=1
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0:none
```

Always set option **fail\_over\_mac=1** in active-backup mode, to avoid problems when shared OSA/RoCE cards are used.

### Bonding multiple network interfaces to a single interface

Optional: You can configure VLANs on bonded interfaces by using the **vlan=** parameter and to use DHCP, for example:

```
ip=bond0.100:dhcp
bond=bond0:em1,em2:mode=active-backup
vlan=bond0.100:bond0
```

Use the following example to configure the bonded interface with a VLAN and to use a static IP address:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0.100:none
bond=bond0:em1,em2:mode=active-backup
vlan=bond0.100:bond0
```

### Using network teaming

Optional: You can use a network teaming as an alternative to bonding by using the **team=** parameter:

- The syntax for configuring a team interface is: **team=name[:network\_interfaces]**  
*name* is the team device name (**team0**) and *network\_interfaces* represents a comma-separated list of physical (ethernet) interfaces (**em1, em2**).

Teaming is planned to be deprecated when RHCOS switches to an upcoming version of RHEL. For more information, see this [Red Hat Knowledgebase Article](#) .

Use the following example to configure a network team:

```
team=team0:em1,em2
ip=team0:dhcp
```

## 12.2.13. Waiting for the bootstrap process to complete

The OpenShift Container Platform bootstrap process begins after the cluster nodes first boot into the persistent RHCOS environment that has been installed to disk. The configuration information provided through the Ignition config files is used to initialize the bootstrap process and install OpenShift Container Platform on the machines. You must wait for the bootstrap process to complete.

### Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have obtained the installation program and generated the Ignition config files for your cluster.
- You installed RHCOS on your cluster machines and provided the Ignition config files that the OpenShift Container Platform installation program generated.
- Your machines have direct internet access or have an HTTP or HTTPS proxy available.

### Procedure

1. Monitor the bootstrap process:

```
$ ./openshift-install --dir <installation_directory> wait-for bootstrap-complete \ 1
--log-level=info 2
```

1 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

### Example output

```
INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...
INFO API v1.22.1 up
INFO Waiting up to 30m0s for bootstrapping to complete...
INFO It is now safe to remove the bootstrap resources
```

The command succeeds when the Kubernetes API server signals that it has been bootstrapped on the control plane machines.

2. After bootstrap process is complete, remove the bootstrap machine from the load balancer.



### IMPORTANT

You must remove the bootstrap machine from the load balancer at this point. You can also remove or reformat the bootstrap machine itself.

## 12.2.14. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

1 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

-

## Example output

```
system:admin
```

### 12.2.15. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

#### Prerequisites

- You added machines to your cluster.

#### Procedure

- Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

#### Example output

```
NAME      STATUS  ROLES  AGE  VERSION
master-0  Ready   master 63m  v1.22.1
master-1  Ready   master 63m  v1.22.1
master-2  Ready   master 64m  v1.22.1
```

The output lists all of the machines that you created.



#### NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

- Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

#### Example output

```
NAME      AGE  REQUESTOR                                CONDITION
csr-mddf5 20m  system:node:master-01.example.com  Approved,Issued
csr-z5rln 16m  system:node:worker-21.example.com  Approved,Issued
```

- If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:



**NOTE**

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.

**NOTE**

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrap** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{"\n"}{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```

**NOTE**

Some Operators might not become available until some CSRs are approved.

4. Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

**Example output**

```
NAME      AGE   REQUESTOR                                     CONDITION
csr-bfd72 5m26s system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv 5m26s system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

5. If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

**1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

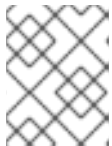
```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{"\n"}\n{{end}}' | xargs oc adm certificate approve
```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

### Example output

```
NAME      STATUS  ROLES  AGE  VERSION
master-0  Ready   master 73m  v1.22.1
master-1  Ready   master 73m  v1.22.1
master-2  Ready   master 74m  v1.22.1
worker-0  Ready   worker 11m  v1.22.1
worker-1  Ready   worker 11m  v1.22.1
```



### NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

### Additional information

- For more information on CSRs, see [Certificate Signing Requests](#).

## 12.2.16. Initial Operator configuration

After the control plane initializes, you must immediately configure some Operators so that they all become available.

### Prerequisites

- Your control plane has initialized.

### Procedure

- Watch the cluster components come online:

```
$ watch -n5 oc get clusteroperators
```

**Example output**

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED
authentication	4.9.0	True	False	False 19m
baremetal	4.9.0	True	False	False 37m
cloud-credential	4.9.0	True	False	False 40m
cluster-autoscaler	4.9.0	True	False	False 37m
config-operator	4.9.0	True	False	False 38m
console	4.9.0	True	False	False 26m
csi-snapshot-controller	4.9.0	True	False	False 37m
dns	4.9.0	True	False	False 37m
etcd	4.9.0	True	False	False 36m
image-registry	4.9.0	True	False	False 31m
ingress	4.9.0	True	False	False 30m
insights	4.9.0	True	False	False 31m
kube-apiserver	4.9.0	True	False	False 26m
kube-controller-manager	4.9.0	True	False	False 36m
kube-scheduler	4.9.0	True	False	False 36m
kube-storage-version-migrator	4.9.0	True	False	False 37m
machine-api	4.9.0	True	False	False 29m
machine-approver	4.9.0	True	False	False 37m
machine-config	4.9.0	True	False	False 36m
marketplace	4.9.0	True	False	False 37m
monitoring	4.9.0	True	False	False 29m
network	4.9.0	True	False	False 38m
node-tuning	4.9.0	True	False	False 37m
openshift-apiserver	4.9.0	True	False	False 32m
openshift-controller-manager	4.9.0	True	False	False 30m
openshift-samples	4.9.0	True	False	False 32m
operator-lifecycle-manager	4.9.0	True	False	False 37m
operator-lifecycle-manager-catalog	4.9.0	True	False	False 37m
operator-lifecycle-manager-packageserver	4.9.0	True	False	False 32m
service-ca	4.9.0	True	False	False 38m
storage	4.9.0	True	False	False 37m

2. Configure the Operators that are not available.

**12.2.16.1. Image registry storage configuration**

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

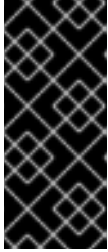
Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

**12.2.16.1.1. Configuring registry storage for IBM Z**

As a cluster administrator, following installation you must configure your registry to use storage.

## Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.
- You have a cluster on IBM Z.
- You have provisioned persistent storage for your cluster, such as Red Hat OpenShift Container Storage.



### IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have 100Gi capacity.

## Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.



### NOTE

When using shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

### Example output

```
No resources found in openshift-image-registry namespace
```



### NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

### Example output

```
storage:
  pvc:
    claim:
```

Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** PVC.

4. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

#### Example output

```
NAME          VERSION          AVAILABLE PROGRESSING DEGRADED SINCE
MESSAGE
image-registry 4.9              True      False      False    6h50m
```

5. Ensure that your registry is set to managed to enable building and pushing of images.

- Run:

```
$ oc edit configs.imageregistry/cluster
```

Then, change the line

```
managementState: Removed
```

to

```
managementState: Managed
```

#### 12.2.16.1.2. Configuring storage for the image registry in non-production clusters

You must configure storage for the Image Registry Operator. For non-production clusters, you can set the image registry to an empty directory. If you do so, all images are lost if you restart the registry.

#### Procedure

- To set the image registry storage to an empty directory:

```
$ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec": {"storage":{"emptyDir":{}}}'
```



#### WARNING

Configure this option for only non-production clusters.

If you run this command before the Image Registry Operator initializes its components, the **oc patch** command fails with the following error:

```
Error from server (NotFound): configs.imageregistry.operator.openshift.io "cluster" not found
```

Wait a few minutes and run the command again.

## 12.2.17. Completing installation on user-provisioned infrastructure

After you complete the Operator configuration, you can finish installing the cluster on infrastructure that you provide.

### Prerequisites

- Your control plane has initialized.
- You have completed the initial Operator configuration.

### Procedure

1. Confirm that all the cluster components are online with the following command:

```
$ watch -n5 oc get clusteroperators
```

### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
authentication	4.9.0	True	False	False	19m
baremetal	4.9.0	True	False	False	37m
cloud-credential	4.9.0	True	False	False	40m
cluster-autoscaler	4.9.0	True	False	False	37m
config-operator	4.9.0	True	False	False	38m
console	4.9.0	True	False	False	26m
csi-snapshot-controller	4.9.0	True	False	False	37m
dns	4.9.0	True	False	False	37m
etcd	4.9.0	True	False	False	36m
image-registry	4.9.0	True	False	False	31m
ingress	4.9.0	True	False	False	30m
insights	4.9.0	True	False	False	31m
kube-apiserver	4.9.0	True	False	False	26m
kube-controller-manager	4.9.0	True	False	False	36m
kube-scheduler	4.9.0	True	False	False	36m
kube-storage-version-migrator	4.9.0	True	False	False	37m
machine-api	4.9.0	True	False	False	29m
machine-approver	4.9.0	True	False	False	37m
machine-config	4.9.0	True	False	False	36m
marketplace	4.9.0	True	False	False	37m
monitoring	4.9.0	True	False	False	29m
network	4.9.0	True	False	False	38m
node-tuning	4.9.0	True	False	False	37m
openshift-apiserver	4.9.0	True	False	False	32m
openshift-controller-manager	4.9.0	True	False	False	30m
openshift-samples	4.9.0	True	False	False	32m
operator-lifecycle-manager	4.9.0	True	False	False	37m
operator-lifecycle-manager-catalog	4.9.0	True	False	False	37m
operator-lifecycle-manager-packageserver	4.9.0	True	False	False	32m
service-ca	4.9.0	True	False	False	38m
storage	4.9.0	True	False	False	37m

Alternatively, the following command notifies you when all of the clusters are available. It also retrieves and displays credentials:

```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

### Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

The command succeeds when the Cluster Version Operator finishes deploying the OpenShift Container Platform cluster from Kubernetes API server.



### IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Confirm that the Kubernetes API server is communicating with the pods.

- a. To view a list of all pods, use the following command:

```
$ oc get pods --all-namespaces
```

### Example output

```

NAMESPACE          NAME                                     READY  STATUS
RESTARTS  AGE
openshift-apiserver-operator  openshift-apiserver-operator-85cb746d55-zqhs8  1/1
Running    1    9m
openshift-apiserver          apiserver-67b9g                                1/1  Running  0
3m
openshift-apiserver          apiserver-ljcmx                                1/1  Running  0
1m
openshift-apiserver          apiserver-z25h4                                1/1  Running  0
2m
openshift-authentication-operator  authentication-operator-69d5d8bf84-vh2n8    1/1
Running    0    5m
...
```

- b. View the logs for a pod that is listed in the output of the previous command by using the following command:

```
$ oc logs <pod_name> -n <namespace> 1
```

- 1 Specify the pod name and namespace, as shown in the output of the previous command.

If the pod logs display, the Kubernetes API server can communicate with the cluster machines.

3. For an installation with Fibre Channel Protocol (FCP), additional steps are required to enable multipathing. Do not enable multipathing during installation. See "Enabling multipathing with kernel arguments on RHCOS" in the *Post-installation machine configuration tasks* documentation for more information.

## 12.2.18. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

## 12.2.19. Collecting debugging information

You can gather debugging information that might help you to troubleshoot and debug certain issues with an OpenShift Container Platform installation on IBM Z.

### Prerequisites

- The **oc** CLI tool installed.

### Procedure

1. Log in to the cluster:

```
$ oc login -u <username>
```

2. On the node you want to gather hardware information about, start a debugging container:

```
$ oc debug node/<nodename>
```

3. Change to the **/host** file system and start **toolbox**:



```
$ chroot /host
$ toolbox
```

4. Collect the **dbginfo** data:

```
$ dbginfo.sh
```

5. You can then retrieve the data, for example, using **scp**.

### Additional resources

- [How to generate SOSREPORT within OpenShift4 nodes without SSH](#) .

### 12.2.20. Next steps

- [Enabling multipathing with kernel arguments on RHCOS](#) .
- [Customize your cluster](#).
- If necessary, you can [opt out of remote health reporting](#) .

## 12.3. INSTALLING A CLUSTER WITH Z/VM ON IBM Z AND LINUXONE IN A RESTRICTED NETWORK

In OpenShift Container Platform version 4.9, you can install a cluster on IBM Z and LinuxONE infrastructure that you provision in a restricted network.



### NOTE

While this document refers to only IBM Z, all information in it also applies to LinuxONE.

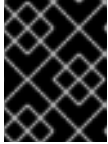


### IMPORTANT

Additional considerations exist for non-bare metal platforms. Review the information in the [guidelines for deploying OpenShift Container Platform on non-tested platforms](#) before you install an OpenShift Container Platform cluster.

### 12.3.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You [created a mirror registry for installation in a restricted network](#) and obtained the **imageContentSources** data for your version of OpenShift Container Platform.
- Before you begin the installation process, you must move or remove any existing installation files. This ensures that the required installation files are created and updated during the installation process.



### IMPORTANT

Ensure that installation steps are done from a machine with access to the installation media.

- You provisioned [persistent storage using NFS](#) for your cluster. To deploy a private image registry, your storage must provide **ReadWriteMany** access modes.
- If you use a firewall and plan to use the Telemetry service, you [configured the firewall to allow the sites](#) that your cluster requires access to.



### NOTE

Be sure to also review this site list if you are configuring a proxy.

## 12.3.2. About installations in restricted networks

In OpenShift Container Platform 4.9, you can perform an installation that does not require an active connection to the internet to obtain software components. Restricted network installations can be completed using installer-provisioned infrastructure or user-provisioned infrastructure, depending on the cloud platform to which you are installing the cluster.

If you choose to perform a restricted network installation on a cloud platform, you still require access to its cloud APIs. Some cloud functions, like Amazon Web Service's Route 53 DNS and IAM services, require internet access. Depending on your network, you might require less internet access for an installation on bare metal hardware or on VMware vSphere.

To complete a restricted network installation, you must create a registry that mirrors the contents of the OpenShift Container Platform registry and contains the installation media. You can create this registry on a mirror host, which can access both the internet and your closed network, or by using other methods that meet your restrictions.



### IMPORTANT

Because of the complexity of the configuration for user-provisioned installations, consider completing a standard user-provisioned infrastructure installation before you attempt a restricted network installation using user-provisioned infrastructure. Completing this test installation might make it easier to isolate and troubleshoot any issues that might arise during your installation in a restricted network.

### 12.3.2.1. Additional limits

Clusters in restricted networks have the following additional limitations and restrictions:

- The **ClusterVersion** status includes an **Unable to retrieve available updates** error.
- By default, you cannot use the contents of the Developer Catalog because you cannot access the required image stream tags.

## 12.3.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to obtain the images that are necessary to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



### IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

## 12.3.4. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

### 12.3.4.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

**Table 12.18. Minimum required hosts**

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.



### IMPORTANT

To improve high availability of your cluster, distribute the control plane machines over different z/VM instances on at least two physical machines.

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 7.9, or RHEL 8.4.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See [Red Hat Enterprise Linux technology capabilities and limits](#) .

### 12.3.4.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

**Table 12.19. Minimum resource requirements**

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS
Bootstrap	RHCOS	4	16 GB	100 GB	N/A
Control plane	RHCOS	4	16 GB	100 GB	N/A
Compute	RHCOS	2	8 GB	100 GB	N/A

1. One physical core (IFL) provides two logical cores (threads) when SMT-2 is enabled. The hypervisor can provide two or more vCPUs.

### 12.3.4.3. Minimum IBM Z system environment

You can install OpenShift Container Platform version 4.9 on the following IBM hardware:

- IBM z15 (all models), IBM z14 (all models), IBM z13, and IBM z13s
- LinuxONE, any version

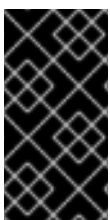
#### Hardware requirements

- The equivalent of 6 IFLs, which are SMT2 enabled, for each cluster.
- At least one network connection to both connect to the **LoadBalancer** service and to serve data for traffic outside the cluster.



#### NOTE

You can use dedicated or shared IFLs to assign sufficient compute resources. Resource sharing is one of the key strengths of IBM Z. However, you must adjust capacity correctly on each hypervisor layer and ensure sufficient resources for every OpenShift Container Platform cluster.



#### IMPORTANT

Since the overall performance of the cluster can be impacted, the LPARs that are used to setup the OpenShift Container Platform clusters must provide sufficient compute capacity. In this context, LPAR weight management, entitlements, and CPU shares on the hypervisor level play an important role.

#### Operating system requirements

- One instance of z/VM 7.1 or later

On your z/VM instance, set up:

- 3 guest virtual machines for OpenShift Container Platform control plane machines
- 2 guest virtual machines for OpenShift Container Platform compute machines
- 1 guest virtual machine for the temporary OpenShift Container Platform bootstrap machine

### IBM Z network connectivity requirements

To install on IBM Z under z/VM, you require a single z/VM virtual NIC in layer 2 mode. You also need:

- A direct-attached OSA or RoCE network adapter
- A z/VM VSwitch set up. For a preferred setup, use OSA link aggregation.

### Disk storage for the z/VM guest virtual machines

- FICON attached disk storage (DASDs). These can be z/VM minidisks, fullpack minidisks, or dedicated DASDs, all of which must be formatted as CDL, which is the default. To reach the minimum required DASD size for Red Hat Enterprise Linux CoreOS (RHCOS) installations, you need extended address volumes (EAV). If available, use HyperPAV to ensure optimal performance.
- FCP attached disk storage

### Storage / Main Memory

- 16 GB for OpenShift Container Platform control plane machines
- 8 GB for OpenShift Container Platform compute machines
- 16 GB for the temporary OpenShift Container Platform bootstrap machine

## 12.3.4.4. Preferred IBM Z system environment

### Hardware requirements

- Three LPARS that each have the equivalent of six IFLs, which are SMT2 enabled, for each cluster.
- Two network connections to both connect to the **LoadBalancer** service and to serve data for traffic outside the cluster.
- HiperSockets, which are attached to a node either directly as a device or by bridging with one z/VM VSWITCH to be transparent to the z/VM guest. To directly connect HiperSockets to a node, you must set up a gateway to the external network via a RHEL 8 guest to bridge to the HiperSockets network.

### Operating system requirements

- Two or three instances of z/VM 7.1 or later for high availability

On your z/VM instances, set up:

- Three guest virtual machines for OpenShift Container Platform control plane machines, one per z/VM instance.

- At least six guest virtual machines for OpenShift Container Platform compute machines, distributed across the z/VM instances.
- One guest virtual machine for the temporary OpenShift Container Platform bootstrap machine.
- To ensure the availability of integral components in an overcommitted environment, increase the priority of the control plane by using the CP command **SET SHARE**. Do the same for infrastructure nodes, if they exist. See [SET SHARE](#) in IBM Documentation.

### IBM Z network connectivity requirements

To install on IBM Z under z/VM, you require a single z/VM virtual NIC in layer 2 mode. You also need:

- A direct-attached OSA or RoCE network adapter
- A z/VM VSwitch set up. For a preferred setup, use OSA link aggregation.

### Disk storage for the z/VM guest virtual machines

- FICON attached disk storage (DASDs). These can be z/VM minidisks, fullpack minidisks, or dedicated DASDs, all of which must be formatted as CDL, which is the default. To reach the minimum required DASD size for Red Hat Enterprise Linux CoreOS (RHCOS) installations, you need extended address volumes (EAV). If available, use HyperPAV and High Performance FICON (zHPF) to ensure optimal performance.
- FCP attached disk storage

### Storage / Main Memory

- 16 GB for OpenShift Container Platform control plane machines
- 8 GB for OpenShift Container Platform compute machines
- 16 GB for the temporary OpenShift Container Platform bootstrap machine

### 12.3.4.5. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

### Additional resources

- See [Bridging a HiperSockets LAN with a z/VM Virtual Switch](#) in IBM Documentation.
- See [Scaling HyperPAV alias devices on Linux guests on z/VM](#) for performance optimization.
- See [Topics in LPAR performance](#) for LPAR weight management and entitlements.
- [Recommended host practices for IBM Z & LinuxONE environments](#)

### 12.3.4.6. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.

It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.



#### NOTE

If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

#### 12.3.4.6.1. Setting the cluster node hostnames through DHCP

On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

#### 12.3.4.6.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.

**Table 12.20. Ports used for all-machine to all-machine communications**

Protocol	Port	Description
ICMP	N/A	Network reachability tests

Protocol	Port	Description
TCP	<b>1936</b>	Metrics
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> and the Cluster Version Operator on port <b>9099</b> .
	<b>10250-10259</b>	The default ports that Kubernetes reserves
	<b>10256</b>	openshift-sdn
UDP	<b>4789</b>	VXLAN and Geneve
	<b>6081</b>	VXLAN and Geneve
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> .
	<b>500</b>	IPsec IKE packets
	<b>4500</b>	IPsec NAT-T packets
TCP/UDP	<b>30000-32767</b>	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 12.21. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	<b>6443</b>	Kubernetes API

Table 12.22. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	<b>2379-2380</b>	etcd server and peer ports

### NTP configuration for user-provisioned infrastructure

OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service*.

### Additional resources

- [Configuring chrony time service](#)



### 12.3.4.7. User-provisioned DNS requirements

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

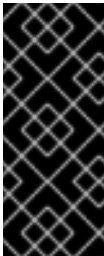
- The Kubernetes API
- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines

Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, **<cluster\_name>** is the cluster name and **<base\_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster\_name>.<base\_domain>..**

**Table 12.23. Required DNS records**

Component	Record	Description
Kubernetes API	<b>api.&lt;cluster_name&gt;.&lt;base_domain&gt;..</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
	<b>api-int.&lt;cluster_name&gt;.&lt;base_domain&gt;..</b>	<p>A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster.</p> <div style="display: flex; align-items: flex-start;"> <div style="flex: 1;">  </div> <div style="flex: 2;"> <p><b>IMPORTANT</b></p> <p>The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.</p> </div> </div>

Component	Record	Description
Routes	<b>*.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.  For example, <b>console-openshift-console.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;</b> is used as a wildcard route to the OpenShift Container Platform console.
Bootstrap machine	<b>bootstrap.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.
Control plane machines	<b>&lt;master&gt;&lt;n&gt;.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.
Compute machines	<b>&lt;worker&gt;&lt;n&gt;.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.



#### NOTE

In OpenShift Container Platform 4.4 and later, you do not need to specify etcd host and SRV records in your DNS configuration.

#### TIP

You can use the **dig** command to verify name and reverse name resolution. See the section on *Validating DNS resolution for user-provisioned infrastructure* for detailed validation steps.

#### 12.3.4.7.1. Example DNS configuration for user-provisioned clusters

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is **ocp4** and the base domain is **example.com**.

#### Example DNS A record configuration for a user-provisioned cluster

The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

#### Example 12.4. Sample DNS zone database

```

$TTL 1W
@ IN SOA ns1.example.com. root (
    2019070700 ; serial
    3H ; refresh (3 hours)
    30M ; retry (30 minutes)
    2W ; expiry (2 weeks)
    1W ) ; minimum (1 week)
IN NS ns1.example.com.
IN MX 10 smtp.example.com.
;
;
ns1.example.com. IN A 192.168.1.5
smtp.example.com. IN A 192.168.1.5
;
helper.example.com. IN A 192.168.1.5
helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com. IN A 192.168.1.5 1
api-int.ocp4.example.com. IN A 192.168.1.5 2
;
*.apps.ocp4.example.com. IN A 192.168.1.5 3
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 4
;
master0.ocp4.example.com. IN A 192.168.1.97 5
master1.ocp4.example.com. IN A 192.168.1.98 6
master2.ocp4.example.com. IN A 192.168.1.99 7
;
worker0.ocp4.example.com. IN A 192.168.1.11 8
worker1.ocp4.example.com. IN A 192.168.1.7 9
;
;EOF

```

- 1 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.
- 2 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.
- 3 Provides name resolution for the wildcard routes. The record refers to the IP address of the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



#### NOTE

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

- 4 Provides name resolution for the bootstrap machine.
- 5 6 7 Provides name resolution for the control plane machines.

**8 9** Provides name resolution for the compute machines.

### Example DNS PTR record configuration for a user-provisioned cluster

The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

#### Example 12.5. Sample DNS zone database for reverse records

```
$TTL 1W
@ IN SOA ns1.example.com. root (
    2019070700 ; serial
    3H ; refresh (3 hours)
    30M ; retry (30 minutes)
    2W ; expiry (2 weeks)
    1W ) ; minimum (1 week)
IN NS ns1.example.com.
;
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. 2
;
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. 3
;
97.1.168.192.in-addr.arpa. IN PTR master0.ocp4.example.com. 4
98.1.168.192.in-addr.arpa. IN PTR master1.ocp4.example.com. 5
99.1.168.192.in-addr.arpa. IN PTR master2.ocp4.example.com. 6
;
11.1.168.192.in-addr.arpa. IN PTR worker0.ocp4.example.com. 7
7.1.168.192.in-addr.arpa. IN PTR worker1.ocp4.example.com. 8
;
;EOF
```

- 1** Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.
- 2** Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.
- 3** Provides reverse DNS resolution for the bootstrap machine.
- 4 5 6** Provides reverse DNS resolution for the control plane machines.
- 7 8** Provides reverse DNS resolution for the compute machines.



#### NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard.

### 12.3.4.8. Load balancing requirements for user-provisioned infrastructure

Before you install OpenShift Container Platform, you must provision the API and application ingress load balancing infrastructure. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.



## NOTE

If you want to deploy the API and application ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer.** Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:
  - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the API routes.
  - A stateless load balancing algorithm. The options vary based on the load balancer implementation.



## NOTE

Session persistence is not required for the API load balancer to function properly.

Configure the following ports on both the front and back of the load balancers:

**Table 12.24. API load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
<b>6443</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the <b>/readyz</b> endpoint for the API server health check probe.	X	X	Kubernetes API server
<b>22623</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server



## NOTE

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the **/readyz** endpoint to the removal of the API server instance from the pool. Within the time frame after **/readyz** returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application ingress load balancer.** Provides an ingress point for application traffic flowing in from outside the cluster. Configure the following conditions:
  - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the ingress routes.
  - A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

**TIP**

If the true IP address of the client can be seen by the application ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

Configure the following ports on both the front and back of the load balancers:

**Table 12.25. Application ingress load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
<b>443</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic
<b>80</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic
<b>1936</b>	The worker nodes that run the Ingress Controller pods, by default. You must configure the <b>/healthz/ready</b> endpoint for the ingress health check probe.	X	X	HTTP traffic

**NOTE**

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

**NOTE**

A working configuration for the Ingress router is required for an OpenShift Container Platform cluster. You must configure the Ingress router after the control plane initializes.

**12.3.4.8.1. Example load balancer configuration for user-provisioned clusters**

This section provides an example API and application ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an **/etc/haproxy/haproxy.cfg** configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing

one load balancing solution over another.



## NOTE

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

### Example 12.6. Sample API and application ingress load balancer configuration

```

global
log      127.0.0.1 local2
pidfile  /var/run/haproxy.pid
maxconn  4000
daemon

defaults
mode      http
log        global
option     dontlognull
option     http-server-close
option     redispatch
retries    3
timeout    http-request 10s
timeout    queue 1m
timeout    connect 10s
timeout    client 1m
timeout    server 1m
timeout    http-keep-alive 10s
timeout    check 10s
maxconn    3000

frontend stats
bind *:1936
mode      http
log        global
maxconn 10
stats enable
stats hide-version
stats refresh 30s
stats show-node
stats show-desc Stats for ocp4 cluster 1
stats auth admin:ocp4
stats uri /stats

listen api-server-6443 2
bind *:6443
mode tcp
server bootstrap bootstrap.ocp4.example.com:6443 check inter 1s backup 3
server master0 master0.ocp4.example.com:6443 check inter 1s
server master1 master1.ocp4.example.com:6443 check inter 1s
server master2 master2.ocp4.example.com:6443 check inter 1s

listen machine-config-server-22623 4
bind *:22623
mode tcp
server bootstrap bootstrap.ocp4.example.com:22623 check inter 1s backup 5

```

```

server master0 master0.ocp4.example.com:22623 check inter 1s
server master1 master1.ocp4.example.com:22623 check inter 1s
server master2 master2.ocp4.example.com:22623 check inter 1s
listen ingress-router-443 6
bind *:443
mode tcp
balance source
server worker0 worker0.ocp4.example.com:443 check inter 1s
server worker1 worker1.ocp4.example.com:443 check inter 1s
listen ingress-router-80 7
bind *:80
mode tcp
balance source
server worker0 worker0.ocp4.example.com:80 check inter 1s
server worker1 worker1.ocp4.example.com:80 check inter 1s

```

- 1 In the example, the cluster name is **ocp4**.
- 2 Port **6443** handles the Kubernetes API traffic and points to the control plane machines.
- 3 5 The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.
- 4 Port **22623** handles the machine config server traffic and points to the control plane machines.
- 6 Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.
- 7 Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



#### NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

#### TIP

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltp** on the HAProxy node.



#### NOTE

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running **setsebool -P haproxy\_connect\_any=1**.

### 12.3.5. Preparing the user-provisioned infrastructure



Before you install OpenShift Container Platform on user-provisioned infrastructure, you must prepare the underlying infrastructure.

This section provides details about the high-level steps required to set up your cluster infrastructure in preparation for an OpenShift Container Platform installation. This includes configuring IP networking and network connectivity for your cluster nodes, preparing a web server for the Ignition files, enabling the required ports through your firewall, and setting up the required DNS and load balancing infrastructure.

After preparation, your cluster infrastructure must meet the requirements outlined in the *Requirements for a cluster with user-provisioned infrastructure* section.

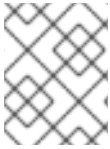
## Prerequisites

- You have reviewed the [OpenShift Container Platform 4.x Tested Integrations](#) page.
- You have reviewed the infrastructure requirements detailed in the *Requirements for a cluster with user-provisioned infrastructure* section.

## Procedure

1. Set up static IP addresses.
2. Set up an HTTP or HTTPS server to provide Ignition files to the cluster nodes.
3. Ensure that your network infrastructure provides the required network connectivity between the cluster components. See the *Networking requirements for user-provisioned infrastructure* section for details about the requirements.
4. Configure your firewall to enable the ports required for the OpenShift Container Platform cluster components to communicate. See *Networking requirements for user-provisioned infrastructure* section for details about the ports that are required.
5. Setup the required DNS infrastructure for your cluster.
  - a. Configure DNS name resolution for the Kubernetes API, the application wildcard, the bootstrap machine, the control plane machines, and the compute machines.
  - b. Configure reverse DNS resolution for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.  
See the *User-provisioned DNS requirements* section for more information about the OpenShift Container Platform DNS requirements.
6. Validate your DNS configuration.
  - a. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses in the responses correspond to the correct components.
  - b. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names in the responses correspond to the correct components.  
See the *Validating DNS resolution for user-provisioned infrastructure* section for detailed DNS validation steps.

7. Provision the required API and application ingress load balancing infrastructure. See the *Load balancing requirements for user-provisioned infrastructure* section for more information about the requirements.

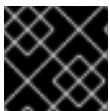


#### NOTE

Some load balancing solutions require the DNS name resolution for the cluster nodes to be in place before the load balancing is initialized.

### 12.3.6. Validating DNS resolution for user-provisioned infrastructure

You can validate your DNS configuration before installing OpenShift Container Platform on user-provisioned infrastructure.



#### IMPORTANT

The validation steps detailed in this section must succeed before you install your cluster.

#### Prerequisites

- You have configured the required DNS records for your user-provisioned infrastructure.

#### Procedure

1. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses contained in the responses correspond to the correct components.
  - a. Perform a lookup against the Kubernetes API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api.<cluster_name>.<base_domain> 1
```

- 1** Replace **<nameserver\_ip>** with the IP address of the nameserver, **<cluster\_name>** with your cluster name, and **<base\_domain>** with your base domain name.

#### Example output

```
api.ocp4.example.com. 0 IN A 192.168.1.5
```

- b. Perform a lookup against the Kubernetes internal API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api-int.<cluster_name>.<base_domain>
```

#### Example output

```
api-int.ocp4.example.com. 0 IN A 192.168.1.5
```

- c. Test an example **\*.apps.<cluster\_name>.<base\_domain>** DNS wildcard lookup. All of the application wildcard lookups must resolve to the IP address of the application ingress load balancer:

```
$ dig +noall +answer @<nameserver_ip> random.apps.<cluster_name>.<base_domain>
```

### Example output

```
random.apps.ocp4.example.com. 0 IN A 192.168.1.5
```



### NOTE

In the example outputs, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

You can replace **random** with another wildcard value. For example, you can query the route to the OpenShift Container Platform console:

```
$ dig +noall +answer @<nameserver_ip> console-openshift-console.apps.<cluster_name>.<base_domain>
```

### Example output

```
console-openshift-console.apps.ocp4.example.com. 0 IN A 192.168.1.5
```

- d. Run a lookup against the bootstrap DNS record name. Check that the result points to the IP address of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> bootstrap.<cluster_name>.<base_domain>
```

### Example output

```
bootstrap.ocp4.example.com. 0 IN A 192.168.1.96
```

- e. Use this method to perform lookups against the DNS record names for the control plane and compute nodes. Check that the results correspond to the IP addresses of each node.
2. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names contained in the responses correspond to the correct components.
    - a. Perform a reverse lookup against the IP address of the API load balancer. Check that the response includes the record names for the Kubernetes API and the Kubernetes internal API:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.5
```

### Example output

```
5.1.168.192.in-addr.arpa. 0 IN PTR api-int.ocp4.example.com. 1  
5.1.168.192.in-addr.arpa. 0 IN PTR api.ocp4.example.com. 2
```

- 1 Provides the record name for the Kubernetes internal API.
- 2 Provides the record name for the Kubernetes API.



#### NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard. No validation step is needed for reverse DNS resolution against the IP address of the application ingress load balancer.

- b. Perform a reverse lookup against the IP address of the bootstrap node. Check that the result points to the DNS record name of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.96
```

#### Example output

```
96.1.168.192.in-addr.arpa. 0 IN PTR bootstrap.ocp4.example.com.
```

- c. Use this method to perform reverse lookups against the IP addresses for the control plane and compute nodes. Check that the results correspond to the DNS record names of each node.

### 12.3.7. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.



#### IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

#### Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.



#### NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.



#### NOTE

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

#### Example output

```
Agent pid 31874
```



#### NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1 Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

#### Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

### Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

## 12.3.8. Manually creating the installation configuration file

For user-provisioned installations of OpenShift Container Platform, you manually generate your installation configuration file.

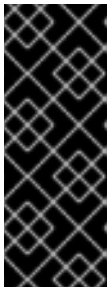
### Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

### Procedure

1. Create an installation directory to store your required installation assets in:

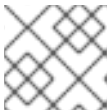
```
$ mkdir <installation_directory>
```



#### IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation\_directory>**.



#### NOTE

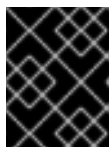
You must name this configuration file **install-config.yaml**.



#### NOTE

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation\_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

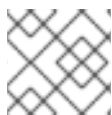
3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

**IMPORTANT**

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

**12.3.8.1. Installation configuration parameters**

Before you deploy an OpenShift Container Platform cluster, you provide a customized **install-config.yaml** installation configuration file that describes the details for your environment.

**NOTE**

After installation, you cannot modify these parameters in the **install-config.yaml** file.

**IMPORTANT**

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

**12.3.8.1.1. Required configuration parameters**

Required installation configuration parameters are described in the following table:

Table 12.26. Required parameters

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;</b> . <b>&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object

Parameter	Description	Values
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}.{{.baseDomain}}</b> .	String of lowercase letters, hyphens (-), and periods (.), such as <b>dev</b> .
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws, baremetal, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } }</pre>

### 12.3.8.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.


Only IPv4 addresses are supported.

Table 12.27. Network parameters

Parameter	Description	Values
-----------	-------------	--------



Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	Object  <b>NOTE</b> You cannot modify parameters specified by the <b>networking</b> object after installation.
<b>networking.networkType</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .
<b>networking.clusterNetwork</b>	The IP address blocks for pods.  The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b> .  If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example:  <pre>networking:   clusterNetwork:     - cidr: 10.128.0.0/14       hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	Required if you use <b>networking.clusterNetwork</b> . An IP address block.  An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b> .
<b>networking.clusterNetwork.hostPrefix</b>	The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b> . A <b>hostPrefix</b> value of <b>23</b> provides 510 ( $2^{(32 - 23)} - 2$ ) pod IP addresses.	A subnet prefix.  The default value is <b>23</b> .


Parameter	Description	Values
<b>networking.serviceNetwork</b>	<p>The IP address block for services. The default value is <b>172.30.0.0/16</b>.</p> <p>The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.</p>	<p>An array with an IP address block in CIDR format. For example:</p> <pre>networking:   serviceNetwork:     - 172.30.0.0/16</pre>
<b>networking.machineNetwork</b>	<p>The IP address blocks for machines.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p> <p>If you specify multiple IP kernel arguments, the <b>machineNetwork.cidr</b> value must be the CIDR of the primary network.</p>	<p>An array of objects. For example:</p> <pre>networking:   machineNetwork:     - cidr: 10.0.0.0/16</pre>
<b>networking.machineNetwork.cidr</b>	<p>Required if you use <b>networking.machineNetwork</b>. An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b>.</p>	<p>An IP network block in CIDR notation. For example, <b>10.0.0.0/16</b>.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p> </div> </div>


### 12.3.8.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

Table 12.28. Optional parameters


Parameter	Description	Values
<b>additionalTrustBundle</b>	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
<b>compute</b>	The configuration for the machines that comprise the compute nodes.	Array of <b>MachinePool</b> objects.

Parameter	Description	Values
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>s390x</b> (the default).	String
<b>compute.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>s390x</b> (the default).	String

Parameter	Description	Values
<b>controlPlane.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platform</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>controlPlane.replicas</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.

Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.</p> <div data-bbox="485 510 595 862" style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p><b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators reference</i> content.</p> </div> <div data-bbox="485 907 595 1258" style="border: 1px solid black; padding: 5px;"> <p><b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p> </div>	<b>Mint, Passthrough, Manual</b> or an empty string ("").

Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start;"> <div style="width: 40px; height: 40px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 40px; height: 40px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<b>Internal</b> or <b>External</b> . The default value is <b>External</b> .  Setting this field to <b>Internal</b> is not supported on non-cloud platforms.

Parameter	Description	Values
<b>sshKey</b>	<p>The SSH key or keys to authenticate access your cluster machines.</p>  <p><b>NOTE</b></p> <p>For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.</p>	<p>One or more keys. For example:</p> <pre>sshKey:   &lt;key1&gt;   &lt;key2&gt;   &lt;key3&gt;</pre>

### 12.3.8.2. Sample install-config.yaml file for IBM Z

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```

apiVersion: v1
baseDomain: example.com 1
compute: 2
- hyperthreading: Enabled 3
  name: worker
  replicas: 0 4
  architecture : s390x
controlPlane: 5
  hyperthreading: Enabled 6
  name: master
  replicas: 3 7
  architecture : s390x
metadata:
  name: test 8
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14 9
    hostPrefix: 23 10
  networkType: OpenShiftSDN
  serviceNetwork: 11
  - 172.30.0.0/16
platform:
  none: {} 12
fips: false 13
pullSecret: '{"auths":{"<local_registry>":{"auth":"<credentials>","email":"you@example.com"}}}' 14

```





- 9 A block of IP addresses from which pod IP addresses are allocated. This block must not overlap with existing physical networks. These IP addresses are used for the pod network. If you need to



#### NOTE

Class E CIDR range is reserved for a future use. To use the Class E CIDR range, you must ensure your networking environment accepts the IP addresses within the Class E CIDR range.

- 10 The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23**, then each node is assigned a **/23** subnet out of the given **cidr**, which allows for 510 ( $2^{(32 - 23)} - 2$ ) pod IP addresses. If you are required to provide access to nodes from an external network, configure load balancers and routers to manage the traffic.
- 11 The IP address pool to use for service IP addresses. You can enter only one IP address pool. This block must not overlap with existing physical networks. If you need to access the services from an external network, configure load balancers and routers to manage the traffic.
- 12 You must set the platform to **none**. You cannot provide additional platform configuration variables for IBM Z infrastructure.



#### IMPORTANT

Clusters that are installed with the platform type **none** are unable to use some features, such as managing compute machines with the Machine API. This limitation applies even if the compute machines that are attached to the cluster are installed on a platform that would normally support the feature. This parameter cannot be changed after installation.

- 13 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.



#### IMPORTANT

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

- 14 For **<local\_registry>**, specify the registry domain name, and optionally the port, that your mirror registry uses to serve content. For example, **registry.example.com** or **registry.example.com:5000**. For **<credentials>**, specify the base64-encoded user name and password for your mirror registry.
- 15 The SSH public key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).



#### NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

- 16 Add the **additionalTrustBundle** parameter and value. The value must be the contents of the certificate file that you used for your mirror registry, which can be an existing, trusted certificate
- 17 Provide the **imageContentSources** section from the output of the command to mirror the repository.

### 12.3.8.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

#### Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



#### NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

#### Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
  -----BEGIN CERTIFICATE-----
  <MY_TRUSTED_CA_CERT>
  -----END CERTIFICATE-----
...
```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.

- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with `.` to match subdomains only. For
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.



#### NOTE

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



#### NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

#### 12.3.8.4. Configuring a three-node cluster

You can optionally deploy zero compute machines in a bare metal cluster that consists of three control plane machines only. This provides smaller, more resource efficient clusters for cluster administrators and developers to use for testing, development, and production.

In three-node OpenShift Container Platform environments, the three control plane machines are schedulable, which means that your application workloads are scheduled to run on them.

#### Prerequisites

- You have an existing **install-config.yaml** file.

#### Procedure

- Ensure that the number of compute replicas is set to **0** in your **install-config.yaml** file, as shown in the following **compute** stanza:

```
compute:
- name: worker
  platform: {}
  replicas: 0
```

**NOTE**

You must set the value of the **replicas** parameter for the compute machines to **0** when you install OpenShift Container Platform on user-provisioned infrastructure, regardless of the number of compute machines you are deploying. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. This does not apply to user-provisioned installations, where the compute machines are deployed manually.

**NOTE**

The preferred resource for control plane nodes is six vCPUs and 21 GB. For three control plane nodes this is the memory + vCPU equivalent of a minimum five-node cluster. You should back the three nodes, each installed on a 120 GB disk, with three IFLs that are SMT2 enabled. The minimum tested setup is three vCPUs and 10 GB on a 120 GB disk for each control plane node.

For three-node cluster installations, follow these next steps:

- If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes. See the *Load balancing requirements for user-provisioned infrastructure* section for more information.
- When you create the Kubernetes manifest files in the following procedure, ensure that the **mastersSchedulable** parameter in the `<installation_directory>/manifests/cluster-scheduler-02-config.yml` file is set to **true**. This enables your application workloads to run on the control plane nodes.
- Do not deploy any compute nodes when you create the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

### 12.3.9. Cluster Network Operator configuration

The configuration for the cluster network is specified as part of the Cluster Network Operator (CNO) configuration and stored in a custom resource (CR) object that is named **cluster**. The CR specifies the fields for the **Network** API in the **operator.openshift.io** API group.

The CNO configuration inherits the following fields during cluster installation from the **Network** API in the **Network.config.openshift.io** API group and these fields cannot be changed:

**clusterNetwork**

IP address pools from which pod IP addresses are allocated.

**serviceNetwork**

IP address pool for services.

**defaultNetwork.type**

Cluster network provider, such as OpenShift SDN or OVN-Kubernetes.

You can specify the cluster network provider configuration for your cluster by setting the fields for the **defaultNetwork** object in the CNO object named **cluster**.

### 12.3.9.1. Cluster Network Operator configuration object

The fields for the Cluster Network Operator (CNO) are described in the following table:


Table 12.29. Cluster Network Operator configuration object

Field	Type	Description
<b>metadata.name</b>	<b>string</b>	The name of the CNO object. This name is always <b>cluster</b> .
<b>spec.clusterNetwork</b>	<b>array</b>	<p>A list specifying the blocks of IP addresses from which pod IP addresses are allocated and the subnet prefix length assigned to each individual node in the cluster. For example:</p> <pre>spec:   clusterNetwork:   - cidr: 10.128.0.0/19     hostPrefix: 23   - cidr: 10.128.32.0/19     hostPrefix: 23</pre> <p>You can customize this field only in the <b>install-config.yaml</b> file before you create the manifests. The value is read-only in the manifest file.</p>
<b>spec.serviceNetwork</b>	<b>array</b>	<p>A block of IP addresses for services. The OpenShift SDN and OVN-Kubernetes Container Network Interface (CNI) network providers support only a single IP address block for the service network. For example:</p> <pre>spec:   serviceNetwork:   - 172.30.0.0/14</pre> <p>You can customize this field only in the <b>install-config.yaml</b> file before you create the manifests. The value is read-only in the manifest file.</p>
<b>spec.defaultNetwork</b>	<b>object</b>	Configures the Container Network Interface (CNI) cluster network provider for the cluster network.
<b>spec.kubeProxy</b> <b>Config</b>	<b>object</b>	The fields for this object specify the kube-proxy configuration. If you are using the OVN-Kubernetes cluster network provider, the kube-proxy configuration has no effect.

#### defaultNetwork object configuration

The values for the **defaultNetwork** object are defined in the following table:

Table 12.30. defaultNetwork object

Field	Type	Description
<b>type</b>	<b>string</b>	<p>Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b>. The cluster network provider is selected during installation. This value cannot be changed after cluster installation.</p> <div style="display: flex; align-items: flex-start;"> <div style="flex: 1;">  </div> <div style="flex: 2;"> <p><b>NOTE</b></p> <p>OpenShift Container Platform uses the OpenShift SDN Container Network Interface (CNI) cluster network provider by default.</p> </div> </div>
<b>openshiftSDNConfig</b>	<b>object</b>	This object is only valid for the OpenShift SDN cluster network provider.
<b>ovnKubernetesConfig</b>	<b>object</b>	This object is only valid for the OVN-Kubernetes cluster network provider.

#### Configuration for the OpenShift SDN CNI cluster network provider

The following table describes the configuration fields for the OpenShift SDN Container Network Interface (CNI) cluster network provider.

**Table 12.31. openshiftSDNConfig object**

Field	Type	Description
<b>mode</b>	<b>string</b>	<p>Configures the network isolation mode for OpenShift SDN. The default value is <b>NetworkPolicy</b>.</p> <p>The values <b>Multitenant</b> and <b>Subnet</b> are available for backwards compatibility with OpenShift Container Platform 3.x but are not recommended. This value cannot be changed after cluster installation.</p>

Field	Type	Description
<b>mtu</b>	<b>integer</b>	<p>The maximum transmission unit (MTU) for the VXLAN overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU.</p> <p>If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes.</p> <p>If your cluster requires different MTU values for different nodes, you must set this value to <b>50</b> less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of <b>9001</b>, and some have an MTU of <b>1500</b>, you must set this value to <b>1450</b>.</p> <p>This value cannot be changed after cluster installation.</p>
<b>vxlanPort</b>	<b>integer</b>	<p>The port to use for all VXLAN packets. The default value is <b>4789</b>. This value cannot be changed after cluster installation.</p> <p>If you are running in a virtualized environment with existing nodes that are part of another VXLAN network, then you might be required to change this. For example, when running an OpenShift SDN overlay on top of VMware NSX-T, you must select an alternate port for the VXLAN, because both SDNs use the same default VXLAN port number.</p> <p>On Amazon Web Services (AWS), you can select an alternate port for the VXLAN between port <b>9000</b> and port <b>9999</b>.</p>

### Example OpenShift SDN configuration

```
defaultNetwork:
  type: OpenShiftSDN
  openshiftSDNConfig:
    mode: NetworkPolicy
    mtu: 1450
    vxlanPort: 4789
```

### Configuration for the OVN-Kubernetes CNI cluster network provider

The following table describes the configuration fields for the OVN-Kubernetes CNI cluster network provider.

Table 12.32. `ovnKubernetesConfig` object

Field	Type	Description
-------	------	-------------

Field	Type	Description
<b>mtu</b>	<b>integer</b>	<p>The maximum transmission unit (MTU) for the Geneve (Generic Network Virtualization Encapsulation) overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU.</p> <p>If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes.</p> <p>If your cluster requires different MTU values for different nodes, you must set this value to <b>100</b> less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of <b>9001</b>, and some have an MTU of <b>1500</b>, you must set this value to <b>1400</b>.</p> <p>This value cannot be changed after cluster installation.</p>
<b>genevePort</b>	<b>integer</b>	The port to use for all Geneve packets. The default value is <b>6081</b> . This value cannot be changed after cluster installation.
<b>policyAuditConfig</b>	<b>object</b>	Specify a configuration object for customizing network policy audit logging. If unset, the defaults audit log settings are used.

Table 12.33. **policyAuditConfig** object

Field	Type	Description
<b>rateLimit</b>	integer	The maximum number of messages to generate every second per node. The default value is <b>20</b> messages per second.
<b>maxFileSize</b>	integer	The maximum size for the audit log in bytes. The default value is <b>50000000</b> or 50 MB.



Field	Type	Description
<b>destination</b>	string	<p>One of the following additional audit log targets:</p> <p><b>libc</b> The libc <b>syslog()</b> function of the journald process on the host.</p> <p><b>udp:&lt;host&gt;:&lt;port&gt;</b> A syslog server. Replace <b>&lt;host&gt;:&lt;port&gt;</b> with the host and port of the syslog server.</p> <p><b>unix:&lt;file&gt;</b> A Unix Domain Socket file specified by <b>&lt;file&gt;</b>.</p> <p><b>null</b> Do not send the audit logs to any additional target.</p>
<b>syslogFacility</b>	string	The syslog facility, such as <b>kern</b> , as defined by RFC5424. The default value is <b>local0</b> .


### Example OVN-Kubernetes configuration

```
defaultNetwork:
  type: OVNKubernetes
  ovnKubernetesConfig:
    mtu: 1400
    genevePort: 6081
```

### kubeProxyConfig object configuration

The values for the **kubeProxyConfig** object are defined in the following table:

Table 12.34. **kubeProxyConfig** object

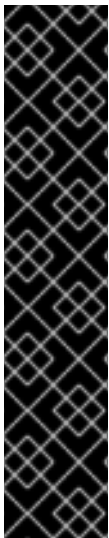
Field	Type	Description
<b>iptablesSyncPeriod</b>	<b>string</b>	<p>The refresh period for <b>iptables</b> rules. The default value is <b>30s</b>. Valid suffixes include <b>s</b>, <b>m</b>, and <b>h</b> and are described in the <a href="#">Go time package</a> documentation.</p> <div style="display: flex; align-items: flex-start;"> <div style="flex: 1;">  </div> <div style="flex: 2;"> <p><b>NOTE</b></p> <p>Because of performance improvements introduced in OpenShift Container Platform 4.3 and greater, adjusting the <b>iptablesSyncPeriod</b> parameter is no longer necessary.</p> </div> </div>

Field	Type	Description
<b>proxyArguments.iptables-min-sync-period</b>	<b>array</b>	<p>The minimum duration before refreshing <b>iptables</b> rules. This field ensures that the refresh does not happen too frequently. Valid suffixes include <b>s</b>, <b>m</b>, and <b>h</b> and are described in the <a href="#">Go time package</a>. The default value is:</p> <pre>kubeProxyConfig:   proxyArguments:     iptables-min-sync-period:       - 0s</pre>

### 12.3.10. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.



#### IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.



#### NOTE

The installation program that generates the manifest and Ignition files is architecture specific and can be obtained from the [client image mirror](#). The Linux version of the installation program runs on s390x only. This installer program is also available as a Mac OS version.

#### Prerequisites

- You obtained the OpenShift Container Platform installation program. For a restricted network installation, these files are on your mirror host.
- You created the **install-config.yaml** installation configuration file.

## Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

- 1 For **<installation\_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.



### WARNING

If you are installing a three-node cluster, skip the following step to allow the control plane nodes to be schedulable.



### IMPORTANT

When you configure control plane nodes from the default unschedulable to schedulable, additional subscriptions are required. This is because control plane nodes then become worker nodes.

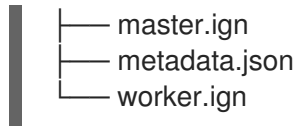
2. Check that the **mastersSchedulable** parameter in the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:
  - a. Open the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** file.
  - b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.
  - c. Save and exit the file.
3. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

- 1 For **<installation\_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation\_directory>/auth** directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
└── bootstrap.ign
```



### 12.3.11. Installing RHCOS and starting the OpenShift Container Platform bootstrap process

To install OpenShift Container Platform on IBM Z infrastructure that you provision, you must install Red Hat Enterprise Linux CoreOS (RHCOS) on z/VM guest virtual machines. When you install RHCOS, you must provide the Ignition config file that was generated by the OpenShift Container Platform installation program for the type of machine you are installing. If you have configured suitable networking, DNS, and load balancing infrastructure, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS z/VM guest virtual machines have rebooted.

Complete the following steps to create the machines.

#### Prerequisites

- An HTTP or HTTPS server running on your provisioning machine that is accessible to the machines you create.

#### Procedure

1. Log in to Linux on your provisioning machine.
2. Obtain the Red Hat Enterprise Linux CoreOS (RHCOS) kernel, initramfs, and rootfs files from the [RHCOS image mirror](#).



#### IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Only use the appropriate kernel, initramfs, and rootfs artifacts described in the following procedure.

The file names contain the OpenShift Container Platform version number. They resemble the following examples:

- kernel: **rhcosp-`<version>`-live-kernel-`<architecture>`**
- initramfs: **rhcosp-`<version>`-live-initramfs.`<architecture>`.img**
- rootfs: **rhcosp-`<version>`-live-rootfs.`<architecture>`.img**



#### NOTE

The rootfs image is the same for FCP and DASD.

3. Create parameter files. The following parameters are specific for a particular virtual machine:
  - For **ip=**, specify the following seven entries:
    - i. The IP address for the machine.

- ii. An empty string.
  - iii. The gateway.
  - iv. The netmask.
  - v. The machine host and domain name in the form **hostname.domainname**. Omit this value to let RHCOS decide.
  - vi. The network interface name. Omit this value to let RHCOS decide.
  - vii. If you use static IP addresses, specify **none**.
- For **coreos.inst.ignition\_url=**, specify the Ignition file for the machine role. Use **bootstrap.ign**, **master.ign**, or **worker.ign**. Only HTTP and HTTPS protocols are supported.
  - For **coreos.live.rootfs\_url=**, specify the matching rootfs artifact for the kernel and initramfs you are booting. Only HTTP and HTTPS protocols are supported.
  - For installations on DASD-type disks, complete the following tasks:
    - i. For **coreos.inst.install\_dev=**, specify **dasda**.
    - ii. Use **rd.dasd=** to specify the DASD where RHCOS is to be installed.
    - iii. Leave all other parameters unchanged.
- Example parameter file, **bootstrap-0.parm**, for the bootstrap machine:

```
rd.neednet=1 \
console=ttysclp0 \
coreos.inst.install_dev=dasda \
coreos.live.rootfs_url=http://cl1.provide.example.com:8080/assets/rhcos-live-
rootfs.s390x.img \
coreos.inst.ignition_url=http://cl1.provide.example.com:8080/ignition/bootstrap.ign \
ip=172.18.78.2::172.18.78.1:255.255.255.0::none nameserver=172.18.78.1 \
rd.znet=qeth,0.0.bdf0,0.0.bdf1,0.0.bdf2,layer2=1,portno=0 \
zfcp.allow_lun_scan=0 \
rd.dasd=0.0.3490
```

Write all options in the parameter file as a single line and make sure you have no newline characters.

- For installations on FCP-type disks, complete the following tasks:
  - i. Use **rd.zfcp=<adapter>,<wwpn>,<lun>** to specify the FCP disk where RHCOS is to be installed. For multipathing repeat this step for each additional path.



#### NOTE

When you install with multiple paths, you must enable multipathing directly after the installation, not at a later point in time, as this can cause problems.

- ii. Set the install device as: **coreos.inst.install\_dev=sda**.

**NOTE**

If additional LUNs are configured with NPIV, FCP requires **zfcplib.allow\_lun\_scan=0**. If you must enable **zfcplib.allow\_lun\_scan=1** because you use a CSI driver, for example, you must configure your NPIV so that each node cannot access the boot partition of another node.

- iii. Leave all other parameters unchanged.

**IMPORTANT**

Additional post-installation steps are required to fully enable multipathing. For more information, see "Enabling multipathing with kernel arguments on RHCOS" in *Post-installation machine configuration tasks*.

The following is an example parameter file **worker-1.parm** for a worker node with multipathing:

```
rd.neednet=1 \
console=ttysclp0 \
coreos.inst.install_dev=sda \
coreos.live.rootfs_url=http://cl1.provide.example.com:8080/assets/rhcos-live-
rootfs.s390x.img \
coreos.inst.ignition_url=http://cl1.provide.example.com:8080/ignition/worker.ign \
ip=172.18.78.2::172.18.78.1:255.255.255.0::none nameserver=172.18.78.1 \
rd.znet=qeth,0.0.bdf0,0.0.bdf1,0.0.bdf2,layer2=1,portno=0 \
zfcplib.allow_lun_scan=0 \
rd.zfcplib=0.0.1987,0x50050763070bc5e3,0x4008400B00000000 \
rd.zfcplib=0.0.19C7,0x50050763070bc5e3,0x4008400B00000000 \
rd.zfcplib=0.0.1987,0x50050763071bc5e3,0x4008400B00000000 \
rd.zfcplib=0.0.19C7,0x50050763071bc5e3,0x4008400B00000000
```

Write all options in the parameter file as a single line and make sure you have no newline characters.

4. Transfer the initramfs, kernel, parameter files, and RHCOS images to z/VM, for example with FTP. For details about how to transfer the files with FTP and boot from the virtual reader, see [Installing under Z/VM](#).
5. Punch the files to the virtual reader of the z/VM guest virtual machine that is to become your bootstrap node.  
See [PUNCH](#) in IBM Documentation.

**TIP**

You can use the CP PUNCH command or, if you use Linux, the **vmur** command to transfer files between two z/VM guest virtual machines.

6. Log in to CMS on the bootstrap machine.
7. IPL the bootstrap machine from the reader:

```
$ ipl c
```

See [IPL](#) in IBM Documentation.

8. Repeat this procedure for the other machines in the cluster.

### 12.3.11.1. Advanced RHCOS installation reference

This section illustrates the networking configuration and other advanced options that allow you to modify the Red Hat Enterprise Linux CoreOS (RHCOS) manual installation process. The following tables describe the kernel arguments and command-line options you can use with the RHCOS live installer and the **coreos-installer** command.

#### 12.3.11.1.1. Networking and bonding options for ISO installations

If you install RHCOS from an ISO image, you can add kernel arguments manually when you boot the image to configure networking for a node. If no networking arguments are specified, DHCP is activated in the initramfs when RHCOS detects that networking is required to fetch the Ignition config file.



#### IMPORTANT

When adding networking arguments manually, you must also add the **rd.neednet=1** kernel argument to bring the network up in the initramfs.

The following table provides examples for configuring networking and bonding on your RHCOS nodes for ISO installations. The examples describe how to use the **ip=**, **nameserver=**, and **bond=** kernel arguments.



#### NOTE

Ordering is important when adding the kernel arguments: **ip=**, **nameserver=**, and then **bond=**.

The networking options are passed to the **dracut** tool during system boot. For more information about the networking options supported by **dracut**, see the **dracut.cmdline** manual page.

The following information provides examples for configuring networking on your RHCOS nodes for ISO installations. The examples describe how to use the **ip=** and **nameserver=** kernel arguments.



#### NOTE

Ordering is important when adding the kernel arguments: **ip=** and **nameserver=**.

The networking options are passed to the **dracut** tool during system boot. For more information about the networking options supported by **dracut**, see the **dracut.cmdline** manual page.

The following examples are the networking options for ISO installation.

#### Configuring DHCP or static IP addresses

To configure an IP address, either use DHCP (**ip=dhcp**) or set an individual static IP address (**ip=<host\_ip>**). If setting a static IP, you must then identify the DNS server IP address (**nameserver=<dns\_ip>**) on each node. The following example sets:

- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**

- The netmask to **255.255.255.0**
- The hostname to **core0.example.com**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
nameserver=4.4.4.41
```



#### NOTE

When you use DHCP to configure IP addressing for the RHCOS machines, the machines also obtain the DNS server information through DHCP. For DHCP-based deployments, you can define the DNS server address that is used by the RHCOS nodes through your DHCP server configuration.

#### Configuring an IP address without a static hostname

You can configure an IP address without assigning a static hostname. If a static hostname is not set by the user, it will be picked up and automatically set by a reverse DNS lookup. To configure an IP address without a static hostname refer to the following example:

- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0::enp1s0:none
nameserver=4.4.4.41
```

#### Specifying multiple network interfaces

You can specify multiple network interfaces by setting multiple **ip=** entries.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=10.10.10.3::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

#### Configuring default gateway and route

Optional: You can configure routes to additional networks by setting an **rd.route=** value.



#### NOTE

When you configure one or multiple networks, one default gateway is required. If the additional network gateway is different from the primary network gateway, the default gateway must be the primary network gateway.

- Run the following command to configure the default gateway:



```
ip=::10.10.10.254:::
```

- Enter the following command to configure the route for the additional network:

```
rd.route=20.20.20.0/24:20.20.20.254:enp2s0
```

### Disabling DHCP on a single interface

You can disable DHCP on a single interface, such as when there are two or more network interfaces and only one interface is being used. In the example, the **enp1s0** interface has a static networking configuration and DHCP is disabled for **enp2s0**, which is not used:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=::::core0.example.com:enp2s0:none
```

### Combining DHCP and static IP configurations

You can combine DHCP and static IP configurations on systems with multiple network interfaces, for example:

```
ip=enp1s0:dhcp
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

### Configuring VLANs on individual interfaces

Optional: You can configure VLANs on individual interfaces by using the **vlan=** parameter.

- To configure a VLAN on a network interface and use a static IP address, run the following command:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0.100:none
vlan=enp2s0.100:enp2s0
```

- To configure a VLAN on a network interface and to use DHCP, run the following command:

```
ip=enp2s0.100:dhcp
vlan=enp2s0.100:enp2s0
```

### Providing multiple DNS servers

You can provide multiple DNS servers by adding a **nameserver=** entry for each server, for example:

```
nameserver=1.1.1.1
nameserver=8.8.8.8
```

### Bonding multiple network interfaces to a single interface

Optional: You can bond multiple network interfaces to a single interface by using the **bond=** option. Refer to the following examples:

- The syntax for configuring a bonded interface is: **bond=name[:network\_interfaces][:options]** *name* is the bonding device name (**bond0**), *network\_interfaces* represents a comma-separated list of physical (ethernet) interfaces (**em1,em2**), and *options* is a comma-separated list of bonding options. Enter **modinfo bonding** to see available options.
- When you create a bonded interface using **bond=**, you must specify how the IP address is assigned and other information for the bonded interface.

- To configure the bonded interface to use DHCP, set the bond's IP address to **dhcp**. For example:

```
bond=bond0:em1,em2:mode=active-backup
ip=bond0:dhcp
```

- To configure the bonded interface to use a static IP address, enter the specific IP address you want and related information. For example:

```
bond=bond0:em1,em2:mode=active-backup,fail_over_mac=1
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0:none
```

Always set option **fail\_over\_mac=1** in active-backup mode, to avoid problems when shared OSA/RoCE cards are used.

### Bonding multiple network interfaces to a single interface

Optional: You can configure VLANs on bonded interfaces by using the **vlan=** parameter and to use DHCP, for example:

```
ip=bond0.100:dhcp
bond=bond0:em1,em2:mode=active-backup
vlan=bond0.100:bond0
```

Use the following example to configure the bonded interface with a VLAN and to use a static IP address:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0.100:none
bond=bond0:em1,em2:mode=active-backup
vlan=bond0.100:bond0
```

### Using network teaming

Optional: You can use a network teaming as an alternative to bonding by using the **team=** parameter:

- The syntax for configuring a team interface is: **team=name[:network\_interfaces]**  
*name* is the team device name (**team0**) and *network\_interfaces* represents a comma-separated list of physical (ethernet) interfaces (**em1, em2**).

Teaming is planned to be deprecated when RHCOS switches to an upcoming version of RHEL. For more information, see this [Red Hat Knowledgebase Article](#) .

Use the following example to configure a network team:

```
team=team0:em1,em2
ip=team0:dhcp
```

## 12.3.12. Waiting for the bootstrap process to complete

The OpenShift Container Platform bootstrap process begins after the cluster nodes first boot into the persistent RHCOS environment that has been installed to disk. The configuration information provided through the Ignition config files is used to initialize the bootstrap process and install OpenShift Container Platform on the machines. You must wait for the bootstrap process to complete.

### Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have obtained the installation program and generated the Ignition config files for your cluster.
- You installed RHCOS on your cluster machines and provided the Ignition config files that the OpenShift Container Platform installation program generated.

## Procedure

1. Monitor the bootstrap process:

```
$ ./openshift-install --dir <installation_directory> wait-for bootstrap-complete \ 1
--log-level=info 2
```

- 1 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

- 2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

## Example output

```
INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...
INFO API v1.22.1 up
INFO Waiting up to 30m0s for bootstrapping to complete...
INFO It is now safe to remove the bootstrap resources
```

The command succeeds when the Kubernetes API server signals that it has been bootstrapped on the control plane machines.

2. After bootstrap process is complete, remove the bootstrap machine from the load balancer.



### IMPORTANT

You must remove the bootstrap machine from the load balancer at this point. You can also remove or reformat the bootstrap machine itself.

## 12.3.13. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

## Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

#### Example output

```
system:admin
```

### 12.3.14. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

#### Prerequisites

- You added machines to your cluster.

#### Procedure

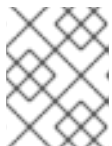
1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

#### Example output

```
NAME      STATUS  ROLES  AGE  VERSION
master-0  Ready   master 63m  v1.22.1
master-1  Ready   master 63m  v1.22.1
master-2  Ready   master 64m  v1.22.1
```

The output lists all of the machines that you created.



#### NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

2. Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

#### Example output

NAME	AGE	REQUESTOR	CONDITION
csr-8b2br	15m	system:serviceaccount:openshift-machine-config-operator:node-bootstrapper	Pending
csr-8vnps	15m	system:serviceaccount:openshift-machine-config-operator:node-bootstrapper	Pending
...			

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

- If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:



#### NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.



#### NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{"\n"}\n{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```



#### NOTE

Some Operators might not become available until some CSRs are approved.

- Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

### Example output

```
NAME      AGE    REQUESTOR                                     CONDITION
csr-bfd72 5m26s  system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv 5m26s  system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

- If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

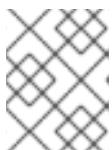
```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{\n"}\n{{end}}\n{{end}}' | xargs oc adm certificate approve
```

- After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

### Example output

```
NAME      STATUS  ROLES  AGE  VERSION
master-0  Ready   master 73m  v1.22.1
master-1  Ready   master 73m  v1.22.1
master-2  Ready   master 74m  v1.22.1
worker-0  Ready   worker 11m  v1.22.1
worker-1  Ready   worker 11m  v1.22.1
```



### NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

### Additional information

- For more information on CSRs, see [Certificate Signing Requests](#).

### 12.3.15. Initial Operator configuration

After the control plane initializes, you must immediately configure some Operators so that they all become available.

#### Prerequisites

- Your control plane has initialized.

#### Procedure

1. Watch the cluster components come online:

```
$ watch -n5 oc get clusteroperators
```

#### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
authentication	4.9.0	True	False	False	19m
baremetal	4.9.0	True	False	False	37m
cloud-credential	4.9.0	True	False	False	40m
cluster-autoscaler	4.9.0	True	False	False	37m
config-operator	4.9.0	True	False	False	38m
console	4.9.0	True	False	False	26m
csi-snapshot-controller	4.9.0	True	False	False	37m
dns	4.9.0	True	False	False	37m
etcd	4.9.0	True	False	False	36m
image-registry	4.9.0	True	False	False	31m
ingress	4.9.0	True	False	False	30m
insights	4.9.0	True	False	False	31m
kube-apiserver	4.9.0	True	False	False	26m
kube-controller-manager	4.9.0	True	False	False	36m
kube-scheduler	4.9.0	True	False	False	36m
kube-storage-version-migrator	4.9.0	True	False	False	37m
machine-api	4.9.0	True	False	False	29m
machine-approver	4.9.0	True	False	False	37m
machine-config	4.9.0	True	False	False	36m
marketplace	4.9.0	True	False	False	37m
monitoring	4.9.0	True	False	False	29m
network	4.9.0	True	False	False	38m
node-tuning	4.9.0	True	False	False	37m
openshift-apiserver	4.9.0	True	False	False	32m
openshift-controller-manager	4.9.0	True	False	False	30m
openshift-samples	4.9.0	True	False	False	32m
operator-lifecycle-manager	4.9.0	True	False	False	37m
operator-lifecycle-manager-catalog	4.9.0	True	False	False	37m
operator-lifecycle-manager-packageserver	4.9.0	True	False	False	32m
service-ca	4.9.0	True	False	False	38m
storage	4.9.0	True	False	False	37m

2. Configure the Operators that are not available.

#### 12.3.15.1. Disabling the default OperatorHub sources

Operator catalogs that source content provided by Red Hat and community projects are configured for OperatorHub by default during an OpenShift Container Platform installation. In a restricted network environment, you must disable the default catalogs as a cluster administrator.

## Procedure

- Disable the sources for the default catalogs by adding **disableAllDefaultSources: true** to the **OperatorHub** object:

```
$ oc patch OperatorHub cluster --type json \
  -p '[{"op": "add", "path": "/spec/disableAllDefaultSources", "value": true}]'
```

## TIP

Alternatively, you can use the web console to manage catalog sources. From the **Administration** → **Cluster Settings** → **Configuration** → **OperatorHub** page, click the **Sources** tab, where you can create, delete, disable, and enable individual sources.

### 12.3.15.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

#### 12.3.15.2.1. Configuring registry storage for IBM Z

As a cluster administrator, following installation you must configure your registry to use storage.

## Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.
- You have a cluster on IBM Z.
- You have provisioned persistent storage for your cluster, such as Red Hat OpenShift Container Storage.



## IMPORTANT

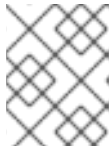
OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have 100Gi capacity.



## Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.



### NOTE

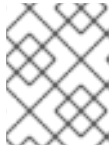
When using shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

### Example output

```
No resources found in openshift-image-registry namespace
```



### NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

### Example output

```
storage:
  pvc:
  claim:
```

Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** PVC.

4. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
image-registry	4.9	True	False	False	6h50m

5. Ensure that your registry is set to managed to enable building and pushing of images.

- Run:

```
$ oc edit configs.imageregistry/cluster
```

Then, change the line

```
managementState: Removed
```

to

```
managementState: Managed
```

### 12.3.15.2.2. Configuring storage for the image registry in non-production clusters

You must configure storage for the Image Registry Operator. For non-production clusters, you can set the image registry to an empty directory. If you do so, all images are lost if you restart the registry.

#### Procedure

- To set the image registry storage to an empty directory:

```
$ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec": {"storage":{"emptyDir":{}}}'
```



#### WARNING

Configure this option for only non-production clusters.

If you run this command before the Image Registry Operator initializes its components, the **oc patch** command fails with the following error:

```
Error from server (NotFound): configs.imageregistry.operator.openshift.io "cluster" not found
```

Wait a few minutes and run the command again.

### 12.3.16. Completing installation on user-provisioned infrastructure

After you complete the Operator configuration, you can finish installing the cluster on infrastructure that you provide.

#### Prerequisites

- Your control plane has initialized.
- You have completed the initial Operator configuration.

#### Procedure

- Confirm that all the cluster components are online with the following command:

```
$ watch -n5 oc get clusteroperators
```

#### Example output

NAME SINCE	VERSION	AVAILABLE	PROGRESSING	DEGRADED
authentication	4.9.0	True	False	False 19m
baremetal	4.9.0	True	False	False 37m
cloud-credential	4.9.0	True	False	False 40m
cluster-autoscaler	4.9.0	True	False	False 37m
config-operator	4.9.0	True	False	False 38m
console	4.9.0	True	False	False 26m
csi-snapshot-controller	4.9.0	True	False	False 37m
dns	4.9.0	True	False	False 37m
etcd	4.9.0	True	False	False 36m
image-registry	4.9.0	True	False	False 31m
ingress	4.9.0	True	False	False 30m
insights	4.9.0	True	False	False 31m
kube-apiserver	4.9.0	True	False	False 26m
kube-controller-manager	4.9.0	True	False	False 36m
kube-scheduler	4.9.0	True	False	False 36m
kube-storage-version-migrator	4.9.0	True	False	False 37m
machine-api	4.9.0	True	False	False 29m
machine-approver	4.9.0	True	False	False 37m
machine-config	4.9.0	True	False	False 36m
marketplace	4.9.0	True	False	False 37m
monitoring	4.9.0	True	False	False 29m
network	4.9.0	True	False	False 38m
node-tuning	4.9.0	True	False	False 37m
openshift-apiserver	4.9.0	True	False	False 32m
openshift-controller-manager	4.9.0	True	False	False 30m
openshift-samples	4.9.0	True	False	False 32m
operator-lifecycle-manager	4.9.0	True	False	False 37m
operator-lifecycle-manager-catalog	4.9.0	True	False	False 37m
operator-lifecycle-manager-packageserver	4.9.0	True	False	False 32m
service-ca	4.9.0	True	False	False 38m
storage	4.9.0	True	False	False 37m

Alternatively, the following command notifies you when all of the clusters are available. It also retrieves and displays credentials:

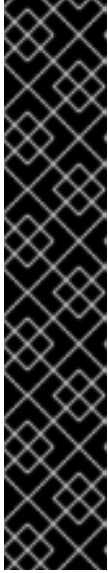
```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

### Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

The command succeeds when the Cluster Version Operator finishes deploying the OpenShift Container Platform cluster from Kubernetes API server.



## IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Confirm that the Kubernetes API server is communicating with the pods.

- a. To view a list of all pods, use the following command:

```
$ oc get pods --all-namespaces
```

### Example output

```

NAMESPACE           NAME                                     READY  STATUS
RESTARTS  AGE
openshift-apiserver-operator  openshift-apiserver-operator-85cb746d55-zqhs8  1/1
Running   1      9m
openshift-apiserver          apiserver-67b9g                                1/1  Running  0
3m
openshift-apiserver          apiserver-ljcmx                                1/1  Running  0
1m
openshift-apiserver          apiserver-z25h4                                1/1  Running  0
2m
openshift-authentication-operator  authentication-operator-69d5d8bf84-vh2n8  1/1
Running   0      5m
...

```

- b. View the logs for a pod that is listed in the output of the previous command by using the following command:

```
$ oc logs <pod_name> -n <namespace> ❶
```

- ❶ Specify the pod name and namespace, as shown in the output of the previous command.

If the pod logs display, the Kubernetes API server can communicate with the cluster machines.

3. For an installation with Fibre Channel Protocol (FCP), additional steps are required to enable multipathing. Do not enable multipathing during installation. See "Enabling multipathing with kernel arguments on RHCOS" in the *Post-installation machine configuration tasks* documentation for more information.

4. Register your cluster on the [Cluster registration](#) page.

### 12.3.17. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

#### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

### 12.3.18. Collecting debugging information

You can gather debugging information that might help you to troubleshoot and debug certain issues with an OpenShift Container Platform installation on IBM Z.

#### Prerequisites

- The **oc** CLI tool installed.

#### Procedure

1. Log in to the cluster:

```
$ oc login -u <username>
```

2. On the node you want to gather hardware information about, start a debugging container:

```
$ oc debug node/<nodename>
```

3. Change to the **/host** file system and start **toolbox**:

```
$ chroot /host
$ toolbox
```

4. Collect the **dbginfo** data:

```
$ dbginfo.sh
```

5. You can then retrieve the data, for example, using **scp**.

#### Additional resources

- [How to generate SOSREPORT within OpenShift Container Platform version 4 nodes without SSH.](#)

### 12.3.19. Next steps

- [Customize your cluster.](#)
- If the mirror registry that you used to install your cluster has a trusted CA, add it to the cluster by [configuring additional trust stores.](#)

## CHAPTER 13. INSTALLING WITH RHEL KVM ON IBM Z AND LINUXONE

### 13.1. PREPARING TO INSTALL WITH RHEL KVM ON IBM Z AND LINUXONE

#### 13.1.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).

#### 13.1.2. Choosing a method to install OpenShift Container Platform with RHEL KVM on IBM Z or LinuxONE

You can install a cluster with RHEL KVM on IBM Z or LinuxONE infrastructure that you provision, by using one of the following methods:

- **Installing a cluster with RHEL KVM on IBM Z and LinuxONE** You can install OpenShift Container Platform with KVM on IBM Z or LinuxONE infrastructure that you provision.
- **Installing a cluster with RHEL KVM on IBM Z and LinuxONE in a restricted network** You can install OpenShift Container Platform with RHEL KVM on IBM Z or LinuxONE infrastructure that you provision in a restricted or disconnected network, by using an internal mirror of the installation release content. You can use this method to install a cluster that does not require an active internet connection to obtain the software components. You can also use this installation method to ensure that your clusters only use container images that satisfy your organizational controls on external content.

### 13.2. INSTALLING A CLUSTER WITH RHEL KVM ON IBM Z AND LINUXONE

In OpenShift Container Platform version 4.9, you can install a cluster on IBM Z or LinuxONE infrastructure that you provision.



#### NOTE

While this document refers only to IBM Z, all information in it also applies to LinuxONE.



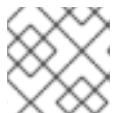
#### IMPORTANT

Additional considerations exist for non-bare metal platforms. Review the information in the [guidelines for deploying OpenShift Container Platform on non-tested platforms](#) before you install an OpenShift Container Platform cluster.

#### 13.2.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.

- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- Before you begin the installation process, you must clean the installation directory. This ensures that the required installation files are created and updated during the installation process.
- You provisioned [persistent storage using NFS](#) for your cluster. To deploy a private image registry, you must set up persistent storage with **ReadWriteMany** access.
- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.
- You provisioned a RHEL Kernel Virtual Machine (KVM) system that is hosted on the logical partition (LPAR) and based on RHEL 8.4 or later.

**NOTE**

Be sure to also review this site list if you are configuring a proxy.

### 13.2.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

**IMPORTANT**

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

### 13.2.3. Machine requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

One or more KVM host machines based on RHEL 8.4 or later. Each RHEL KVM host machine must have libvirt installed and running. The virtual machines are provisioned under each RHEL KVM host machine.

#### 13.2.3.1. Required machines

The smallest OpenShift Container Platform clusters require the following hosts:

**Table 13.1. Minimum required hosts**



Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.



### IMPORTANT

To improve high availability of your cluster, distribute the control plane machines over different RHEL instances on at least two physical machines.

The bootstrap, control plane, and compute machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system.

See [Red Hat Enterprise Linux technology capabilities and limits](#) .

#### 13.2.3.2. Network connectivity requirements

The OpenShift Container Platform installer creates the Ignition files, which are necessary for all the Red Hat Enterprise Linux CoreOS (RHCOS) virtual machines. The automated installation of OpenShift Container Platform is performed by the bootstrap machine. It starts the installation of OpenShift Container Platform on each node, starts the Kubernetes cluster, and then finishes. During this bootstrap, the virtual machine must have an established network connection either through a Dynamic Host Configuration Protocol (DHCP) server or static IP address.

#### 13.2.3.3. IBM Z network connectivity requirements

To install on IBM Z under RHEL KVM, you need:

- A RHEL KVM host configured with an OSA or RoCE network adapter.
- Either a RHEL KVM host that is configured to use bridged networking in libvirt or MacVTap to connect the network to the guests.  
See [Types of virtual network connections](#) .

#### 13.2.3.4. Host machine resource requirements

The RHEL KVM host in your environment must meet the following requirements to host the virtual machines that you plan for the OpenShift Container Platform environment. See [Getting started with virtualization](#).

You can install OpenShift Container Platform version 4.9 on the following IBM hardware:

- IBM z15 (all models), IBM z14 (all models), IBM z13, and IBM z13s

- LinuxONE, any version

### 13.2.3.5. Minimum IBM Z system environment

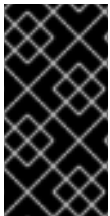
#### Hardware requirements

- The equivalent of six IFLs, which are SMT2 enabled, for each cluster.
- At least one network connection to both connect to the **LoadBalancer** service and to serve data for traffic outside the cluster.



#### NOTE

You can use dedicated or shared IFLs to assign sufficient compute resources. Resource sharing is one of the key strengths of IBM Z. However, you must adjust capacity correctly on each hypervisor layer and ensure sufficient resources for every OpenShift Container Platform cluster.



#### IMPORTANT

Since the overall performance of the cluster can be impacted, the LPARs that are used to setup the OpenShift Container Platform clusters must provide sufficient compute capacity. In this context, LPAR weight management, entitlements, and CPU shares on the hypervisor level play an important role.

#### Operating system requirements

- One LPAR running RHEL 8.4 or later with KVM, which is managed by libvirt

On your RHEL KVM host, set up:

- Three guest virtual machines for OpenShift Container Platform control plane machines
- Two guest virtual machines for OpenShift Container Platform compute machines
- One guest virtual machine for the temporary OpenShift Container Platform bootstrap machine

### 13.2.3.6. Minimum resource requirements

Each cluster virtual machine must meet the following minimum requirements:

Virtual Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS
Bootstrap	RHCOS	4	16 GB	100 GB	N/A
Control plane	RHCOS	4	16 GB	100 GB	N/A
Compute	RHCOS	2	8 GB	100 GB	N/A

1. One physical core (IFL) provides two logical cores (threads) when SMT-2 is enabled. The hypervisor can provide two or more vCPUs.

### 13.2.3.7. Preferred IBM Z system environment

#### Hardware requirements

- Three LPARS that each have the equivalent of six IFLs, which are SMT2 enabled, for each cluster.
- Two network connections to both connect to the **LoadBalancer** service and to serve data for traffic outside the cluster.

#### Operating system requirements

- For high availability, two or three LPARs running RHEL 8.4 or later with KVM, which are managed by libvirt.

On your RHEL KVM host, set up:

- Three guest virtual machines for OpenShift Container Platform control plane machines, distributed across the RHEL KVM host machines.
- At least six guest virtual machines for OpenShift Container Platform compute machines, distributed across the RHEL KVM host machines.
- One guest virtual machine for the temporary OpenShift Container Platform bootstrap machine.
- To ensure the availability of integral components in an overcommitted environment, increase the priority of the control plane by using **cpu\_shares**. Do the same for infrastructure nodes, if they exist. See [schedinfo](#) in IBM Documentation.

### 13.2.3.8. Preferred resource requirements

The preferred requirements for each cluster virtual machine are:

Virtual Machine	Operating System	vCPU	Virtual RAM	Storage
Bootstrap	RHCOS	4	16 GB	120 GB
Control plane	RHCOS	8	16 GB	120 GB
Compute	RHCOS	6	8 GB	120 GB

### 13.2.3.9. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

#### Additional resources

- [Recommended host practices for IBM Z & LinuxONE environments](#)

### 13.2.3.10. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.

It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.



#### NOTE

If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

#### 13.2.3.10.1. Setting the cluster node hostnames through DHCP

On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

#### 13.2.3.10.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.



#### IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

**NOTE**

The RHEL KVM host must be configured to use bridged networking in libvirt or MacVTap to connect the network to the virtual machines. The virtual machines must have access to the network, which is attached to the RHEL KVM host. Virtual Networks, for example network address translation (NAT), within KVM are not a supported configuration.

**Table 13.2. Ports used for all-machine to all-machine communications**

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	<b>1936</b>	Metrics
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> and the Cluster Version Operator on port <b>9099</b> .
	<b>10250-10259</b>	The default ports that Kubernetes reserves
	<b>10256</b>	openshift-sdn
UDP	<b>4789</b>	VXLAN and Geneve
	<b>6081</b>	VXLAN and Geneve
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> .
	<b>500</b>	IPsec IKE packets
	<b>4500</b>	IPsec NAT-T packets
TCP/UDP	<b>30000-32767</b>	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

**Table 13.3. Ports used for all-machine to control plane communications**

Protocol	Port	Description
TCP	<b>6443</b>	Kubernetes API

**Table 13.4. Ports used for control plane machine to control plane machine communications**

Protocol	Port	Description
TCP	<b>2379-2380</b>	etcd server and peer ports

### NTP configuration for user-provisioned infrastructure

OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service*.

If a DHCP server provides NTP server information, the chrony time service on the Red Hat Enterprise Linux CoreOS (RHCOS) machines read the information and can sync the clock with the NTP servers.

### Additional resources

- [Configuring chrony time service](#)

### 13.2.3.11. User-provisioned DNS requirements

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API
- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines


Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, **<cluster\_name>** is the cluster name and **<base\_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster\_name>.<base\_domain>..**

**Table 13.5. Required DNS records**

Component	Record	Description
Kubernetes API	<b>api.&lt;cluster_name&gt;.&lt;base_domain&gt;..</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.

Component	Record	Description
	<b>api-int.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	<p>A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>IMPORTANT</b></p> <p>The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.</p> </div> </div>
Routes	<b>*.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	<p>A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.</p> <p>For example, <b>console-openshift-console.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;</b> is used as a wildcard route to the OpenShift Container Platform console.</p>
Bootstrap machine	<b>bootstrap.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.
Control plane machines	<b>&lt;master&gt;&lt;n&gt;.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.
Compute machines	<b>&lt;worker&gt;&lt;n&gt;.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.



#### NOTE

In OpenShift Container Platform 4.4 and later, you do not need to specify etcd host and SRV records in your DNS configuration.

**TIP**

You can use the **dig** command to verify name and reverse name resolution. See the section on *Validating DNS resolution for user-provisioned infrastructure* for detailed validation steps.

**13.2.3.11.1. Example DNS configuration for user-provisioned clusters**

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is **ocp4** and the base domain is **example.com**.

**Example DNS A record configuration for a user-provisioned cluster**

The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

**Example 13.1. Sample DNS zone database**

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H ; refresh (3 hours)
  30M ; retry (30 minutes)
  2W ; expiry (2 weeks)
  1W ) ; minimum (1 week)
IN NS ns1.example.com.
IN MX 10 smtp.example.com.
;
;
ns1.example.com. IN A 192.168.1.5
smtp.example.com. IN A 192.168.1.5
;
helper.example.com. IN A 192.168.1.5
helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com. IN A 192.168.1.5 1
api-int.ocp4.example.com. IN A 192.168.1.5 2
;
*.apps.ocp4.example.com. IN A 192.168.1.5 3
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 4
;
master0.ocp4.example.com. IN A 192.168.1.97 5
master1.ocp4.example.com. IN A 192.168.1.98 6
master2.ocp4.example.com. IN A 192.168.1.99 7
;
worker0.ocp4.example.com. IN A 192.168.1.11 8
worker1.ocp4.example.com. IN A 192.168.1.7 9
;
;EOF
```

- 1 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.



- 2 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.
- 3 Provides name resolution for the wildcard routes. The record refers to the IP address of the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



#### NOTE

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

- 4 Provides name resolution for the bootstrap machine.
- 5 6 7 Provides name resolution for the control plane machines.
- 8 9 Provides name resolution for the compute machines.

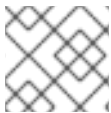
### Example DNS PTR record configuration for a user-provisioned cluster

The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

#### Example 13.2. Sample DNS zone database for reverse records

```
$TTL 1W
@ IN SOA ns1.example.com. root (
    2019070700 ; serial
    3H ; refresh (3 hours)
    30M ; retry (30 minutes)
    2W ; expiry (2 weeks)
    1W ) ; minimum (1 week)
IN NS ns1.example.com.
;
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. 2
;
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. 3
;
97.1.168.192.in-addr.arpa. IN PTR master0.ocp4.example.com. 4
98.1.168.192.in-addr.arpa. IN PTR master1.ocp4.example.com. 5
99.1.168.192.in-addr.arpa. IN PTR master2.ocp4.example.com. 6
;
11.1.168.192.in-addr.arpa. IN PTR worker0.ocp4.example.com. 7
7.1.168.192.in-addr.arpa. IN PTR worker1.ocp4.example.com. 8
;
;EOF
```

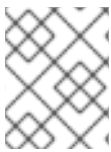
- 1 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.
- 2 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.
- 3 Provides reverse DNS resolution for the bootstrap machine.
- 4 5 6 Provides reverse DNS resolution for the control plane machines.
- 7 8 Provides reverse DNS resolution for the compute machines.

**NOTE**

A PTR record is not required for the OpenShift Container Platform application wildcard.

### 13.2.3.12. Load balancing requirements for user-provisioned infrastructure

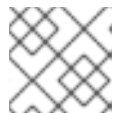
Before you install OpenShift Container Platform, you must provision the API and application ingress load balancing infrastructure. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

**NOTE**

If you want to deploy the API and application ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer.** Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:
  - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the API routes.
  - A stateless load balancing algorithm. The options vary based on the load balancer implementation.

**NOTE**

Session persistence is not required for the API load balancer to function properly.

Configure the following ports on both the front and back of the load balancers:

**Table 13.6. API load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
------	----------------------------------	----------	----------	-------------

Port	Back-end machines (pool members)	Internal	External	Description
<b>6443</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the <b>/readyz</b> endpoint for the API server health check probe.	X	X	Kubernetes API server
<b>22623</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server



### NOTE

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the **/readyz** endpoint to the removal of the API server instance from the pool. Within the time frame after **/readyz** returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application ingress load balancer:** Provides an ingress point for application traffic flowing in from outside the cluster. Configure the following conditions:
  - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the ingress routes.
  - A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

### TIP

If the true IP address of the client can be seen by the application ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

Configure the following ports on both the front and back of the load balancers:

**Table 13.7. Application ingress load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
<b>443</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic

Port	Back-end machines (pool members)	Internal	External	Description
80	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic
1936	The worker nodes that run the Ingress Controller pods, by default. You must configure the <b>/healthz/ready</b> endpoint for the ingress health check probe.	X	X	HTTP traffic

**NOTE**

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

**NOTE**

A working configuration for the Ingress router is required for an OpenShift Container Platform cluster. You must configure the Ingress router after the control plane initializes.

### 13.2.3.12.1. Example load balancer configuration for user-provisioned clusters

This section provides an example API and application ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an **/etc/haproxy/haproxy.cfg** configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing one load balancing solution over another.

**NOTE**

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

#### Example 13.3. Sample API and application ingress load balancer configuration

```
global
  log      127.0.0.1 local2
  pidfile /var/run/haproxy.pid
  maxconn 4000
  daemon
defaults
  mode      http
  log       global
  option    dontlognull
  option    http-server-close
  option    redispatch
```

```

retries          3
timeout http-request 10s
timeout queue    1m
timeout connect  10s
timeout client   1m
timeout server   1m
timeout http-keep-alive 10s
timeout check    10s
maxconn          3000
frontend stats
bind *:1936
mode             http
log              global
maxconn 10
stats enable
stats hide-version
stats refresh 30s
stats show-node
stats show-desc Stats for ocp4 cluster 1
stats auth admin:ocp4
stats uri /stats
listen api-server-6443 2
bind *:6443
mode tcp
server bootstrap bootstrap.ocp4.example.com:6443 check inter 1s backup 3
server master0 master0.ocp4.example.com:6443 check inter 1s
server master1 master1.ocp4.example.com:6443 check inter 1s
server master2 master2.ocp4.example.com:6443 check inter 1s
listen machine-config-server-22623 4
bind *:22623
mode tcp
server bootstrap bootstrap.ocp4.example.com:22623 check inter 1s backup 5
server master0 master0.ocp4.example.com:22623 check inter 1s
server master1 master1.ocp4.example.com:22623 check inter 1s
server master2 master2.ocp4.example.com:22623 check inter 1s
listen ingress-router-443 6
bind *:443
mode tcp
balance source
server worker0 worker0.ocp4.example.com:443 check inter 1s
server worker1 worker1.ocp4.example.com:443 check inter 1s
listen ingress-router-80 7
bind *:80
mode tcp
balance source
server worker0 worker0.ocp4.example.com:80 check inter 1s
server worker1 worker1.ocp4.example.com:80 check inter 1s

```

- 1** In the example, the cluster name is **ocp4**.
- 2** Port **6443** handles the Kubernetes API traffic and points to the control plane machines.
- 3** **5** The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.

- 4 Port **22623** handles the machine config server traffic and points to the control plane machines.
- 6 Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.
- 7 Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

**NOTE**

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

**TIP**

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltp** on the HAProxy node.

**NOTE**

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running **setsebool -P haproxy\_connect\_any=1**.

### 13.2.4. Preparing the user-provisioned infrastructure

Before you install OpenShift Container Platform on user-provisioned infrastructure, you must prepare the underlying infrastructure.

This section provides details about the high-level steps required to set up your cluster infrastructure in preparation for an OpenShift Container Platform installation. This includes configuring IP networking and network connectivity for your cluster nodes, enabling the required ports through your firewall, and setting up the required DNS and load balancing infrastructure.

After preparation, your cluster infrastructure must meet the requirements outlined in the *Requirements for a cluster with user-provisioned infrastructure* section.

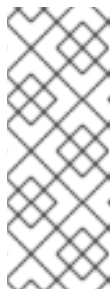
#### Prerequisites

- You have reviewed the [OpenShift Container Platform 4.x Tested Integrations](#) page.
- You have reviewed the infrastructure requirements detailed in the *Requirements for a cluster with user-provisioned infrastructure* section.

#### Procedure

1. If you are using DHCP to provide the IP networking configuration to your cluster nodes, configure your DHCP service.

- a. Add persistent IP addresses for the nodes to your DHCP server configuration. In your configuration, match the MAC address of the relevant network interface to the intended IP address for each node.
- b. When you use DHCP to configure IP addressing for the cluster machines, the machines also obtain the DNS server information through DHCP. Define the persistent DNS server address that is used by the cluster nodes through your DHCP server configuration.

**NOTE**

If you are not using a DHCP service, you must provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

- c. Define the hostnames of your cluster nodes in your DHCP server configuration. See the *Setting the cluster node hostnames through DHCP* section for details about hostname considerations.

**NOTE**

If you are not using a DHCP service, the cluster nodes obtain their hostname through a reverse DNS lookup.

2. Choose to perform either a fast track installation of Red Hat Enterprise Linux CoreOS (RHCOS) or a full installation of Red Hat Enterprise Linux CoreOS (RHCOS). For the full installation, you must set up an HTTP or HTTPS server to provide Ignition files and install images to the cluster nodes. For the fast track installation an HTTP or HTTPS server is not required, however, a DHCP server is required. See sections "Fast-track installation: Creating Red Hat Enterprise Linux CoreOS (RHCOS) machines" and "Full installation: Creating Red Hat Enterprise Linux CoreOS (RHCOS) machines".
3. Ensure that your network infrastructure provides the required network connectivity between the cluster components. See the *Networking requirements for user-provisioned infrastructure* section for details about the requirements.
4. Configure your firewall to enable the ports required for the OpenShift Container Platform cluster components to communicate. See *Networking requirements for user-provisioned infrastructure* section for details about the ports that are required.
5. Setup the required DNS infrastructure for your cluster.
  - a. Configure DNS name resolution for the Kubernetes API, the application wildcard, the bootstrap machine, the control plane machines, and the compute machines.
  - b. Configure reverse DNS resolution for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.  
See the *User-provisioned DNS requirements* section for more information about the OpenShift Container Platform DNS requirements.
6. Validate your DNS configuration.

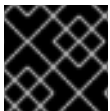
- a. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses in the responses correspond to the correct components.
  - b. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names in the responses correspond to the correct components.  
See the *Validating DNS resolution for user-provisioned infrastructure* section for detailed DNS validation steps.
7. Provision the required API and application ingress load balancing infrastructure. See the *Load balancing requirements for user-provisioned infrastructure* section for more information about the requirements.

**NOTE**

Some load balancing solutions require the DNS name resolution for the cluster nodes to be in place before the load balancing is initialized.

### 13.2.5. Validating DNS resolution for user-provisioned infrastructure

You can validate your DNS configuration before installing OpenShift Container Platform on user-provisioned infrastructure.

**IMPORTANT**

The validation steps detailed in this section must succeed before you install your cluster.

**Prerequisites**

- You have configured the required DNS records for your user-provisioned infrastructure.

**Procedure**

1. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses contained in the responses correspond to the correct components.
  - a. Perform a lookup against the Kubernetes API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api.<cluster_name>.<base_domain> 1
```

- 1 Replace **<nameserver\_ip>** with the IP address of the nameserver, **<cluster\_name>** with your cluster name, and **<base\_domain>** with your base domain name.

**Example output**

```
api.ocp4.example.com. 0 IN A 192.168.1.5
```

- b. Perform a lookup against the Kubernetes internal API record name. Check that the result points to the IP address of the API load balancer:



```
$ dig +noall +answer @<nameserver_ip> api-int.<cluster_name>.<base_domain>
```

### Example output

```
api-int.ocp4.example.com. 0 IN A 192.168.1.5
```

- c. Test an example **\*.apps.<cluster\_name>.<base\_domain>** DNS wildcard lookup. All of the application wildcard lookups must resolve to the IP address of the application ingress load balancer:

```
$ dig +noall +answer @<nameserver_ip> random.apps.<cluster_name>.<base_domain>
```

### Example output

```
random.apps.ocp4.example.com. 0 IN A 192.168.1.5
```



### NOTE

In the example outputs, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

You can replace **random** with another wildcard value. For example, you can query the route to the OpenShift Container Platform console:

```
$ dig +noall +answer @<nameserver_ip> console-openshift-console.apps.<cluster_name>.<base_domain>
```

### Example output

```
console-openshift-console.apps.ocp4.example.com. 0 IN A 192.168.1.5
```

- d. Run a lookup against the bootstrap DNS record name. Check that the result points to the IP address of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> bootstrap.<cluster_name>.<base_domain>
```

### Example output

```
bootstrap.ocp4.example.com. 0 IN A 192.168.1.96
```

- e. Use this method to perform lookups against the DNS record names for the control plane and compute nodes. Check that the results correspond to the IP addresses of each node.
2. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names contained in the responses correspond to the correct components.
- a. Perform a reverse lookup against the IP address of the API load balancer. Check that the response includes the record names for the Kubernetes API and the Kubernetes internal

API:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.5
```

### Example output

```
5.1.168.192.in-addr.arpa. 0 IN PTR api-int.ocp4.example.com. 1  
5.1.168.192.in-addr.arpa. 0 IN PTR api.ocp4.example.com. 2
```

- 1** Provides the record name for the Kubernetes internal API.
- 2** Provides the record name for the Kubernetes API.



### NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard. No validation step is needed for reverse DNS resolution against the IP address of the application ingress load balancer.

- b. Perform a reverse lookup against the IP address of the bootstrap node. Check that the result points to the DNS record name of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.96
```

### Example output

```
96.1.168.192.in-addr.arpa. 0 IN PTR bootstrap.ocp4.example.com.
```

- c. Use this method to perform reverse lookups against the IP addresses for the control plane and compute nodes. Check that the results correspond to the DNS record names of each node.

## 13.2.6. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.



### IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

## Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.



### NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.



### NOTE

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

### Example output

```
Agent pid 31874
```



### NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

■

```
$ ssh-add <path>/<file_name> 1
```

- 1** Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

### Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

### Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

## 13.2.7. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on your provisioning machine.

### Prerequisites

- You have a machine that runs Linux, for example Red Hat Enterprise Linux 8, with 500 MB of local disk space

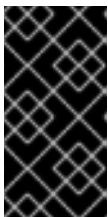
### Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



#### IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



#### IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#) . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

### 13.2.8. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



#### IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

#### Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

##### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

```
$ tar xvf <file>
```

5. Place the **oc** binary in a directory that is on your **PATH**.  
To check your **PATH**, execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

#### Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

##### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.

5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

### Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### 13.2.9. Manually creating the installation configuration file

For user-provisioned installations of OpenShift Container Platform, you manually generate your installation configuration file.

#### Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

#### Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```

**IMPORTANT**

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation\_directory>**.

**NOTE**

You must name this configuration file **install-config.yaml**.

**NOTE**

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation\_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

**IMPORTANT**

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

**13.2.9.1. Installation configuration parameters**

Before you deploy an OpenShift Container Platform cluster, you provide a customized **install-config.yaml** installation configuration file that describes the details for your environment.

**NOTE**

After installation, you cannot modify these parameters in the **install-config.yaml** file.

**IMPORTANT**

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

**13.2.9.1.1. Required configuration parameters**

Required installation configuration parameters are described in the following table:

**Table 13.8. Required parameters**

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;</b> . <b>&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}</b> . <b>{{.baseDomain}}</b> .	String of lowercase letters, hyphens (-), and periods (.), such as <b>dev</b> .
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws</b> , <b>baremetal</b> , <b>azure</b> , <b>gcp</b> , <b>openstack</b> , <b>ovirt</b> , <b>vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object




Parameter	Description	Values
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } }</pre>

### 13.2.9.1.2. Network configuration parameters


You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

Table 13.9. Network parameters

Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	Object  <div style="margin-left: 20px;"> <p><b>NOTE</b></p> <p>You cannot modify parameters specified by the <b>networking</b> object after installation.</p> </div>
<b>networking.network Type</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .

Parameter	Description	Values
<b>networking.clusterNetwork</b>	<p>The IP address blocks for pods.</p> <p>The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b>.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   clusterNetwork:     - cidr: 10.128.0.0/14       hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	<p>Required if you use <b>networking.clusterNetwork</b>. An IP address block.</p> <p>An IPv4 network.</p>	<p>An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b>.</p>
<b>networking.clusterNetwork.hostPrefix</b>	<p>The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b>. A <b>hostPrefix</b> value of <b>23</b> provides 510 (<math>2^{(32 - 23)} - 2</math>) pod IP addresses.</p>	<p>A subnet prefix.</p> <p>The default value is <b>23</b>.</p>
<b>networking.serviceNetwork</b>	<p>The IP address block for services. The default value is <b>172.30.0.0/16</b>.</p> <p>The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.</p>	<p>An array with an IP address block in CIDR format. For example:</p> <pre>networking:   serviceNetwork:     - 172.30.0.0/16</pre>
<b>networking.machineNetwork</b>	<p>The IP address blocks for machines.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p> <p>If you specify multiple IP kernel arguments, the <b>machineNetwork.cidr</b> value must be the CIDR of the primary network.</p>	<p>An array of objects. For example:</p> <pre>networking:   machineNetwork:     - cidr: 10.0.0.0/16</pre>


Parameter	Description	Values
<b>networking.machineNetwork.cidr</b>	Required if you use <b>networking.machineNetwork</b> . An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b> .	<p>An IP network block in CIDR notation.</p> <p>For example, <b>10.0.0.0/16</b>.</p>  <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p>

### 13.2.9.1.3. Optional configuration parameters



Optional installation configuration parameters are described in the following table:

Table 13.10. Optional parameters


Parameter	Description	Values
<b>additionalTrustBundle</b>	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
<b>compute</b>	The configuration for the machines that comprise the compute nodes.	Array of <b>MachinePool</b> objects.
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>s390x</b> (the default).	String

Parameter	Description	Values
<b>compute.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b>
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>s390x</b> (the default).	String

Parameter	Description	Values
<b>controlPlane.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platform</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>controlPlane.replicas</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.

Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.</p> <p> <b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators reference content</i>.</p> <p> <b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p>	<b>Mint, Passthrough, Manual</b> or an empty string ("").

Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start;"> <div style="width: 60px; height: 60px; background-color: black; margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 60px; height: 60px; background-color: black; margin-right: 10px;"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings

Parameter	Description	Values
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<b>Internal</b> or <b>External</b> . The default value is <b>External</b> .  Setting this field to <b>Internal</b> is not supported on non-cloud platforms.
<b>sshKey</b>	The SSH key or keys to authenticate access your cluster machines.   <p><b>NOTE</b></p> <p>For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.</p>	One or more keys. For example:  <pre>sshKey:   &lt;key1&gt;   &lt;key2&gt;   &lt;key3&gt;</pre>

### 13.2.9.2. Sample install-config.yaml file for IBM Z

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```

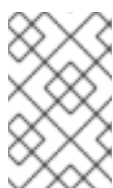
apiVersion: v1
baseDomain: example.com 1
compute: 2
- hyperthreading: Enabled 3
  name: worker
  replicas: 0 4
  architecture : s390x
controlPlane: 5
  hyperthreading: Enabled 6
  name: master
  replicas: 3 7
  architecture : s390x
metadata:
  name: test 8
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14 9
    hostPrefix: 23 10
  networkType: OpenShiftSDN
  serviceNetwork: 11
  - 172.30.0.0/16
platform:
  none: {} 12

```



```
fips: false 13
pullSecret: '{"auths": ...}' 14
sshKey: 'ssh-ed25519 AAAA...' 15
```

- 1** The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.
- 2 5** The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. Only one control plane pool is used.
- 3 6** Specifies whether to enable or disable simultaneous multithreading (SMT), or hyperthreading. By default, SMT is enabled to increase the performance of the cores in your machines. You can disable it by setting the parameter value to **Disabled**. If you disable SMT, you must disable it in all cluster machines; this includes both control plane and compute machines.



#### NOTE

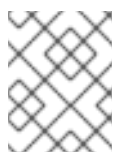
Simultaneous multithreading (SMT) is enabled by default. If SMT is not available on your OpenShift Container Platform nodes, the **hyperthreading** parameter has no effect.



#### IMPORTANT

If you disable **hyperthreading**, whether on your OpenShift Container Platform nodes or in the **install-config.yaml** file, ensure that your capacity planning accounts for the dramatically decreased machine performance.

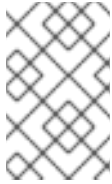
- 4** You must set this value to **0** when you install OpenShift Container Platform on user-provisioned infrastructure. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. In user-provisioned installations, you must manually deploy the compute machines before you finish installing the cluster.



#### NOTE

If you are installing a three-node cluster, do not deploy any compute machines when you install the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

- 7** The number of control plane machines that you add to the cluster. Because the cluster uses these values as the number of etcd endpoints in the cluster, the value must match the number of control plane machines that you deploy.
- 8** The cluster name that you specified in your DNS records.
- 9** A block of IP addresses from which pod IP addresses are allocated. This block must not overlap with existing physical networks. These IP addresses are used for the pod network. If you need to access the pods from an external network, you must configure load balancers and routers to manage the traffic.

**NOTE**

Class E CIDR range is reserved for a future use. To use the Class E CIDR range, you must ensure your networking environment accepts the IP addresses within the Class E CIDR range.

- 10 The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23**, then each node is assigned a **/23** subnet out of the given **cidr**, which allows for 510 ( $2^{(32 - 23)} - 2$ ) pod IP addresses. If you are required to provide access to nodes from an external network, configure load balancers and routers to manage the traffic.
- 11 The IP address pool to use for service IP addresses. You can enter only one IP address pool. This block must not overlap with existing physical networks. If you need to access the services from an external network, configure load balancers and routers to manage the traffic.
- 12 You must set the platform to **none**. You cannot provide additional platform configuration variables for IBM Z infrastructure.

**IMPORTANT**

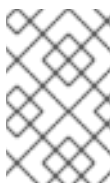
Clusters that are installed with the platform type **none** are unable to use some features, such as managing compute machines with the Machine API. This limitation applies even if the compute machines that are attached to the cluster are installed on a platform that would normally support the feature. This parameter cannot be changed after installation.

- 13 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

**IMPORTANT**

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

- 14 The [pull secret from the Red Hat OpenShift Cluster Manager](#) . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.
- 15 The SSH public key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).

**NOTE**

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

### 13.2.9.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

## Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



### NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

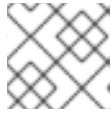
## Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
  additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
  ...
```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations.
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents

specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.



#### NOTE

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



#### NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

### 13.2.9.4. Configuring a three-node cluster

You can optionally deploy zero compute machines in a bare metal cluster that consists of three control plane machines only. This provides smaller, more resource efficient clusters for cluster administrators and developers to use for testing, development, and production.

In three-node OpenShift Container Platform environments, the three control plane machines are schedulable, which means that your application workloads are scheduled to run on them.

#### Prerequisites

- You have an existing **install-config.yaml** file.

#### Procedure

- Ensure that the number of compute replicas is set to **0** in your **install-config.yaml** file, as shown in the following **compute** stanza:

```
compute:
- name: worker
  platform: {}
  replicas: 0
```



#### NOTE

You must set the value of the **replicas** parameter for the compute machines to **0** when you install OpenShift Container Platform on user-provisioned infrastructure, regardless of the number of compute machines you are deploying. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. This does not apply to user-provisioned installations, where the compute machines are deployed manually.

**NOTE**

The preferred resource for control plane nodes is six vCPUs and 21 GB. For three control plane nodes this is the memory + vCPU equivalent of a minimum five-node cluster. You should back the three nodes, each installed on a 120 GB disk, with three IFLs that are SMT2 enabled. The minimum tested setup is three vCPUs and 10 GB on a 120 GB disk for each control plane node.

For three-node cluster installations, follow these next steps:

- If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes. See the *Load balancing requirements for user-provisioned infrastructure* section for more information.
- When you create the Kubernetes manifest files in the following procedure, ensure that the **mastersSchedulable** parameter in the `<installation_directory>/manifests/cluster-scheduler-02-config.yml` file is set to **true**. This enables your application workloads to run on the control plane nodes.
- Do not deploy any compute nodes when you create the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

### 13.2.10. Cluster Network Operator configuration

The configuration for the cluster network is specified as part of the Cluster Network Operator (CNO) configuration and stored in a custom resource (CR) object that is named **cluster**. The CR specifies the fields for the **Network** API in the **operator.openshift.io** API group.

The CNO configuration inherits the following fields during cluster installation from the **Network** API in the **Network.config.openshift.io** API group and these fields cannot be changed:

#### **clusterNetwork**

IP address pools from which pod IP addresses are allocated.

#### **serviceNetwork**

IP address pool for services.

#### **defaultNetwork.type**

Cluster network provider, such as OpenShift SDN or OVN-Kubernetes.

You can specify the cluster network provider configuration for your cluster by setting the fields for the **defaultNetwork** object in the CNO object named **cluster**.

#### 13.2.10.1. Cluster Network Operator configuration object

The fields for the Cluster Network Operator (CNO) are described in the following table:

**Table 13.11. Cluster Network Operator configuration object**

Field	Type	Description
<b>metadata.name</b>	<b>string</b>	The name of the CNO object. This name is always <b>cluster</b> .


Field	Type	Description
<b>spec.clusterNetwork</b>	<b>array</b>	<p>A list specifying the blocks of IP addresses from which pod IP addresses are allocated and the subnet prefix length assigned to each individual node in the cluster. For example:</p> <pre>spec:   clusterNetwork:   - cidr: 10.128.0.0/19     hostPrefix: 23   - cidr: 10.128.32.0/19     hostPrefix: 23</pre> <p>You can customize this field only in the <b>install-config.yaml</b> file before you create the manifests. The value is read-only in the manifest file.</p>
<b>spec.serviceNetwork</b>	<b>array</b>	<p>A block of IP addresses for services. The OpenShift SDN and OVN-Kubernetes Container Network Interface (CNI) network providers support only a single IP address block for the service network. For example:</p> <pre>spec:   serviceNetwork:   - 172.30.0.0/14</pre> <p>You can customize this field only in the <b>install-config.yaml</b> file before you create the manifests. The value is read-only in the manifest file.</p>
<b>spec.defaultNetwork</b>	<b>object</b>	Configures the Container Network Interface (CNI) cluster network provider for the cluster network.
<b>spec.kubeProxyConfig</b>	<b>object</b>	The fields for this object specify the kube-proxy configuration. If you are using the OVN-Kubernetes cluster network provider, the kube-proxy configuration has no effect.

### defaultNetwork object configuration

The values for the **defaultNetwork** object are defined in the following table:

Table 13.12. **defaultNetwork** object

Field	Type	Description
-------	------	-------------

Field	Type	Description
<b>type</b>	<b>string</b>	<p>Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b>. The cluster network provider is selected during installation. This value cannot be changed after cluster installation.</p> <div style="display: flex; align-items: flex-start;">  <p><b>NOTE</b></p> <p>OpenShift Container Platform uses the OpenShift SDN Container Network Interface (CNI) cluster network provider by default.</p> </div>
<b>openshiftSDNConfig</b>	<b>object</b>	This object is only valid for the OpenShift SDN cluster network provider.
<b>ovnKubernetesConfig</b>	<b>object</b>	This object is only valid for the OVN-Kubernetes cluster network provider.

#### Configuration for the OpenShift SDN CNI cluster network provider

The following table describes the configuration fields for the OpenShift SDN Container Network Interface (CNI) cluster network provider.

**Table 13.13. openshiftSDNConfig object**

Field	Type	Description
<b>mode</b>	<b>string</b>	<p>Configures the network isolation mode for OpenShift SDN. The default value is <b>NetworkPolicy</b>.</p> <p>The values <b>Multitenant</b> and <b>Subnet</b> are available for backwards compatibility with OpenShift Container Platform 3.x but are not recommended. This value cannot be changed after cluster installation.</p>

Field	Type	Description
<b>mtu</b>	<b>integer</b>	<p>The maximum transmission unit (MTU) for the VXLAN overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU.</p> <p>If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes.</p> <p>If your cluster requires different MTU values for different nodes, you must set this value to <b>50</b> less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of <b>9001</b>, and some have an MTU of <b>1500</b>, you must set this value to <b>1450</b>.</p> <p>This value cannot be changed after cluster installation.</p>
<b>vxlanPort</b>	<b>integer</b>	<p>The port to use for all VXLAN packets. The default value is <b>4789</b>. This value cannot be changed after cluster installation.</p> <p>If you are running in a virtualized environment with existing nodes that are part of another VXLAN network, then you might be required to change this. For example, when running an OpenShift SDN overlay on top of VMware NSX-T, you must select an alternate port for the VXLAN, because both SDNs use the same default VXLAN port number.</p> <p>On Amazon Web Services (AWS), you can select an alternate port for the VXLAN between port <b>9000</b> and port <b>9999</b>.</p>

### Example OpenShift SDN configuration

```
defaultNetwork:
  type: OpenShiftSDN
  openshiftSDNConfig:
    mode: NetworkPolicy
    mtu: 1450
    vxlanPort: 4789
```

### Configuration for the OVN-Kubernetes CNI cluster network provider

The following table describes the configuration fields for the OVN-Kubernetes CNI cluster network provider.

Table 13.14. `ovnKubernetesConfig` object

Field	Type	Description
-------	------	-------------



Field	Type	Description
<b>mtu</b>	<b>integer</b>	<p>The maximum transmission unit (MTU) for the Geneve (Generic Network Virtualization Encapsulation) overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU.</p> <p>If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes.</p> <p>If your cluster requires different MTU values for different nodes, you must set this value to <b>100</b> less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of <b>9001</b>, and some have an MTU of <b>1500</b>, you must set this value to <b>1400</b>.</p> <p>This value cannot be changed after cluster installation.</p>
<b>genevePort</b>	<b>integer</b>	The port to use for all Geneve packets. The default value is <b>6081</b> . This value cannot be changed after cluster installation.
<b>policyAuditConfig</b>	<b>object</b>	Specify a configuration object for customizing network policy audit logging. If unset, the defaults audit log settings are used.

Table 13.15. **policyAuditConfig** object

Field	Type	Description
<b>rateLimit</b>	integer	The maximum number of messages to generate every second per node. The default value is <b>20</b> messages per second.
<b>maxFileSize</b>	integer	The maximum size for the audit log in bytes. The default value is <b>50000000</b> or 50 MB.
<b>destination</b>	string	<p>One of the following additional audit log targets:</p> <p><b>libc</b> The libc <b>syslog()</b> function of the journald process on the host.</p> <p><b>udp:&lt;host&gt;:&lt;port&gt;</b> A syslog server. Replace <b>&lt;host&gt;:&lt;port&gt;</b> with the host and port of the syslog server.</p> <p><b>unix:&lt;file&gt;</b> A Unix Domain Socket file specified by <b>&lt;file&gt;</b>.</p> <p><b>null</b> Do not send the audit logs to any additional target.</p>

Field	Type	Description
<b>syslogFacility</b>	string	The syslog facility, such as <b>kern</b> , as defined by RFC5424. The default value is <b>local0</b> .


### Example OVN-Kubernetes configuration

```
defaultNetwork:
  type: OVNKubernetes
  ovnKubernetesConfig:
    mtu: 1400
    genevePort: 6081
```

### kubeProxyConfig object configuration

The values for the **kubeProxyConfig** object are defined in the following table:

Table 13.16. **kubeProxyConfig** object

Field	Type	Description
<b>iptablesSyncPeriod</b>	<b>string</b>	<p>The refresh period for <b>iptables</b> rules. The default value is <b>30s</b>. Valid suffixes include <b>s</b>, <b>m</b>, and <b>h</b> and are described in the <a href="#">Go time package</a> documentation.</p> <div style="display: flex; align-items: flex-start;"> <div style="border: 1px solid gray; padding: 5px; margin-right: 10px;">  </div> <div> <p><b>NOTE</b></p> <p>Because of performance improvements introduced in OpenShift Container Platform 4.3 and greater, adjusting the <b>iptablesSyncPeriod</b> parameter is no longer necessary.</p> </div> </div>
<b>proxyArguments.iptables-min-sync-period</b>	<b>array</b>	<p>The minimum duration before refreshing <b>iptables</b> rules. This field ensures that the refresh does not happen too frequently. Valid suffixes include <b>s</b>, <b>m</b>, and <b>h</b> and are described in the <a href="#">Go time package</a>. The default value is:</p> <pre>kubeProxyConfig:   proxyArguments:     iptables-min-sync-period:       - 0s</pre>

### 13.2.11. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.



## IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.



## NOTE

The installation program that generates the manifest and Ignition files is architecture specific and can be obtained from the [client image mirror](#). The Linux version of the installation program runs on s390x only. This installer program is also available as a Mac OS version.

## Prerequisites

- You obtained the OpenShift Container Platform installation program.
- You created the **install-config.yaml** installation configuration file.

## Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

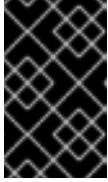
```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

- 1** For **<installation\_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.



## WARNING

If you are installing a three-node cluster, skip the following step to allow the control plane nodes to be schedulable.



## IMPORTANT

When you configure control plane nodes from the default unschedulable to schedulable, additional subscriptions are required. This is because control plane nodes then become worker nodes.

2. Check that the **mastersSchedulable** parameter in the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:
  - a. Open the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** file.
  - b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.
  - c. Save and exit the file.
3. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

**1** For **<installation\_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation\_directory>/auth** directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

### 13.2.12. Installing RHCOS and starting the OpenShift Container Platform bootstrap process

To install OpenShift Container Platform on IBM Z infrastructure that you provision, you must install Red Hat Enterprise Linux CoreOS (RHCOS) as Red Hat Enterprise Linux (RHEL) guest virtual machines. When you install RHCOS, you must provide the Ignition config file that was generated by the OpenShift Container Platform installation program for the type of machine you are installing. If you have configured suitable networking, DNS, and load balancing infrastructure, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS machines have rebooted.

You can perform a fast-track installation of RHCOS that uses a prepackaged QEMU copy-on-write (QCOW2) disk image. Alternatively, you can perform a full installation on a new QCOW2 disk image.

#### 13.2.12.1. Fast-track installation by using a prepackaged QCOW2 disk image

Complete the following steps to create the machines in a fast-track installation of Red Hat Enterprise Linux CoreOS (RHCOS), importing a prepackaged Red Hat Enterprise Linux CoreOS (RHCOS) QEMU copy-on-write (QCOW2) disk image.

### Prerequisites

- At least one LPAR running RHEL 8.4 with KVM, referred to as RHEL KVM host in this procedure.
- The KVM/QEMU hypervisor is installed on the RHEL KVM host.
- A domain name server (DNS) that can perform hostname and reverse lookup for the nodes.
- A DHCP server that provides IP addresses.

### Procedure

1. Obtain the RHEL QEMU copy-on-write (QCOW2) disk image file from the [Product Downloads](#) page on the Red Hat Customer Portal or from the [RHCOS image mirror](#) page.



#### IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Only use the appropriate RHCOS QCOW2 image described in the following procedure.

2. Download the QCOW2 disk image and Ignition files to a common directory on the RHEL KVM host.

For example: `/var/lib/libvirt/images`



#### NOTE

The Ignition files are generated by the OpenShift Container Platform installer.

3. Create a new disk image with the QCOW2 disk image backing file for each KVM guest node.

```
$ qemu-img create -f qcow2 -F qcow2 -b /var/lib/libvirt/images/{source_rhcos_qemu}
/var/lib/libvirt/images/{vmname}.qcow2 {size}
```

4. Create the new KVM guest nodes using the Ignition file and the new disk image.

```
$ virt-install --noautoconsole \
  --connect qemu:///system \
  --name {vn_name} \
  --memory {memory} \
  --vcpus {vcpus} \
  --disk {disk} \
  --import \
  --network network={network},mac={mac} \
  --disk path={ign_file},format=raw,readonly=on,serial=ignition,startup_policy=optional
```

### 13.2.12.2. Full installation on a new QCOW2 disk image

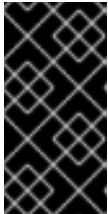
Complete the following steps to create the machines in a full installation on a new QEMU copy-on-write (QCOW2) disk image.

## Prerequisites

- At least one LPAR running RHEL 8.4 with KVM, referred to as RHEL KVM host in this procedure.
- The KVM/QEMU hypervisor is installed on the RHEL KVM host.
- A domain name server (DNS) that can perform hostname and reverse lookup for the nodes.
- An HTTP or HTTPS server is set up.

## Procedure

1. Obtain the RHEL kernel, initramfs, and rootfs files from the [Product Downloads](#) page on the Red Hat Customer Portal or from the [RHCOS image mirror](#) page.

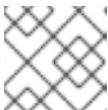


### IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Only use the appropriate RHCOS QCOW2 image described in the following procedure.

The file names contain the OpenShift Container Platform version number. They resemble the following examples:

- kernel: **rhcos-<version>-live-kernel-<architecture>**
  - initramfs: **rhcos-<version>-live-initramfs.<architecture>.img**
  - rootfs: **rhcos-<version>-live-rootfs.<architecture>.img**
2. Move the downloaded RHEL live kernel, initramfs, and rootfs as well as the Ignition files to an HTTP or HTTPS server before you launch **virt-install**.



### NOTE

The Ignition files are generated by the OpenShift Container Platform installer.

3. Create the new KVM guest nodes using the RHEL kernel, initramfs, and ignition files, the new disk image, and adjusted parm line arguments.
  - For **--location**, specify the location of the kernel/initrd on the HTTP or HTTPS server.
  - For **coreos.inst.ignition\_url=**, specify the Ignition file for the machine role. Use **bootstrap.ign**, **master.ign**, or **worker.ign**. Only HTTP and HTTPS protocols are supported.
  - For **coreos.live.rootfs\_url=**, specify the matching rootfs artifact for the kernel and initramfs you are booting. Only HTTP and HTTPS protocols are supported.

```
$ virt-install \
  --connect qemu:///system \
  --name {vn_name} \
```

```

--vcpus {vcpus} \
--memory {memory_mb} \
--disk {vn_name}.qcow2,size={image_size| default(10,true)} \
--network network={virt_network_parm} \
--boot hd \
--location {media_location},kernel={rhcos_kernel},initrd={rhcos_initrd} \
--extra-args "rd.neednet=1 coreos.inst=yes coreos.inst.install_dev=vda
coreos.live.rootfs_url={rhcos_liveos} ip={ip}::{default_gateway}:{subnet_mask_length}:
{vn_name}:enc1:none:{MTU} nameserver={dns} coreos.inst.ignition_url={rhcos_ign}" \
--noautoconsole \
--wait

```

### 13.2.12.3. Advanced RHCOS installation reference

This section illustrates the networking configuration and other advanced options that allow you to modify the Red Hat Enterprise Linux CoreOS (RHCOS) manual installation process. The following tables describe the kernel arguments and command-line options you can use with the RHCOS live installer and the **coreos-installer** command.

#### 13.2.12.3.1. Networking options for ISO installations

If you install RHCOS from an ISO image, you can add kernel arguments manually when you boot the image to configure networking for a node. If no networking arguments are specified, DHCP is activated in the initramfs when RHCOS detects that networking is required to fetch the Ignition config file.



#### IMPORTANT

When adding networking arguments manually, you must also add the **rd.neednet=1** kernel argument to bring the network up in the initramfs.

The following information provides examples for configuring networking on your RHCOS nodes for ISO installations. The examples describe how to use the **ip=** and **nameserver=** kernel arguments.



#### NOTE

Ordering is important when adding the kernel arguments: **ip=** and **nameserver=**.

The networking options are passed to the **dracut** tool during system boot. For more information about the networking options supported by **dracut**, see the **dracut.cmdline** manual page.

The following examples are the networking options for ISO installation.

#### Configuring DHCP or static IP addresses

To configure an IP address, either use DHCP (**ip=dhcp**) or set an individual static IP address (**ip=<host\_ip>**). If setting a static IP, you must then identify the DNS server IP address (**nameserver=<dns\_ip>**) on each node. The following example sets:

- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The hostname to **core0.example.com**

- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
nameserver=4.4.4.41
```



## NOTE

When you use DHCP to configure IP addressing for the RHCOS machines, the machines also obtain the DNS server information through DHCP. For DHCP-based deployments, you can define the DNS server address that is used by the RHCOS nodes through your DHCP server configuration.

### Configuring an IP address without a static hostname

You can configure an IP address without assigning a static hostname. If a static hostname is not set by the user, it will be picked up and automatically set by a reverse DNS lookup. To configure an IP address without a static hostname refer to the following example:

- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0::enp1s0:none
nameserver=4.4.4.41
```

### Specifying multiple network interfaces

You can specify multiple network interfaces by setting multiple **ip=** entries.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=10.10.10.3::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

### Configuring default gateway and route

Optional: You can configure routes to additional networks by setting an **rd.route=** value.



## NOTE

When you configure one or multiple networks, one default gateway is required. If the additional network gateway is different from the primary network gateway, the default gateway must be the primary network gateway.

- Run the following command to configure the default gateway:

```
ip=::10.10.10.254:::
```



- Enter the following command to configure the route for the additional network:

```
rd.route=20.20.20.0/24:20.20.20.254:enp2s0
```

### Disabling DHCP on a single interface

You can disable DHCP on a single interface, such as when there are two or more network interfaces and only one interface is being used. In the example, the **enp1s0** interface has a static networking configuration and DHCP is disabled for **enp2s0**, which is not used:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=::::core0.example.com:enp2s0:none
```

### Combining DHCP and static IP configurations

You can combine DHCP and static IP configurations on systems with multiple network interfaces, for example:

```
ip=enp1s0:dhcp
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

### Configuring VLANs on individual interfaces

Optional: You can configure VLANs on individual interfaces by using the **vlan=** parameter.

- To configure a VLAN on a network interface and use a static IP address, run the following command:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0.100:none
vlan=enp2s0.100:enp2s0
```

- To configure a VLAN on a network interface and to use DHCP, run the following command:

```
ip=enp2s0.100:dhcp
vlan=enp2s0.100:enp2s0
```

### Providing multiple DNS servers

You can provide multiple DNS servers by adding a **nameserver=** entry for each server, for example:

```
nameserver=1.1.1.1
nameserver=8.8.8.8
```

## 13.2.13. Waiting for the bootstrap process to complete

The OpenShift Container Platform bootstrap process begins after the cluster nodes first boot into the persistent RHCOS environment that has been installed to disk. The configuration information provided through the Ignition config files is used to initialize the bootstrap process and install OpenShift Container Platform on the machines. You must wait for the bootstrap process to complete.

### Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.

- You have obtained the installation program and generated the Ignition config files for your cluster.
- You installed RHCOS on your cluster machines and provided the Ignition config files that the OpenShift Container Platform installation program generated.
- Your machines have direct internet access or have an HTTP or HTTPS proxy available.

## Procedure

1. Monitor the bootstrap process:

```
┌ $ ./openshift-install --dir <installation_directory> wait-for bootstrap-complete \ 1  
└ --log-level=info 2
```

1 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

## Example output

```
┌ INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...  
└ INFO API v1.22.1 up  
└ INFO Waiting up to 30m0s for bootstrapping to complete...  
└ INFO It is now safe to remove the bootstrap resources
```

The command succeeds when the Kubernetes API server signals that it has been bootstrapped on the control plane machines.

2. After bootstrap process is complete, remove the bootstrap machine from the load balancer.



### IMPORTANT

You must remove the bootstrap machine from the load balancer at this point. You can also remove or reformat the bootstrap machine itself.

## 13.2.14. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

## Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

### Example output

```
system:admin
```

## 13.2.15. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

### Prerequisites

- You added machines to your cluster.

### Procedure

1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

### Example output

```
NAME      STATUS   ROLES    AGE   VERSION
master-0  Ready    master   63m   v1.22.1
master-1  Ready    master   63m   v1.22.1
master-2  Ready    master   64m   v1.22.1
```

The output lists all of the machines that you created.



### NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

2. Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

### Example output

NAME	AGE	REQUESTOR	CONDITION
csr-mddf5	20m	system:node:master-01.example.com	Approved,Issued
csr-z5rln	16m	system:node:worker-21.example.com	Approved,Issued

- If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:



#### NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.



#### NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{\n"}\n{{end}}\n{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```



#### NOTE

Some Operators might not become available until some CSRs are approved.

- Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

### Example output

```

NAME      AGE    REQUESTOR                                CONDITION
csr-bfd72 5m26s system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv 5m26s system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...

```

5. If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{"\n"}
{{end}}{{end}}' | xargs oc adm certificate approve
```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

### Example output

```

NAME      STATUS  ROLES  AGE  VERSION
master-0  Ready   master 73m  v1.22.1
master-1  Ready   master 73m  v1.22.1
master-2  Ready   master 74m  v1.22.1
worker-0  Ready   worker 11m  v1.22.1
worker-1  Ready   worker 11m  v1.22.1

```



#### NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

#### Additional information

- For more information on CSRs, see [Certificate Signing Requests](#).

### 13.2.16. Initial Operator configuration

After the control plane initializes, you must immediately configure some Operators so that they all become available.

## Prerequisites

- Your control plane has initialized.

## Procedure

1. Watch the cluster components come online:

```
$ watch -n5 oc get clusteroperators
```

## Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
authentication	4.9.0	True	False	False	19m
baremetal	4.9.0	True	False	False	37m
cloud-credential	4.9.0	True	False	False	40m
cluster-autoscaler	4.9.0	True	False	False	37m
config-operator	4.9.0	True	False	False	38m
console	4.9.0	True	False	False	26m
csi-snapshot-controller	4.9.0	True	False	False	37m
dns	4.9.0	True	False	False	37m
etcd	4.9.0	True	False	False	36m
image-registry	4.9.0	True	False	False	31m
ingress	4.9.0	True	False	False	30m
insights	4.9.0	True	False	False	31m
kube-apiserver	4.9.0	True	False	False	26m
kube-controller-manager	4.9.0	True	False	False	36m
kube-scheduler	4.9.0	True	False	False	36m
kube-storage-version-migrator	4.9.0	True	False	False	37m
machine-api	4.9.0	True	False	False	29m
machine-approver	4.9.0	True	False	False	37m
machine-config	4.9.0	True	False	False	36m
marketplace	4.9.0	True	False	False	37m
monitoring	4.9.0	True	False	False	29m
network	4.9.0	True	False	False	38m
node-tuning	4.9.0	True	False	False	37m
openshift-apiserver	4.9.0	True	False	False	32m
openshift-controller-manager	4.9.0	True	False	False	30m
openshift-samples	4.9.0	True	False	False	32m
operator-lifecycle-manager	4.9.0	True	False	False	37m
operator-lifecycle-manager-catalog	4.9.0	True	False	False	37m
operator-lifecycle-manager-packageserver	4.9.0	True	False	False	32m
service-ca	4.9.0	True	False	False	38m
storage	4.9.0	True	False	False	37m

2. Configure the Operators that are not available.

### 13.2.16.1. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

### 13.2.16.1.1. Configuring registry storage for IBM Z

As a cluster administrator, following installation you must configure your registry to use storage.

#### Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.
- You have a cluster on IBM Z.
- You have provisioned persistent storage for your cluster, such as Red Hat OpenShift Container Storage.



#### IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have 100Gi capacity.

#### Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.



#### NOTE

When using shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

#### Example output

```
No resources found in openshift-image-registry namespace
```



#### NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

#### Example output

```
storage:
  pvc:
    claim:
```

Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** PVC.

4. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

#### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
image-registry	4.9	True	False	False	6h50m

5. Ensure that your registry is set to managed to enable building and pushing of images.

- Run:

```
$ oc edit configs.imageregistry/cluster
```

Then, change the line

```
managementState: Removed
```

to

```
managementState: Managed
```

### 13.2.16.1.2. Configuring storage for the image registry in non-production clusters

You must configure storage for the Image Registry Operator. For non-production clusters, you can set the image registry to an empty directory. If you do so, all images are lost if you restart the registry.

#### Procedure

- To set the image registry storage to an empty directory:

```
$ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec": {"storage":{"emptyDir":{}}}'
```



**WARNING**

Configure this option for only non-production clusters.

If you run this command before the Image Registry Operator initializes its components, the **oc patch** command fails with the following error:

```
Error from server (NotFound): configs.imageregistry.operator.openshift.io "cluster" not found
```

Wait a few minutes and run the command again.

### 13.2.17. Completing installation on user-provisioned infrastructure

After you complete the Operator configuration, you can finish installing the cluster on infrastructure that you provide.

#### Prerequisites

- Your control plane has initialized.
- You have completed the initial Operator configuration.

#### Procedure

1. Confirm that all the cluster components are online with the following command:

```
$ watch -n5 oc get clusteroperators
```

#### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
authentication	4.9.0	True	False	False	19m
baremetal	4.9.0	True	False	False	37m
cloud-credential	4.9.0	True	False	False	40m
cluster-autoscaler	4.9.0	True	False	False	37m
config-operator	4.9.0	True	False	False	38m
console	4.9.0	True	False	False	26m
csi-snapshot-controller	4.9.0	True	False	False	37m
dns	4.9.0	True	False	False	37m
etcd	4.9.0	True	False	False	36m
image-registry	4.9.0	True	False	False	31m
ingress	4.9.0	True	False	False	30m
insights	4.9.0	True	False	False	31m
kube-apiserver	4.9.0	True	False	False	26m
kube-controller-manager	4.9.0	True	False	False	36m
kube-scheduler	4.9.0	True	False	False	36m
kube-storage-version-migrator	4.9.0	True	False	False	37m
machine-api	4.9.0	True	False	False	29m

machine-approver	4.9.0	True	False	False	37m
machine-config	4.9.0	True	False	False	36m
marketplace	4.9.0	True	False	False	37m
monitoring	4.9.0	True	False	False	29m
network	4.9.0	True	False	False	38m
node-tuning	4.9.0	True	False	False	37m
openshift-apiserver	4.9.0	True	False	False	32m
openshift-controller-manager	4.9.0	True	False	False	30m
openshift-samples	4.9.0	True	False	False	32m
operator-lifecycle-manager	4.9.0	True	False	False	37m
operator-lifecycle-manager-catalog	4.9.0	True	False	False	37m
operator-lifecycle-manager-packageserver	4.9.0	True	False	False	32m
service-ca	4.9.0	True	False	False	38m
storage	4.9.0	True	False	False	37m

Alternatively, the following command notifies you when all of the clusters are available. It also retrieves and displays credentials:

```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

## Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

The command succeeds when the Cluster Version Operator finishes deploying the OpenShift Container Platform cluster from Kubernetes API server.



### IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Confirm that the Kubernetes API server is communicating with the pods.

- a. To view a list of all pods, use the following command:

```
$ oc get pods --all-namespaces
```

**Example output**

```

NAMESPACE          NAME                                     READY  STATUS
RESTARTS  AGE
openshift-apiserver-operator  openshift-apiserver-operator-85cb746d55-zqhs8  1/1
Running    1    9m
openshift-apiserver          apiserver-67b9g                                1/1  Running  0
3m
openshift-apiserver          apiserver-ljcmx                                1/1  Running  0
1m
openshift-apiserver          apiserver-z25h4                                1/1  Running  0
2m
openshift-authentication-operator  authentication-operator-69d5d8bf84-vh2n8    1/1
Running    0    5m
...

```

- b. View the logs for a pod that is listed in the output of the previous command by using the following command:

```
$ oc logs <pod_name> -n <namespace> 1
```

- 1** Specify the pod name and namespace, as shown in the output of the previous command.

If the pod logs display, the Kubernetes API server can communicate with the cluster machines.

3. For an installation with Fibre Channel Protocol (FCP), additional steps are required to enable multipathing. Do not enable multipathing during installation. See "Enabling multipathing with kernel arguments on RHCOS" in the *Post-installation machine configuration tasks* documentation for more information.

**13.2.18. Telemetry access for OpenShift Container Platform**

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

**Additional resources**

- See [About remote health monitoring](#) for more information about the Telemetry service

**13.2.19. Collecting debugging information**

You can gather debugging information that might help you to troubleshoot and debug certain issues with an OpenShift Container Platform installation on IBM Z.

**Prerequisites**

- The **oc** CLI tool installed.

### Procedure

1. Log in to the cluster:

```
$ oc login -u <username>
```

2. On the node you want to gather hardware information about, start a debugging container:

```
$ oc debug node/<nodename>
```

3. Change to the **/host** file system and start **toolbox**:

```
$ chroot /host  
$ toolbox
```

4. Collect the **dbginfo** data:

```
$ dbginfo.sh
```

5. You can then retrieve the data, for example, using **scp**.

### Additional resources

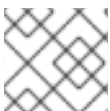
- [How to generate SOSREPORT within OpenShift4 nodes without SSH](#) .

### 13.2.20. Next steps

- [Customize your cluster](#).
- If necessary, you can [opt out of remote health reporting](#) .

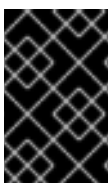
## 13.3. INSTALLING A CLUSTER WITH RHEL KVM ON IBM Z AND LINUXONE IN A RESTRICTED NETWORK

In OpenShift Container Platform version 4.9, you can install a cluster on IBM Z and LinuxONE infrastructure that you provision in a restricted network.



### NOTE

While this document refers to only IBM Z, all information in it also applies to LinuxONE.

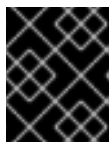


### IMPORTANT

Additional considerations exist for non-bare metal platforms. Review the information in the [guidelines for deploying OpenShift Container Platform on non-tested platforms](#) before you install an OpenShift Container Platform cluster.

### 13.3.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You [created a registry on your mirror host](#) and obtained the **imageContentSources** data for your version of OpenShift Container Platform.
- You must move or remove any existing installation files, before you begin the installation process. This ensures that the required installation files are created and updated during the installation process.



### IMPORTANT

Ensure that installation steps are done from a machine with access to the installation media.

- You provisioned [persistent storage using NFS](#) for your cluster. To deploy a private image registry, you must set up persistent storage with **ReadWriteMany** access.
- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.
- You provisioned a RHEL Kernel Virtual Machine (KVM) system that is hosted on the logical partition (LPAR) and based on RHEL 8.4 or later.



### NOTE

Be sure to also review this site list if you are configuring a proxy.

## 13.3.2. About installations in restricted networks

In OpenShift Container Platform 4.9, you can perform an installation that does not require an active connection to the internet to obtain software components. Restricted network installations can be completed using installer-provisioned infrastructure or user-provisioned infrastructure, depending on the cloud platform to which you are installing the cluster.

If you choose to perform a restricted network installation on a cloud platform, you still require access to its cloud APIs. Some cloud functions, like Amazon Web Service's Route 53 DNS and IAM services, require internet access. Depending on your network, you might require less internet access for an installation on bare metal hardware or on VMware vSphere.

To complete a restricted network installation, you must create a registry that mirrors the contents of the OpenShift Container Platform registry and contains the installation media. You can create this registry on a mirror host, which can access both the internet and your closed network, or by using other methods that meet your restrictions.



### IMPORTANT

Because of the complexity of the configuration for user-provisioned installations, consider completing a standard user-provisioned infrastructure installation before you attempt a restricted network installation using user-provisioned infrastructure. Completing this test installation might make it easier to isolate and troubleshoot any issues that might arise during your installation in a restricted network.

### 13.3.2.1. Additional limits

Clusters in restricted networks have the following additional limitations and restrictions:

- The **ClusterVersion** status includes an **Unable to retrieve available updates** error.
- By default, you cannot use the contents of the Developer Catalog because you cannot access the required image stream tags.

### 13.3.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to obtain the images that are necessary to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



#### IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

### 13.3.4. Machine requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

One or more KVM host machines based on RHEL 8.4 or later. Each RHEL KVM host machine must have libvirt installed and running. The virtual machines are provisioned under each RHEL KVM host machine.

#### 13.3.4.1. Required machines

The smallest OpenShift Container Platform clusters require the following hosts:

**Table 13.17. Minimum required hosts**

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.

Hosts	Description
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.



### IMPORTANT

To improve high availability of your cluster, distribute the control plane machines over different RHEL instances on at least two physical machines.

The bootstrap, control plane, and compute machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system.

See [Red Hat Enterprise Linux technology capabilities and limits](#) .

#### 13.3.4.2. Network connectivity requirements

The OpenShift Container Platform installer creates the Ignition files, which are necessary for all the Red Hat Enterprise Linux CoreOS (RHCOS) virtual machines. The automated installation of OpenShift Container Platform is performed by the bootstrap machine. It starts the installation of OpenShift Container Platform on each node, starts the Kubernetes cluster, and then finishes. During this bootstrap, the virtual machine must have an established network connection either through a Dynamic Host Configuration Protocol (DHCP) server or static IP address.

#### 13.3.4.3. IBM Z network connectivity requirements

To install on IBM Z under RHEL KVM, you need:

- A RHEL KVM host configured with an OSA or RoCE network adapter.
- Either a RHEL KVM host that is configured to use bridged networking in libvirt or MacVTap to connect the network to the guests.  
See [Types of virtual network connections](#) .

#### 13.3.4.4. Host machine resource requirements

The RHEL KVM host in your environment must meet the following requirements to host the virtual machines that you plan for the OpenShift Container Platform environment. See [Getting started with virtualization](#).

You can install OpenShift Container Platform version 4.9 on the following IBM hardware:

- IBM z15 (all models), IBM z14 (all models), IBM z13, and IBM z13s
- LinuxONE, any version

### 13.3.4.5. Minimum IBM Z system environment

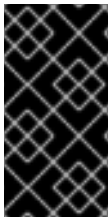
#### Hardware requirements

- The equivalent of six IFLs, which are SMT2 enabled, for each cluster.
- At least one network connection to both connect to the **LoadBalancer** service and to serve data for traffic outside the cluster.



#### NOTE

You can use dedicated or shared IFLs to assign sufficient compute resources. Resource sharing is one of the key strengths of IBM Z. However, you must adjust capacity correctly on each hypervisor layer and ensure sufficient resources for every OpenShift Container Platform cluster.



#### IMPORTANT

Since the overall performance of the cluster can be impacted, the LPARs that are used to setup the OpenShift Container Platform clusters must provide sufficient compute capacity. In this context, LPAR weight management, entitlements, and CPU shares on the hypervisor level play an important role.

#### Operating system requirements

- One LPAR running RHEL 8.4 or later with KVM, which is managed by libvirt

On your RHEL KVM host, set up:

- Three guest virtual machines for OpenShift Container Platform control plane machines
- Two guest virtual machines for OpenShift Container Platform compute machines
- One guest virtual machine for the temporary OpenShift Container Platform bootstrap machine

### 13.3.4.6. Minimum resource requirements

Each cluster virtual machine must meet the following minimum requirements:

Virtual Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS
Bootstrap	RHCOS	4	16 GB	100 GB	N/A
Control plane	RHCOS	4	16 GB	100 GB	N/A
Compute	RHCOS	2	8 GB	100 GB	N/A

1. One physical core (IFL) provides two logical cores (threads) when SMT-2 is enabled. The hypervisor can provide two or more vCPUs.

### 13.3.4.7. Preferred IBM Z system environment



## Hardware requirements

- Three LPARS that each have the equivalent of six IFLs, which are SMT2 enabled, for each cluster.
- Two network connections to both connect to the **LoadBalancer** service and to serve data for traffic outside the cluster.

## Operating system requirements

- For high availability, two or three LPARs running RHEL 8.4 or later with KVM, which are managed by libvirt.

On your RHEL KVM host, set up:

- Three guest virtual machines for OpenShift Container Platform control plane machines, distributed across the RHEL KVM host machines.
- At least six guest virtual machines for OpenShift Container Platform compute machines, distributed across the RHEL KVM host machines.
- One guest virtual machine for the temporary OpenShift Container Platform bootstrap machine.
- To ensure the availability of integral components in an overcommitted environment, increase the priority of the control plane by using **cpu\_shares**. Do the same for infrastructure nodes, if they exist. See [schedinfo](#) in IBM Documentation.

### 13.3.4.8. Preferred resource requirements

The preferred requirements for each cluster virtual machine are:

Virtual Machine	Operating System	vCPU	Virtual RAM	Storage
Bootstrap	RHCOS	4	16 GB	120 GB
Control plane	RHCOS	8	16 GB	120 GB
Compute	RHCOS	6	8 GB	120 GB

### 13.3.4.9. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

## Additional resources

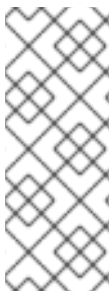
- [Recommended host practices for IBM Z & LinuxONE environments](#)

### 13.3.4.10. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.

It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.



#### NOTE

If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

#### 13.3.4.10.1. Setting the cluster node hostnames through DHCP

On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

#### 13.3.4.10.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.

#### Table 13.18. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	<b>1936</b>	Metrics
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> and the Cluster Version Operator on port <b>9099</b> .
	<b>10250-10259</b>	The default ports that Kubernetes reserves
	<b>10256</b>	openshift-sdn
UDP	<b>4789</b>	VXLAN and Geneve
	<b>6081</b>	VXLAN and Geneve
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> .
	<b>500</b>	IPsec IKE packets
	<b>4500</b>	IPsec NAT-T packets
TCP/UDP	<b>30000-32767</b>	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 13.19. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	<b>6443</b>	Kubernetes API

Table 13.20. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	<b>2379-2380</b>	etcd server and peer ports

### NTP configuration for user-provisioned infrastructure

OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service*.

If a DHCP server provides NTP server information, the chrony time service on the Red Hat Enterprise Linux CoreOS (RHCOS) machines read the information and can sync the clock with the NTP servers.

### Additional resources

- [Configuring chrony time service](#)

#### 13.3.4.11. User-provisioned DNS requirements

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:


- The Kubernetes API
- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines

Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, **<cluster\_name>** is the cluster name and **<base\_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster\_name>.<base\_domain>..**

**Table 13.21. Required DNS records**

Component	Record	Description
Kubernetes API	<b>api.&lt;cluster_name&gt;.&lt;base_domain&gt;..</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
	<b>api-int.&lt;cluster_name&gt;.&lt;base_domain&gt;..</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster.
		 <p><b>IMPORTANT</b></p> <p>The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.</p>

Component	Record	Description
Routes	<b>*.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.  For example, <b>console-openshift-console.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;</b> is used as a wildcard route to the OpenShift Container Platform console.
Bootstrap machine	<b>bootstrap.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.
Control plane machines	<b>&lt;master&gt;&lt;n&gt;.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.
Compute machines	<b>&lt;worker&gt;&lt;n&gt;.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.



## NOTE

In OpenShift Container Platform 4.4 and later, you do not need to specify etcd host and SRV records in your DNS configuration.

## TIP

You can use the **dig** command to verify name and reverse name resolution. See the section on *Validating DNS resolution for user-provisioned infrastructure* for detailed validation steps.

### 13.3.4.11.1. Example DNS configuration for user-provisioned clusters

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is **ocp4** and the base domain is **example.com**.

#### Example DNS A record configuration for a user-provisioned cluster

The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

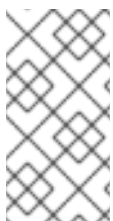
### Example 13.4. Sample DNS zone database

```

$TTL 1W
@ IN SOA ns1.example.com. root (
    2019070700 ; serial
    3H ; refresh (3 hours)
    30M ; retry (30 minutes)
    2W ; expiry (2 weeks)
    1W ) ; minimum (1 week)
IN NS ns1.example.com.
IN MX 10 smtp.example.com.
;
;
;
ns1.example.com. IN A 192.168.1.5
smtp.example.com. IN A 192.168.1.5
;
helper.example.com. IN A 192.168.1.5
helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com. IN A 192.168.1.5 1
api-int.ocp4.example.com. IN A 192.168.1.5 2
;
*.apps.ocp4.example.com. IN A 192.168.1.5 3
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 4
;
master0.ocp4.example.com. IN A 192.168.1.97 5
master1.ocp4.example.com. IN A 192.168.1.98 6
master2.ocp4.example.com. IN A 192.168.1.99 7
;
worker0.ocp4.example.com. IN A 192.168.1.11 8
worker1.ocp4.example.com. IN A 192.168.1.7 9
;
;EOF

```

- 1 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.
- 2 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.
- 3 Provides name resolution for the wildcard routes. The record refers to the IP address of the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



#### NOTE

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

- 4 Provides name resolution for the bootstrap machine.
- 5 6 7 Provides name resolution for the control plane machines.
- 8 9 Provides name resolution for the compute machines.

### Example DNS PTR record configuration for a user-provisioned cluster

The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

#### Example 13.5. Sample DNS zone database for reverse records

```
$TTL 1W
@ IN SOA ns1.example.com. root (
    2019070700 ; serial
    3H ; refresh (3 hours)
    30M ; retry (30 minutes)
    2W ; expiry (2 weeks)
    1W ) ; minimum (1 week)
IN NS ns1.example.com.
;
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. 2
;
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. 3
;
97.1.168.192.in-addr.arpa. IN PTR master0.ocp4.example.com. 4
98.1.168.192.in-addr.arpa. IN PTR master1.ocp4.example.com. 5
99.1.168.192.in-addr.arpa. IN PTR master2.ocp4.example.com. 6
;
11.1.168.192.in-addr.arpa. IN PTR worker0.ocp4.example.com. 7
7.1.168.192.in-addr.arpa. IN PTR worker1.ocp4.example.com. 8
;
;EOF
```

- 1 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.
- 2 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.
- 3 Provides reverse DNS resolution for the bootstrap machine.
- 4 5 6 Provides reverse DNS resolution for the control plane machines.
- 7 8 Provides reverse DNS resolution for the compute machines.

**NOTE**

A PTR record is not required for the OpenShift Container Platform application wildcard.

**13.3.4.12. Load balancing requirements for user-provisioned infrastructure**

Before you install OpenShift Container Platform, you must provision the API and application ingress load balancing infrastructure. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

**NOTE**

If you want to deploy the API and application ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer.** Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:
  - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the API routes.
  - A stateless load balancing algorithm. The options vary based on the load balancer implementation.

**NOTE**

Session persistence is not required for the API load balancer to function properly.

Configure the following ports on both the front and back of the load balancers:

**Table 13.22. API load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
<b>6443</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the <b>/readyz</b> endpoint for the API server health check probe.	X	X	Kubernetes API server
<b>22623</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server



**NOTE**

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the **/readyz** endpoint to the removal of the API server instance from the pool. Within the time frame after **/readyz** returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application ingress load balancer.** Provides an ingress point for application traffic flowing in from outside the cluster. Configure the following conditions:

- Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the ingress routes.
- A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

**TIP**

If the true IP address of the client can be seen by the application ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

Configure the following ports on both the front and back of the load balancers:

**Table 13.23. Application ingress load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
<b>443</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic
<b>80</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic
<b>1936</b>	The worker nodes that run the Ingress Controller pods, by default. You must configure the <b>/healthz/ready</b> endpoint for the ingress health check probe.	X	X	HTTP traffic

**NOTE**

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

**NOTE**

A working configuration for the Ingress router is required for an OpenShift Container Platform cluster. You must configure the Ingress router after the control plane initializes.

**13.3.4.12.1. Example load balancer configuration for user-provisioned clusters**

This section provides an example API and application ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an `/etc/haproxy/haproxy.cfg` configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing one load balancing solution over another.

**NOTE**

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

**Example 13.6. Sample API and application ingress load balancer configuration**

```

global
  log      127.0.0.1 local2
  pidfile /var/run/haproxy.pid
  maxconn 4000
  daemon
defaults
  mode          http
  log           global
  option        dontlognull
  option http-server-close
  option        redispatch
  retries       3
  timeout http-request 10s
  timeout queue   1m
  timeout connect 10s
  timeout client  1m
  timeout server  1m
  timeout http-keep-alive 10s
  timeout check   10s
  maxconn        3000
frontend stats
  bind *:1936
  mode          http
  log           global
  maxconn 10
  stats enable
  stats hide-version
  stats refresh 30s
  stats show-node
  stats show-desc Stats for ocp4 cluster 1
  stats auth admin:ocp4
  stats uri /stats
listen api-server-6443 2

```

```

bind *:6443
mode tcp
server bootstrap bootstrap.ocp4.example.com:6443 check inter 1s backup 3
server master0 master0.ocp4.example.com:6443 check inter 1s
server master1 master1.ocp4.example.com:6443 check inter 1s
server master2 master2.ocp4.example.com:6443 check inter 1s
listen machine-config-server-22623 4
bind *:22623
mode tcp
server bootstrap bootstrap.ocp4.example.com:22623 check inter 1s backup 5
server master0 master0.ocp4.example.com:22623 check inter 1s
server master1 master1.ocp4.example.com:22623 check inter 1s
server master2 master2.ocp4.example.com:22623 check inter 1s
listen ingress-router-443 6
bind *:443
mode tcp
balance source
server worker0 worker0.ocp4.example.com:443 check inter 1s
server worker1 worker1.ocp4.example.com:443 check inter 1s
listen ingress-router-80 7
bind *:80
mode tcp
balance source
server worker0 worker0.ocp4.example.com:80 check inter 1s
server worker1 worker1.ocp4.example.com:80 check inter 1s

```

- 1** In the example, the cluster name is **ocp4**.
- 2** Port **6443** handles the Kubernetes API traffic and points to the control plane machines.
- 3** **5** The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.
- 4** Port **22623** handles the machine config server traffic and points to the control plane machines.
- 6** Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.
- 7** Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



#### NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

#### TIP

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltupe** on the HAProxy node.

**NOTE**

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running **setsebool -P haproxy\_connect\_any=1**.

### 13.3.5. Preparing the user-provisioned infrastructure

Before you install OpenShift Container Platform on user-provisioned infrastructure, you must prepare the underlying infrastructure.

This section provides details about the high-level steps required to set up your cluster infrastructure in preparation for an OpenShift Container Platform installation. This includes configuring IP networking and network connectivity for your cluster nodes, enabling the required ports through your firewall, and setting up the required DNS and load balancing infrastructure.

After preparation, your cluster infrastructure must meet the requirements outlined in the *Requirements for a cluster with user-provisioned infrastructure* section.

#### Prerequisites

- You have reviewed the [OpenShift Container Platform 4.x Tested Integrations](#) page.
- You have reviewed the infrastructure requirements detailed in the *Requirements for a cluster with user-provisioned infrastructure* section.

#### Procedure

1. If you are using DHCP to provide the IP networking configuration to your cluster nodes, configure your DHCP service.
  - a. Add persistent IP addresses for the nodes to your DHCP server configuration. In your configuration, match the MAC address of the relevant network interface to the intended IP address for each node.
  - b. When you use DHCP to configure IP addressing for the cluster machines, the machines also obtain the DNS server information through DHCP. Define the persistent DNS server address that is used by the cluster nodes through your DHCP server configuration.

**NOTE**

If you are not using a DHCP service, you must provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

- c. Define the hostnames of your cluster nodes in your DHCP server configuration. See the *Setting the cluster node hostnames through DHCP* section for details about hostname considerations.

**NOTE**

If you are not using a DHCP service, the cluster nodes obtain their hostname through a reverse DNS lookup.

2. Choose to perform either a fast track installation of Red Hat Enterprise Linux CoreOS (RHCOS) or a full installation of Red Hat Enterprise Linux CoreOS (RHCOS). For the full installation, you must set up an HTTP or HTTPS server to provide Ignition files and install images to the cluster nodes. For the fast track installation an HTTP or HTTPS server is not required, however, a DHCP server is required. See sections "Fast-track installation: Creating Red Hat Enterprise Linux CoreOS (RHCOS) machines" and "Full installation: Creating Red Hat Enterprise Linux CoreOS (RHCOS) machines".
3. Ensure that your network infrastructure provides the required network connectivity between the cluster components. See the *Networking requirements for user-provisioned infrastructure* section for details about the requirements.
4. Configure your firewall to enable the ports required for the OpenShift Container Platform cluster components to communicate. See *Networking requirements for user-provisioned infrastructure* section for details about the ports that are required.
5. Setup the required DNS infrastructure for your cluster.
  - a. Configure DNS name resolution for the Kubernetes API, the application wildcard, the bootstrap machine, the control plane machines, and the compute machines.
  - b. Configure reverse DNS resolution for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.  
See the *User-provisioned DNS requirements* section for more information about the OpenShift Container Platform DNS requirements.
6. Validate your DNS configuration.
  - a. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses in the responses correspond to the correct components.
  - b. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names in the responses correspond to the correct components.  
See the *Validating DNS resolution for user-provisioned infrastructure* section for detailed DNS validation steps.
7. Provision the required API and application ingress load balancing infrastructure. See the *Load balancing requirements for user-provisioned infrastructure* section for more information about the requirements.

**NOTE**

Some load balancing solutions require the DNS name resolution for the cluster nodes to be in place before the load balancing is initialized.

### 13.3.6. Validating DNS resolution for user-provisioned infrastructure

You can validate your DNS configuration before installing OpenShift Container Platform on user-provisioned infrastructure.



## IMPORTANT

The validation steps detailed in this section must succeed before you install your cluster.

### Prerequisites

- You have configured the required DNS records for your user-provisioned infrastructure.

### Procedure

- From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses contained in the responses correspond to the correct components.
  - Perform a lookup against the Kubernetes API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api.<cluster_name>.<base_domain> 1
```

- Replace **<nameserver\_ip>** with the IP address of the nameserver, **<cluster\_name>** with your cluster name, and **<base\_domain>** with your base domain name.

#### Example output

```
api.ocp4.example.com. 0 IN A 192.168.1.5
```

- Perform a lookup against the Kubernetes internal API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api-int.<cluster_name>.<base_domain>
```

#### Example output

```
api-int.ocp4.example.com. 0 IN A 192.168.1.5
```

- Test an example **\*.apps.<cluster\_name>.<base\_domain>** DNS wildcard lookup. All of the application wildcard lookups must resolve to the IP address of the application ingress load balancer:

```
$ dig +noall +answer @<nameserver_ip> random.apps.<cluster_name>.<base_domain>
```

#### Example output

```
random.apps.ocp4.example.com. 0 IN A 192.168.1.5
```



## NOTE

In the example outputs, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

You can replace **random** with another wildcard value. For example, you can query the route to the OpenShift Container Platform console:

```
$ dig +noall +answer @<nameserver_ip> console-openshift-console.apps.
<cluster_name>.<base_domain>
```

### Example output

```
console-openshift-console.apps.ocp4.example.com. 0 IN A 192.168.1.5
```

- d. Run a lookup against the bootstrap DNS record name. Check that the result points to the IP address of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> bootstrap.<cluster_name>.<base_domain>
```

### Example output

```
bootstrap.ocp4.example.com. 0 IN A 192.168.1.96
```

- e. Use this method to perform lookups against the DNS record names for the control plane and compute nodes. Check that the results correspond to the IP addresses of each node.
2. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names contained in the responses correspond to the correct components.
- a. Perform a reverse lookup against the IP address of the API load balancer. Check that the response includes the record names for the Kubernetes API and the Kubernetes internal API:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.5
```

### Example output

```
5.1.168.192.in-addr.arpa. 0 IN PTR api-int.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. 0 IN PTR api.ocp4.example.com. 2
```

- 1** Provides the record name for the Kubernetes internal API.

- 2** Provides the record name for the Kubernetes API.



### NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard. No validation step is needed for reverse DNS resolution against the IP address of the application ingress load balancer.

- b. Perform a reverse lookup against the IP address of the bootstrap node. Check that the result points to the DNS record name of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.96
```

## Example output

```
96.1.168.192.in-addr.arpa. 0 IN PTR bootstrap.ocp4.example.com.
```

- c. Use this method to perform reverse lookups against the IP addresses for the control plane and compute nodes. Check that the results correspond to the DNS record names of each node.

### 13.3.7. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.



#### IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

#### Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.



#### NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:



```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.



#### NOTE

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

#### Example output

```
Agent pid 31874
```



#### NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1** Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

#### Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

#### Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

### 13.3.8. Manually creating the installation configuration file

For user-provisioned installations of OpenShift Container Platform, you manually generate your installation configuration file.

#### Prerequisites

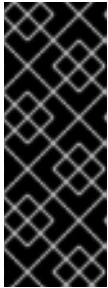
- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.

- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

## Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```



### IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation\_directory>**.



### NOTE

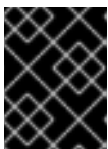
You must name this configuration file **install-config.yaml**.



### NOTE

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation\_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



### IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

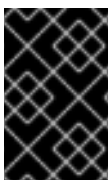
### 13.3.8.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide a customized **install-config.yaml** installation configuration file that describes the details for your environment.



### NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.



### IMPORTANT

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

## 13.3.8.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 13.24. Required parameters

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;</b> . <b>&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}</b> . <b>{{.baseDomain}}</b> .	String of lowercase letters, hyphens (-), and periods (.), such as <b>dev</b> .
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws</b> , <b>baremetal</b> , <b>azure</b> , <b>gcp</b> , <b>openstack</b> , <b>ovirt</b> , <b>vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object


Parameter	Description	Values
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } }</pre>

### 13.3.8.1.2. Network configuration parameters


You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

Table 13.25. Network parameters

Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	Object <div style="display: flex; align-items: center; margin-top: 10px;">  <div> <p><b>NOTE</b></p> <p>You cannot modify parameters specified by the <b>networking</b> object after installation.</p> </div> </div>
<b>networking.network Type</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .

Parameter	Description	Values
<b>networking.clusterNetwork</b>	<p>The IP address blocks for pods.</p> <p>The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b>.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   clusterNetwork:     - cidr: 10.128.0.0/14       hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	<p>Required if you use <b>networking.clusterNetwork</b>. An IP address block.</p> <p>An IPv4 network.</p>	<p>An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b>.</p>
<b>networking.clusterNetwork.hostPrefix</b>	<p>The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b>. A <b>hostPrefix</b> value of <b>23</b> provides 510 (<math>2^{(32 - 23)} - 2</math>) pod IP addresses.</p>	<p>A subnet prefix.</p> <p>The default value is <b>23</b>.</p>
<b>networking.serviceNetwork</b>	<p>The IP address block for services. The default value is <b>172.30.0.0/16</b>.</p> <p>The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.</p>	<p>An array with an IP address block in CIDR format. For example:</p> <pre>networking:   serviceNetwork:     - 172.30.0.0/16</pre>
<b>networking.machineNetwork</b>	<p>The IP address blocks for machines.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p> <p>If you specify multiple IP kernel arguments, the <b>machineNetwork.cidr</b> value must be the CIDR of the primary network.</p>	<p>An array of objects. For example:</p> <pre>networking:   machineNetwork:     - cidr: 10.0.0.0/16</pre>


Parameter	Description	Values
<b>networking.machineNetwork.cidr</b>	Required if you use <b>networking.machineNetwork</b> . An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b> .	<p>An IP network block in CIDR notation.</p> <p>For example, <b>10.0.0.0/16</b>.</p>  <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p>

### 13.3.8.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

Table 13.26. Optional parameters

Parameter	Description	Values
<b>additionalTrustBundle</b>	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
<b>compute</b>	The configuration for the machines that comprise the compute nodes.	Array of <b>MachinePool</b> objects.
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>s390x</b> (the default).	String


Parameter	Description	Values
<b>compute.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b>
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>s390x</b> (the default).	String

Parameter	Description	Values
<b>controlPlane.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platform</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>controlPlane.replicas</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.



Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.</p> <div data-bbox="486 510 595 864" style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p><b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators</i> reference content.</p> </div> <div data-bbox="486 909 595 1263" style="border: 1px solid black; padding: 5px;"> <p><b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p> </div>	<b>Mint, Passthrough, Manual</b> or an empty string ("").

Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start;"> <div style="width: 60px; height: 60px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 60px; height: 60px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings

Parameter	Description	Values
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<b>Internal</b> or <b>External</b> . The default value is <b>External</b> .  Setting this field to <b>Internal</b> is not supported on non-cloud platforms.
<b>sshKey</b>	The SSH key or keys to authenticate access your cluster machines.   <b>NOTE</b>  For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.	One or more keys. For example:  sshKey: <key1> <key2> <key3>

### 13.3.8.2. Sample install-config.yaml file for IBM Z

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```

apiVersion: v1
baseDomain: example.com 1
compute: 2
- hyperthreading: Enabled 3
  name: worker
  replicas: 0 4
  architecture : s390x
controlPlane: 5
  hyperthreading: Enabled 6
  name: master
  replicas: 3 7
  architecture : s390x
metadata:
  name: test 8
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14 9
    hostPrefix: 23 10
  networkType: OpenShiftSDN
  serviceNetwork: 11
  - 172.30.0.0/16
platform:
  none: {} 12

```



- 8 The cluster name that you specified in your DNS records.
- 9 A block of IP addresses from which pod IP addresses are allocated. This block must not overlap with existing physical networks. These IP addresses are used for the pod network. If you need to access the pods from an external network, you must configure load balancers and routers to manage the traffic.



#### NOTE

Class E CIDR range is reserved for a future use. To use the Class E CIDR range, you must ensure your networking environment accepts the IP addresses within the Class E CIDR range.

- 10 The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23**, then each node is assigned a **/23** subnet out of the given **cidr**, which allows for 510 ( $2^{(32 - 23)} - 2$ ) pod IP addresses. If you are required to provide access to nodes from an external network, configure load balancers and routers to manage the traffic.
- 11 The IP address pool to use for service IP addresses. You can enter only one IP address pool. This block must not overlap with existing physical networks. If you need to access the services from an external network, configure load balancers and routers to manage the traffic.
- 12 You must set the platform to **none**. You cannot provide additional platform configuration variables for IBM Z infrastructure.



#### IMPORTANT

Clusters that are installed with the platform type **none** are unable to use some features, such as managing compute machines with the Machine API. This limitation applies even if the compute machines that are attached to the cluster are installed on a platform that would normally support the feature. This parameter cannot be changed after installation.

- 13 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.



#### IMPORTANT

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

- 14 For **<local\_registry>**, specify the registry domain name, and optionally the port, that your mirror registry uses to serve content. For example, **registry.example.com** or **registry.example.com:5000**. For **<credentials>**, specify the base64-encoded user name and password for your mirror registry.
- 15 The SSH public key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).

**NOTE**

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

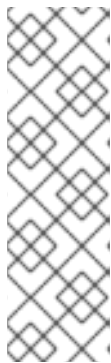
- 16 Add the **additionalTrustBundle** parameter and value. The value must be the contents of the certificate file that you used for your mirror registry, which can be an existing, trusted certificate authority or the self-signed certificate that you generated for the mirror registry.
- 17 Provide the **imageContentSources** section from the output of the command to mirror the repository.

**13.3.8.3. Configuring the cluster-wide proxy during installation**

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

**Prerequisites**

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

**NOTE**

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

**Procedure**

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
  -----BEGIN CERTIFICATE-----
```

```
<MY_TRUSTED_CA_CERT>
-----END CERTIFICATE-----
```

...

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations.
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.



#### NOTE

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



#### NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

#### 13.3.8.4. Configuring a three-node cluster

You can optionally deploy zero compute machines in a bare metal cluster that consists of three control plane machines only. This provides smaller, more resource efficient clusters for cluster administrators and developers to use for testing, development, and production.

In three-node OpenShift Container Platform environments, the three control plane machines are schedulable, which means that your application workloads are scheduled to run on them.

#### Prerequisites

- You have an existing **install-config.yaml** file.

#### Procedure

- Ensure that the number of compute replicas is set to **0** in your **install-config.yaml** file, as shown in the following **compute** stanza:

```
compute:
- name: worker
  platform: {}
  replicas: 0
```



#### NOTE

You must set the value of the **replicas** parameter for the compute machines to **0** when you install OpenShift Container Platform on user-provisioned infrastructure, regardless of the number of compute machines you are deploying. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. This does not apply to user-provisioned installations, where the compute machines are deployed manually.



#### NOTE

The preferred resource for control plane nodes is six vCPUs and 21 GB. For three control plane nodes this is the memory + vCPU equivalent of a minimum five-node cluster. You should back the three nodes, each installed on a 120 GB disk, with three IFLs that are SMT2 enabled. The minimum tested setup is three vCPUs and 10 GB on a 120 GB disk for each control plane node.

For three-node cluster installations, follow these next steps:

- If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes. See the *Load balancing requirements for user-provisioned infrastructure* section for more information.
- When you create the Kubernetes manifest files in the following procedure, ensure that the **mastersSchedulable** parameter in the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** file is set to **true**. This enables your application workloads to run on the control plane nodes.
- Do not deploy any compute nodes when you create the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

### 13.3.9. Cluster Network Operator configuration

The configuration for the cluster network is specified as part of the Cluster Network Operator (CNO) configuration and stored in a custom resource (CR) object that is named **cluster**. The CR specifies the fields for the **Network** API in the **operator.openshift.io** API group.

The CNO configuration inherits the following fields during cluster installation from the **Network** API in the **Network.config.openshift.io** API group and these fields cannot be changed:

#### **clusterNetwork**

IP address pools from which pod IP addresses are allocated.

#### **serviceNetwork**



IP address pool for services.

### **defaultNetwork.type**

Cluster network provider, such as OpenShift SDN or OVN-Kubernetes.

You can specify the cluster network provider configuration for your cluster by setting the fields for the **defaultNetwork** object in the CNO object named **cluster**.

#### 13.3.9.1. Cluster Network Operator configuration object

The fields for the Cluster Network Operator (CNO) are described in the following table:


**Table 13.27. Cluster Network Operator configuration object**

Field	Type	Description
<b>metadata.name</b>	<b>string</b>	The name of the CNO object. This name is always <b>cluster</b> .
<b>spec.clusterNetwork</b>	<b>array</b>	<p>A list specifying the blocks of IP addresses from which pod IP addresses are allocated and the subnet prefix length assigned to each individual node in the cluster. For example:</p> <pre>spec:   clusterNetwork:   - cidr: 10.128.0.0/19     hostPrefix: 23   - cidr: 10.128.32.0/19     hostPrefix: 23</pre> <p>You can customize this field only in the <b>install-config.yaml</b> file before you create the manifests. The value is read-only in the manifest file.</p>
<b>spec.serviceNetwork</b>	<b>array</b>	<p>A block of IP addresses for services. The OpenShift SDN and OVN-Kubernetes Container Network Interface (CNI) network providers support only a single IP address block for the service network. For example:</p> <pre>spec:   serviceNetwork:   - 172.30.0.0/14</pre> <p>You can customize this field only in the <b>install-config.yaml</b> file before you create the manifests. The value is read-only in the manifest file.</p>
<b>spec.defaultNetwork</b>	<b>object</b>	Configures the Container Network Interface (CNI) cluster network provider for the cluster network.
<b>spec.kubeProxyConfig</b>	<b>object</b>	The fields for this object specify the kube-proxy configuration. If you are using the OVN-Kubernetes cluster network provider, the kube-proxy configuration has no effect.

**defaultNetwork object configuration**

The values for the **defaultNetwork** object are defined in the following table:

**Table 13.28. defaultNetwork object**

Field	Type	Description
<b>type</b>	<b>string</b>	<p>Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b>. The cluster network provider is selected during installation. This value cannot be changed after cluster installation.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>OpenShift Container Platform uses the OpenShift SDN Container Network Interface (CNI) cluster network provider by default.</p> </div> </div>
<b>openshiftSDNConfig</b>	<b>object</b>	This object is only valid for the OpenShift SDN cluster network provider.
<b>ovnKubernetesConfig</b>	<b>object</b>	This object is only valid for the OVN-Kubernetes cluster network provider.

**Configuration for the OpenShift SDN CNI cluster network provider**

The following table describes the configuration fields for the OpenShift SDN Container Network Interface (CNI) cluster network provider.

**Table 13.29. openshiftSDNConfig object**

Field	Type	Description
<b>mode</b>	<b>string</b>	<p>Configures the network isolation mode for OpenShift SDN. The default value is <b>NetworkPolicy</b>.</p> <p>The values <b>Multitenant</b> and <b>Subnet</b> are available for backwards compatibility with OpenShift Container Platform 3.x but are not recommended. This value cannot be changed after cluster installation.</p>

Field	Type	Description
<b>mtu</b>	<b>integer</b>	<p>The maximum transmission unit (MTU) for the VXLAN overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU.</p> <p>If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes.</p> <p>If your cluster requires different MTU values for different nodes, you must set this value to <b>50</b> less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of <b>9001</b>, and some have an MTU of <b>1500</b>, you must set this value to <b>1450</b>.</p> <p>This value cannot be changed after cluster installation.</p>
<b>vxlanPort</b>	<b>integer</b>	<p>The port to use for all VXLAN packets. The default value is <b>4789</b>. This value cannot be changed after cluster installation.</p> <p>If you are running in a virtualized environment with existing nodes that are part of another VXLAN network, then you might be required to change this. For example, when running an OpenShift SDN overlay on top of VMware NSX-T, you must select an alternate port for the VXLAN, because both SDNs use the same default VXLAN port number.</p> <p>On Amazon Web Services (AWS), you can select an alternate port for the VXLAN between port <b>9000</b> and port <b>9999</b>.</p>

### Example OpenShift SDN configuration

```
defaultNetwork:
  type: OpenShiftSDN
  openshiftSDNConfig:
    mode: NetworkPolicy
    mtu: 1450
    vxlanPort: 4789
```

### Configuration for the OVN-Kubernetes CNI cluster network provider

The following table describes the configuration fields for the OVN-Kubernetes CNI cluster network provider.

Table 13.30. `ovnKubernetesConfig` object

Field	Type	Description
<b>mtu</b>	<b>integer</b>	<p>The maximum transmission unit (MTU) for the Geneve (Generic Network Virtualization Encapsulation) overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU.</p> <p>If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes.</p> <p>If your cluster requires different MTU values for different nodes, you must set this value to <b>100</b> less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of <b>9001</b>, and some have an MTU of <b>1500</b>, you must set this value to <b>1400</b>.</p> <p>This value cannot be changed after cluster installation.</p>
<b>genevePort</b>	<b>integer</b>	The port to use for all Geneve packets. The default value is <b>6081</b> . This value cannot be changed after cluster installation.
<b>policyAuditConfig</b>	<b>object</b>	Specify a configuration object for customizing network policy audit logging. If unset, the defaults audit log settings are used.

Table 13.31. **policyAuditConfig** object

Field	Type	Description
<b>rateLimit</b>	integer	The maximum number of messages to generate every second per node. The default value is <b>20</b> messages per second.
<b>maxFileSize</b>	integer	The maximum size for the audit log in bytes. The default value is <b>50000000</b> or 50 MB.
<b>destination</b>	string	<p>One of the following additional audit log targets:</p> <p><b>libc</b> The libc <b>syslog()</b> function of the journald process on the host.</p> <p><b>udp:&lt;host&gt;:&lt;port&gt;</b> A syslog server. Replace <b>&lt;host&gt;:&lt;port&gt;</b> with the host and port of the syslog server.</p> <p><b>unix:&lt;file&gt;</b> A Unix Domain Socket file specified by <b>&lt;file&gt;</b>.</p> <p><b>null</b> Do not send the audit logs to any additional target.</p>

Field	Type	Description
<b>syslogFacility</b>	string	The syslog facility, such as <b>kern</b> , as defined by RFC5424. The default value is <b>local0</b> .


### Example OVN-Kubernetes configuration

```
defaultNetwork:
  type: OVNKubernetes
  ovnKubernetesConfig:
    mtu: 1400
    genevePort: 6081
```

### kubeProxyConfig object configuration

The values for the **kubeProxyConfig** object are defined in the following table:

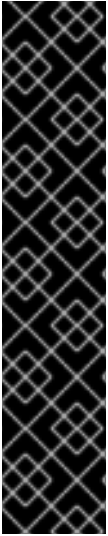
Table 13.32. **kubeProxyConfig** object

Field	Type	Description
<b>iptablesSyncPeriod</b>	<b>string</b>	<p>The refresh period for <b>iptables</b> rules. The default value is <b>30s</b>. Valid suffixes include <b>s</b>, <b>m</b>, and <b>h</b> and are described in the <a href="#">Go time package</a> documentation.</p> <div style="display: flex; align-items: flex-start;"> <div style="border: 1px solid gray; padding: 5px; margin-right: 10px;">  </div> <div> <p><b>NOTE</b></p> <p>Because of performance improvements introduced in OpenShift Container Platform 4.3 and greater, adjusting the <b>iptablesSyncPeriod</b> parameter is no longer necessary.</p> </div> </div>
<b>proxyArguments.iptables-min-sync-period</b>	<b>array</b>	<p>The minimum duration before refreshing <b>iptables</b> rules. This field ensures that the refresh does not happen too frequently. Valid suffixes include <b>s</b>, <b>m</b>, and <b>h</b> and are described in the <a href="#">Go time package</a>. The default value is:</p> <pre>kubeProxyConfig:   proxyArguments:     iptables-min-sync-period:       - 0s</pre>

### 13.3.10. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.



### IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.



### NOTE

The installation program that generates the manifest and Ignition files is architecture specific and can be obtained from the [client image mirror](#). The Linux version of the installation program runs on s390x only. This installer program is also available as a Mac OS version.

### Prerequisites

- You obtained the OpenShift Container Platform installation program. For a restricted network installation, these files are on your mirror host.
- You created the **install-config.yaml** installation configuration file.

### Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

- 1** For **<installation\_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.



### WARNING

If you are installing a three-node cluster, skip the following step to allow the control plane nodes to be schedulable.



## IMPORTANT

When you configure control plane nodes from the default unschedulable to schedulable, additional subscriptions are required. This is because control plane nodes then become worker nodes.

2. Check that the **mastersSchedulable** parameter in the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:
  - a. Open the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** file.
  - b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.
  - c. Save and exit the file.
3. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

**1** For **<installation\_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation\_directory>/auth** directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

### 13.3.11. Installing RHCOS and starting the OpenShift Container Platform bootstrap process

To install OpenShift Container Platform on IBM Z infrastructure that you provision, you must install Red Hat Enterprise Linux CoreOS (RHCOS) as Red Hat Enterprise Linux (RHEL) guest virtual machines. When you install RHCOS, you must provide the Ignition config file that was generated by the OpenShift Container Platform installation program for the type of machine you are installing. If you have configured suitable networking, DNS, and load balancing infrastructure, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS machines have rebooted.

You can perform a fast-track installation of RHCOS that uses a prepackaged QEMU copy-on-write (QCOW2) disk image. Alternatively, you can perform a full installation on a new QCOW2 disk image.

#### 13.3.11.1. Fast-track installation by using a prepackaged QCOW2 disk image

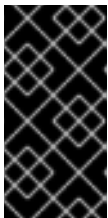
Complete the following steps to create the machines in a fast-track installation of Red Hat Enterprise Linux CoreOS (RHCOS), importing a prepackaged Red Hat Enterprise Linux CoreOS (RHCOS) QEMU copy-on-write (QCOW2) disk image.

### Prerequisites

- At least one LPAR running RHEL 8.4 with KVM, referred to as RHEL KVM host in this procedure.
- The KVM/QEMU hypervisor is installed on the RHEL KVM host.
- A domain name server (DNS) that can perform hostname and reverse lookup for the nodes.
- A DHCP server that provides IP addresses.

### Procedure

1. Obtain the RHEL QEMU copy-on-write (QCOW2) disk image file from the [Product Downloads](#) page on the Red Hat Customer Portal or from the [RHCOS image mirror](#) page.



#### IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Only use the appropriate RHCOS QCOW2 image described in the following procedure.

2. Download the QCOW2 disk image and Ignition files to a common directory on the RHEL KVM host.

For example: **`/var/lib/libvirt/images`**



#### NOTE

The Ignition files are generated by the OpenShift Container Platform installer.

3. Create a new disk image with the QCOW2 disk image backing file for each KVM guest node.

```
$ qemu-img create -f qcow2 -F qcow2 -b /var/lib/libvirt/images/{source_rhcos_qemu}
/var/lib/libvirt/images/{vmname}.qcow2 {size}
```

4. Create the new KVM guest nodes using the Ignition file and the new disk image.

```
$ virt-install --noautoconsole \
  --connect qemu:///system \
  --name {vn_name} \
  --memory {memory} \
  --vcpus {vcpus} \
  --disk {disk} \
  --import \
  --network network={network},mac={mac} \
  --disk path={ign_file},format=raw,readonly=on,serial=ignition,startup_policy=optional
```

### 13.3.11.2. Full installation on a new QCOW2 disk image



Complete the following steps to create the machines in a full installation on a new QEMU copy-on-write (QCOW2) disk image.

## Prerequisites

- At least one LPAR running RHEL 8.4 with KVM, referred to as RHEL KVM host in this procedure.
- The KVM/QEMU hypervisor is installed on the RHEL KVM host.
- A domain name server (DNS) that can perform hostname and reverse lookup for the nodes.
- An HTTP or HTTPS server is set up.

## Procedure

1. Obtain the RHEL kernel, initramfs, and rootfs files from the [Product Downloads](#) page on the Red Hat Customer Portal or from the [RHCOS image mirror](#) page.



### IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Only use the appropriate RHCOS QCOW2 image described in the following procedure.

The file names contain the OpenShift Container Platform version number. They resemble the following examples:

- kernel: **rhcos-`<version>`-live-kernel-`<architecture>`**
  - initramfs: **rhcos-`<version>`-live-initramfs.`<architecture>`.img**
  - rootfs: **rhcos-`<version>`-live-rootfs.`<architecture>`.img**
2. Move the downloaded RHEL live kernel, initramfs, and rootfs as well as the Ignition files to an HTTP or HTTPS server before you launch **virt-install**.



### NOTE

The Ignition files are generated by the OpenShift Container Platform installer.

3. Create the new KVM guest nodes using the RHEL kernel, initramfs, and ignition files, the new disk image, and adjusted parm line arguments.
  - For **--location**, specify the location of the kernel/initrd on the HTTP or HTTPS server.
  - For **coreos.inst.ignition\_url=**, specify the Ignition file for the machine role. Use **bootstrap.ign**, **master.ign**, or **worker.ign**. Only HTTP and HTTPS protocols are supported.
  - For **coreos.live.rootfs\_url=**, specify the matching rootfs artifact for the kernel and initramfs you are booting. Only HTTP and HTTPS protocols are supported.

```
$ virt-install \
  --connect qemu:///system \
  --name {vn_name} \
```

```

--vcpus {vcpus} \
--memory {memory_mb} \
--disk {vn_name}.qcow2,size={image_size| default(10,true)} \
--network network={virt_network_parm} \
--boot hd \
--location {media_location},kernel={rhcos_kernel},initrd={rhcos_initrd} \
--extra-args "rd.neednet=1 coreos.inst=yes coreos.inst.install_dev=vda
coreos.live.rootfs_url={rhcos_liveos} ip={ip}::{default_gateway}:{subnet_mask_length}:
{vn_name}:enc1:none:{MTU} nameserver={dns} coreos.inst.ignition_url={rhcos_ign}" \
--noautoconsole \
--wait

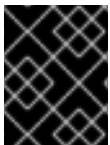
```

### 13.3.11.3. Advanced RHCOS installation reference

This section illustrates the networking configuration and other advanced options that allow you to modify the Red Hat Enterprise Linux CoreOS (RHCOS) manual installation process. The following tables describe the kernel arguments and command-line options you can use with the RHCOS live installer and the **coreos-installer** command.

#### 13.3.11.3.1. Networking options for ISO installations

If you install RHCOS from an ISO image, you can add kernel arguments manually when you boot the image to configure networking for a node. If no networking arguments are specified, DHCP is activated in the initramfs when RHCOS detects that networking is required to fetch the Ignition config file.



#### IMPORTANT

When adding networking arguments manually, you must also add the **rd.neednet=1** kernel argument to bring the network up in the initramfs.

The following information provides examples for configuring networking on your RHCOS nodes for ISO installations. The examples describe how to use the **ip=** and **nameserver=** kernel arguments.



#### NOTE

Ordering is important when adding the kernel arguments: **ip=** and **nameserver=**.

The networking options are passed to the **dracut** tool during system boot. For more information about the networking options supported by **dracut**, see the **dracut.cmdline** manual page.

The following examples are the networking options for ISO installation.

#### Configuring DHCP or static IP addresses

To configure an IP address, either use DHCP (**ip=dhcp**) or set an individual static IP address (**ip=<host\_ip>**). If setting a static IP, you must then identify the DNS server IP address (**nameserver=<dns\_ip>**) on each node. The following example sets:

- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The hostname to **core0.example.com**

- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
nameserver=4.4.4.41
```



## NOTE

When you use DHCP to configure IP addressing for the RHCOS machines, the machines also obtain the DNS server information through DHCP. For DHCP-based deployments, you can define the DNS server address that is used by the RHCOS nodes through your DHCP server configuration.

### Configuring an IP address without a static hostname

You can configure an IP address without assigning a static hostname. If a static hostname is not set by the user, it will be picked up and automatically set by a reverse DNS lookup. To configure an IP address without a static hostname refer to the following example:

- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0::enp1s0:none
nameserver=4.4.4.41
```

### Specifying multiple network interfaces

You can specify multiple network interfaces by setting multiple **ip=** entries.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=10.10.10.3::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

### Configuring default gateway and route

Optional: You can configure routes to additional networks by setting an **rd.route=** value.



## NOTE

When you configure one or multiple networks, one default gateway is required. If the additional network gateway is different from the primary network gateway, the default gateway must be the primary network gateway.

- Run the following command to configure the default gateway:

```
ip=::10.10.10.254:::
```

- Enter the following command to configure the route for the additional network:

```
rd.route=20.20.20.0/24:20.20.20.254:enp2s0
```

### Disabling DHCP on a single interface

You can disable DHCP on a single interface, such as when there are two or more network interfaces and only one interface is being used. In the example, the **enp1s0** interface has a static networking configuration and DHCP is disabled for **enp2s0**, which is not used:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none  
ip=::::core0.example.com:enp2s0:none
```

### Combining DHCP and static IP configurations

You can combine DHCP and static IP configurations on systems with multiple network interfaces, for example:

```
ip=enp1s0:dhcp  
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

### Configuring VLANs on individual interfaces

Optional: You can configure VLANs on individual interfaces by using the **vlan=** parameter.

- To configure a VLAN on a network interface and use a static IP address, run the following command:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0.100:none  
vlan=enp2s0.100:enp2s0
```

- To configure a VLAN on a network interface and to use DHCP, run the following command:

```
ip=enp2s0.100:dhcp  
vlan=enp2s0.100:enp2s0
```

### Providing multiple DNS servers

You can provide multiple DNS servers by adding a **nameserver=** entry for each server, for example:

```
nameserver=1.1.1.1  
nameserver=8.8.8.8
```

## 13.3.12. Waiting for the bootstrap process to complete

The OpenShift Container Platform bootstrap process begins after the cluster nodes first boot into the persistent RHCOS environment that has been installed to disk. The configuration information provided through the Ignition config files is used to initialize the bootstrap process and install OpenShift Container Platform on the machines. You must wait for the bootstrap process to complete.

### Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.

- You have obtained the installation program and generated the Ignition config files for your cluster.
- You installed RHCOS on your cluster machines and provided the Ignition config files that the OpenShift Container Platform installation program generated.

## Procedure

1. Monitor the bootstrap process:

```
$ ./openshift-install --dir <installation_directory> wait-for bootstrap-complete \ 1
--log-level=info 2
```

1 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

## Example output

```
INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...
INFO API v1.22.1 up
INFO Waiting up to 30m0s for bootstrapping to complete...
INFO It is now safe to remove the bootstrap resources
```

The command succeeds when the Kubernetes API server signals that it has been bootstrapped on the control plane machines.

2. After bootstrap process is complete, remove the bootstrap machine from the load balancer.



### IMPORTANT

You must remove the bootstrap machine from the load balancer at this point. You can also remove or reformat the bootstrap machine itself.

## 13.3.13. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1 For `<installation_directory>`, specify the path to the directory that you stored the installation files in.

2. Verify you can run `oc` commands successfully using the exported configuration:

```
$ oc whoami
```

#### Example output

```
system:admin
```

### 13.3.14. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

#### Prerequisites

- You added machines to your cluster.

#### Procedure

1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

#### Example output

```
NAME      STATUS   ROLES    AGE   VERSION
master-0  Ready    master   63m   v1.22.1
master-1  Ready    master   63m   v1.22.1
master-2  Ready    master   64m   v1.22.1
```

The output lists all of the machines that you created.



#### NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

2. Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

#### Example output

```
NAME      AGE   REQUESTOR                                     CONDITION
csr-8b2br  15m   system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper  Pending
```

```
csr-8vnps 15m system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper Pending
...
```

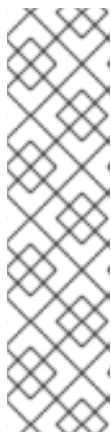
In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

- If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:



#### NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.



#### NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{"\n"}
{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```



#### NOTE

Some Operators might not become available until some CSRs are approved.

- Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

### Example output

```
NAME      AGE   REQUESTOR                                     CONDITION
csr-bfd72 5m26s system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv 5m26s system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

- If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{"\n"}\n{{end}}{{end}}' | xargs oc adm certificate approve
```

- After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

### Example output

```
NAME      STATUS   ROLES    AGE   VERSION
master-0  Ready   master   73m   v1.22.1
master-1  Ready   master   73m   v1.22.1
master-2  Ready   master   74m   v1.22.1
worker-0  Ready   worker   11m   v1.22.1
worker-1  Ready   worker   11m   v1.22.1
```



### NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

### Additional information

- For more information on CSRs, see [Certificate Signing Requests](#).

## 13.3.15. Initial Operator configuration



After the control plane initializes, you must immediately configure some Operators so that they all become available.

## Prerequisites

- Your control plane has initialized.

## Procedure

1. Watch the cluster components come online:

```
$ watch -n5 oc get clusteroperators
```

## Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
authentication	4.9.0	True	False	False	19m
baremetal	4.9.0	True	False	False	37m
cloud-credential	4.9.0	True	False	False	40m
cluster-autoscaler	4.9.0	True	False	False	37m
config-operator	4.9.0	True	False	False	38m
console	4.9.0	True	False	False	26m
csi-snapshot-controller	4.9.0	True	False	False	37m
dns	4.9.0	True	False	False	37m
etcd	4.9.0	True	False	False	36m
image-registry	4.9.0	True	False	False	31m
ingress	4.9.0	True	False	False	30m
insights	4.9.0	True	False	False	31m
kube-apiserver	4.9.0	True	False	False	26m
kube-controller-manager	4.9.0	True	False	False	36m
kube-scheduler	4.9.0	True	False	False	36m
kube-storage-version-migrator	4.9.0	True	False	False	37m
machine-api	4.9.0	True	False	False	29m
machine-approver	4.9.0	True	False	False	37m
machine-config	4.9.0	True	False	False	36m
marketplace	4.9.0	True	False	False	37m
monitoring	4.9.0	True	False	False	29m
network	4.9.0	True	False	False	38m
node-tuning	4.9.0	True	False	False	37m
openshift-apiserver	4.9.0	True	False	False	32m
openshift-controller-manager	4.9.0	True	False	False	30m
openshift-samples	4.9.0	True	False	False	32m
operator-lifecycle-manager	4.9.0	True	False	False	37m
operator-lifecycle-manager-catalog	4.9.0	True	False	False	37m
operator-lifecycle-manager-packageserver	4.9.0	True	False	False	32m
service-ca	4.9.0	True	False	False	38m
storage	4.9.0	True	False	False	37m

2. Configure the Operators that are not available.

### 13.3.15.1. Disabling the default OperatorHub sources

Operator catalogs that source content provided by Red Hat and community projects are configured for OperatorHub by default during an OpenShift Container Platform installation. In a restricted network environment, you must disable the default catalogs as a cluster administrator.

### Procedure

- Disable the sources for the default catalogs by adding **disableAllDefaultSources: true** to the **OperatorHub** object:

```
$ oc patch OperatorHub cluster --type json \
  -p '[{"op": "add", "path": "/spec/disableAllDefaultSources", "value": true}]'
```

### TIP

Alternatively, you can use the web console to manage catalog sources. From the **Administration** → **Cluster Settings** → **Configuration** → **OperatorHub** page, click the **Sources** tab, where you can create, delete, disable, and enable individual sources.

### 13.3.15.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

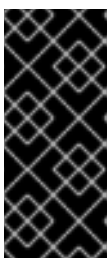
Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

#### 13.3.15.2.1. Configuring registry storage for IBM Z

As a cluster administrator, following installation you must configure your registry to use storage.

### Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.
- You have a cluster on IBM Z.
- You have provisioned persistent storage for your cluster, such as Red Hat OpenShift Container Storage.



### IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have 100Gi capacity.

## Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.



### NOTE

When using shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

### Example output

```
No resources found in openshift-image-registry namespace
```



### NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

### Example output

```
storage:
  pvc:
    claim:
```

Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** PVC.

4. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
image-registry	4.9	True	False	False	6h50m

5. Ensure that your registry is set to managed to enable building and pushing of images.

- Run:

```
$ oc edit configs.imageregistry/cluster
```

Then, change the line

```
managementState: Removed
```

to

```
managementState: Managed
```

### 13.3.15.2.2. Configuring storage for the image registry in non-production clusters

You must configure storage for the Image Registry Operator. For non-production clusters, you can set the image registry to an empty directory. If you do so, all images are lost if you restart the registry.

#### Procedure

- To set the image registry storage to an empty directory:

```
$ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec": {"storage":{"emptyDir":{}}}'
```



#### WARNING

Configure this option for only non-production clusters.

If you run this command before the Image Registry Operator initializes its components, the **oc patch** command fails with the following error:

```
Error from server (NotFound): configs.imageregistry.operator.openshift.io "cluster" not found
```

Wait a few minutes and run the command again.

### 13.3.16. Completing installation on user-provisioned infrastructure

After you complete the Operator configuration, you can finish installing the cluster on infrastructure that you provide.

#### Prerequisites

- Your control plane has initialized.
- You have completed the initial Operator configuration.

#### Procedure

1. Confirm that all the cluster components are online with the following command:

```
$ watch -n5 oc get clusteroperators
```

## Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
authentication	4.9.0	True	False	False	19m
baremetal	4.9.0	True	False	False	37m
cloud-credential	4.9.0	True	False	False	40m
cluster-autoscaler	4.9.0	True	False	False	37m
config-operator	4.9.0	True	False	False	38m
console	4.9.0	True	False	False	26m
csi-snapshot-controller	4.9.0	True	False	False	37m
dns	4.9.0	True	False	False	37m
etcd	4.9.0	True	False	False	36m
image-registry	4.9.0	True	False	False	31m
ingress	4.9.0	True	False	False	30m
insights	4.9.0	True	False	False	31m
kube-apiserver	4.9.0	True	False	False	26m
kube-controller-manager	4.9.0	True	False	False	36m
kube-scheduler	4.9.0	True	False	False	36m
kube-storage-version-migrator	4.9.0	True	False	False	37m
machine-api	4.9.0	True	False	False	29m
machine-approver	4.9.0	True	False	False	37m
machine-config	4.9.0	True	False	False	36m
marketplace	4.9.0	True	False	False	37m
monitoring	4.9.0	True	False	False	29m
network	4.9.0	True	False	False	38m
node-tuning	4.9.0	True	False	False	37m
openshift-apiserver	4.9.0	True	False	False	32m
openshift-controller-manager	4.9.0	True	False	False	30m
openshift-samples	4.9.0	True	False	False	32m
operator-lifecycle-manager	4.9.0	True	False	False	37m
operator-lifecycle-manager-catalog	4.9.0	True	False	False	37m
operator-lifecycle-manager-packageserver	4.9.0	True	False	False	32m
service-ca	4.9.0	True	False	False	38m
storage	4.9.0	True	False	False	37m

Alternatively, the following command notifies you when all of the clusters are available. It also retrieves and displays credentials:

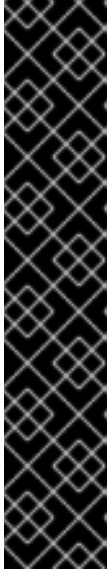
```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

## Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

The command succeeds when the Cluster Version Operator finishes deploying the OpenShift Container Platform cluster from Kubernetes API server.



## IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Confirm that the Kubernetes API server is communicating with the pods.

a. To view a list of all pods, use the following command:

```
$ oc get pods --all-namespaces
```

### Example output

```

NAMESPACE           NAME                               READY  STATUS
RESTARTS  AGE
openshift-apiserver-operator  openshift-apiserver-operator-85cb746d55-zqhs8  1/1
Running   1    9m
openshift-apiserver          apiserver-67b9g                               1/1  Running  0
3m
openshift-apiserver          apiserver-ljcmx                               1/1  Running  0
1m
openshift-apiserver          apiserver-z25h4                               1/1  Running  0
2m
openshift-authentication-operator  authentication-operator-69d5d8bf84-vh2n8  1/1
Running   0    5m
...

```

b. View the logs for a pod that is listed in the output of the previous command by using the following command:

```
$ oc logs <pod_name> -n <namespace> ❶
```

- ❶ Specify the pod name and namespace, as shown in the output of the previous command.

If the pod logs display, the Kubernetes API server can communicate with the cluster machines.

3. For an installation with Fibre Channel Protocol (FCP), additional steps are required to enable multipathing. Do not enable multipathing during installation. See "Enabling multipathing with kernel arguments on RHCOS" in the *Post-installation machine configuration tasks* documentation for more information.

4. Register your cluster on the [Cluster registration](#) page.

### 13.3.17. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

#### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

### 13.3.18. Collecting debugging information

You can gather debugging information that might help you to troubleshoot and debug certain issues with an OpenShift Container Platform installation on IBM Z.

#### Prerequisites

- The **oc** CLI tool installed.

#### Procedure

1. Log in to the cluster:

```
$ oc login -u <username>
```

2. On the node you want to gather hardware information about, start a debugging container:

```
$ oc debug node/<nodename>
```

3. Change to the **/host** file system and start **toolbox**:

```
$ chroot /host  
$ toolbox
```

4. Collect the **dbginfo** data:

```
$ dbginfo.sh
```

5. You can then retrieve the data, for example, using **scp**.

#### Additional resources

- [How to generate SOSREPORT within OpenShift Container Platform version 4 nodes without SSH.](#)

### 13.3.19. Next steps

- [Customize your cluster.](#)
- If the mirror registry that you used to install your cluster has a trusted CA, add it to the cluster by [configuring additional trust stores.](#)



## CHAPTER 14. INSTALLING ON IBM POWER

### 14.1. PREPARING TO INSTALL ON IBM POWER

#### 14.1.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).

#### 14.1.2. Choosing a method to install OpenShift Container Platform on IBM Power

You can install a cluster on IBM Power infrastructure that you provision, by using one of the following methods:

- **Installing a cluster on IBM Power** You can install OpenShift Container Platform on IBM Power infrastructure that you provision.
- **Installing a cluster on IBM Power in a restricted network** You can install OpenShift Container Platform on IBM Power infrastructure that you provision in a restricted or disconnected network, by using an internal mirror of the installation release content. You can use this method to install a cluster that does not require an active internet connection to obtain the software components. You can also use this installation method to ensure that your clusters only use container images that satisfy your organizational controls on external content.

### 14.2. INSTALLING A CLUSTER ON IBM POWER

In OpenShift Container Platform version 4.9, you can install a cluster on IBM Power infrastructure that you provision.

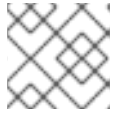


#### IMPORTANT

Additional considerations exist for non-bare metal platforms. Review the information in the [guidelines for deploying OpenShift Container Platform on non-tested platforms](#) before you install an OpenShift Container Platform cluster.

#### 14.2.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- Before you begin the installation process, you must clean the installation directory. This ensures that the required installation files are created and updated during the installation process.
- You provisioned [persistent storage using NFS](#) for your cluster. To deploy a private image registry, your storage must provide **ReadWriteMany** access modes.
- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.

**NOTE**

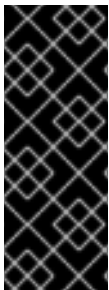
Be sure to also review this site list if you are configuring a proxy.

**14.2.2. Internet access for OpenShift Container Platform**

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

**IMPORTANT**

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

**14.2.3. Requirements for a cluster with user-provisioned infrastructure**

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

**14.2.3.1. Required machines for cluster installation**

The smallest OpenShift Container Platform clusters require the following hosts:

**Table 14.1. Minimum required hosts**

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.



## IMPORTANT

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 7.9, or RHEL 8.4.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See [Red Hat Enterprise Linux technology capabilities and limits](#).

### 14.2.3.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

**Table 14.2. Minimum resource requirements**

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	2	16 GB	100 GB	300
Control plane	RHCOS	2	16 GB	100 GB	300
Compute	RHCOS	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio:  $(\text{threads per core} \times \text{cores}) \times \text{sockets} = \text{vCPUs}$ .
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.

### 14.2.3.3. Minimum IBM Power requirements

You can install OpenShift Container Platform version 4.9 on the following IBM hardware:

- IBM Power8, Power9, or Power10 processor-based systems

#### Hardware requirements

- Six IBM Power bare metal servers or six LPARs across multiple PowerVM servers

#### Operating system requirements

- One instance of an IBM Power8, Power9, or Power10 processor-based system

- One instance of an IBM Power8, Power9, or Power10 processor-based system

On your IBM Power instance, set up:

- Three guest virtual machines for OpenShift Container Platform control plane machines
- Two guest virtual machines for OpenShift Container Platform compute machines
- One guest virtual machine for the temporary OpenShift Container Platform bootstrap machine

#### **Disk storage for the IBM Power guest virtual machines**

- Storage provisioned by the Virtual I/O Server using vSCSI, NPIV (N-Port ID Virtualization) or SSP (shared storage pools)

#### **Network for the PowerVM guest virtual machines**

- Virtualized by the Virtual I/O Server using Shared Ethernet Adapter
- Virtualized by the Virtual I/O Server using IBM vNIC

#### **Storage / main memory**

- 100 GB / 16 GB for OpenShift Container Platform control plane machines
- 100 GB / 8 GB for OpenShift Container Platform compute machines
- 100 GB / 16 GB for the temporary OpenShift Container Platform bootstrap machine

### **14.2.3.4. Recommended IBM Power system requirements**

#### **Hardware requirements**

- Six IBM Power bare metal servers or six LPARs across multiple PowerVM servers

#### **Operating system requirements**

- One instance of an IBM Power8, Power9, or Power10 processor-based system

On your IBM Power instance, set up:

- Three guest virtual machines for OpenShift Container Platform control plane machines
- Two guest virtual machines for OpenShift Container Platform compute machines
- One guest virtual machine for the temporary OpenShift Container Platform bootstrap machine

#### **Disk storage for the IBM Power guest virtual machines**

- Storage provisioned by the Virtual I/O Server using vSCSI, NPIV (N-Port ID Virtualization) or SSP (shared storage pools)

#### **Network for the PowerVM guest virtual machines**

- Virtualized by the Virtual I/O Server using Shared Ethernet Adapter
- Virtualized by the Virtual I/O Server using IBM vNIC

#### **Storage / main memory**

- 120 GB / 32 GB for OpenShift Container Platform control plane machines
- 120 GB / 32 GB for OpenShift Container Platform compute machines
- 120 GB / 16 GB for the temporary OpenShift Container Platform bootstrap machine

#### 14.2.3.5. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

#### 14.2.3.6. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.

It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.



#### NOTE

If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

##### 14.2.3.6.1. Setting the cluster node hostnames through DHCP

On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

#### 14.2.3.6.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.



#### IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

**Table 14.3. Ports used for all-machine to all-machine communications**

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	<b>1936</b>	Metrics
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> and the Cluster Version Operator on port <b>9099</b> .
	<b>10250-10259</b>	The default ports that Kubernetes reserves
	<b>10256</b>	openshift-sdn
UDP	<b>4789</b>	VXLAN and Geneve
	<b>6081</b>	VXLAN and Geneve
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> .
	<b>500</b>	IPsec IKE packets
	<b>4500</b>	IPsec NAT-T packets
TCP/UDP	<b>30000-32767</b>	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

**Table 14.4. Ports used for all-machine to control plane communications**

Protocol	Port	Description
TCP	<b>6443</b>	Kubernetes API

**Table 14.5. Ports used for control plane machine to control plane machine communications**

Protocol	Port	Description
TCP	<b>2379-2380</b>	etcd server and peer ports

### NTP configuration for user-provisioned infrastructure

OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service*.

If a DHCP server provides NTP server information, the chrony time service on the Red Hat Enterprise Linux CoreOS (RHCOS) machines read the information and can sync the clock with the NTP servers.

### Additional resources

- [Configuring chrony time service](#)

### 14.2.3.7. User-provisioned DNS requirements

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API
- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines

Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.




### NOTE

It is recommended to use a DHCP server to provide the hostnames to each cluster node. See the *DHCP recommendations for user-provisioned infrastructure* section for more information.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, **<cluster\_name>** is the cluster name and **<base\_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS

record takes the form: **<component>.<cluster\_name>.<base\_domain>.**

**Table 14.6. Required DNS records**

Component	Record	Description
Kubernetes API	<b>api.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
	<b>api-int.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster. <div data-bbox="740 721 844 976" style="display: inline-block; vertical-align: middle;">  </div> <div data-bbox="922 725 1114 759" style="display: inline-block; vertical-align: middle; margin-left: 10px;"> <p><b>IMPORTANT</b></p> </div> <div data-bbox="919 790 1415 976" style="display: inline-block; vertical-align: middle; margin-left: 10px;"> <p>The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.</p> </div>
Routes	<b>*.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster. <p>For example, <b>console-openshift-console.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;</b> is used as a wildcard route to the OpenShift Container Platform console.</p>
Bootstrap machine	<b>bootstrap.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.
Control plane machines	<b>&lt;master&gt;&lt;n&gt;.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.
Compute machines	<b>&lt;worker&gt;&lt;n&gt;.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.



**NOTE**

In OpenShift Container Platform 4.4 and later, you do not need to specify etcd host and SRV records in your DNS configuration.

**TIP**

You can use the **dig** command to verify name and reverse name resolution. See the section on *Validating DNS resolution for user-provisioned infrastructure* for detailed validation steps.

**14.2.3.7.1. Example DNS configuration for user-provisioned clusters**

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is **ocp4** and the base domain is **example.com**.

**Example DNS A record configuration for a user-provisioned cluster**

The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

**Example 14.1. Sample DNS zone database**

```
$TTL 1W
@ IN SOA ns1.example.com. root (
    2019070700 ; serial
    3H ; refresh (3 hours)
    30M ; retry (30 minutes)
    2W ; expiry (2 weeks)
    1W ) ; minimum (1 week)
IN NS ns1.example.com.
IN MX 10 smtp.example.com.
;
;
ns1.example.com. IN A 192.168.1.5
smtp.example.com. IN A 192.168.1.5
;
helper.example.com. IN A 192.168.1.5
helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com. IN A 192.168.1.5 1
api-int.ocp4.example.com. IN A 192.168.1.5 2
;
*.apps.ocp4.example.com. IN A 192.168.1.5 3
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 4
;
master0.ocp4.example.com. IN A 192.168.1.97 5
master1.ocp4.example.com. IN A 192.168.1.98 6
master2.ocp4.example.com. IN A 192.168.1.99 7
;
worker0.ocp4.example.com. IN A 192.168.1.11 8
```

```
worker1.ocp4.example.com. IN A 192.168.1.7 9
```

```
;
```

```
;EOF
```

- 1 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.
- 2 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.
- 3 Provides name resolution for the wildcard routes. The record refers to the IP address of the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



#### NOTE

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

- 4 Provides name resolution for the bootstrap machine.
- 5 6 7 Provides name resolution for the control plane machines.
- 8 9 Provides name resolution for the compute machines.

### Example DNS PTR record configuration for a user-provisioned cluster

The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

#### Example 14.2. Sample DNS zone database for reverse records

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H ; refresh (3 hours)
  30M ; retry (30 minutes)
  2W ; expiry (2 weeks)
  1W ) ; minimum (1 week)
IN NS ns1.example.com.
;
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. 2
;
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. 3
;
97.1.168.192.in-addr.arpa. IN PTR master0.ocp4.example.com. 4
98.1.168.192.in-addr.arpa. IN PTR master1.ocp4.example.com. 5
99.1.168.192.in-addr.arpa. IN PTR master2.ocp4.example.com. 6
```

```

;
11.1.168.192.in-addr.arpa. IN PTR worker0.ocp4.example.com. 7
7.1.168.192.in-addr.arpa. IN PTR worker1.ocp4.example.com. 8
;
;EOF

```

- 1 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.
- 2 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.
- 3 Provides reverse DNS resolution for the bootstrap machine.
- 4 5 6 Provides reverse DNS resolution for the control plane machines.
- 7 8 Provides reverse DNS resolution for the compute machines.

**NOTE**

A PTR record is not required for the OpenShift Container Platform application wildcard.

#### 14.2.3.8. Load balancing requirements for user-provisioned infrastructure

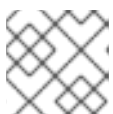
Before you install OpenShift Container Platform, you must provision the API and application ingress load balancing infrastructure. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

**NOTE**

If you want to deploy the API and application ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer.** Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:
  - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the API routes.
  - A stateless load balancing algorithm. The options vary based on the load balancer implementation.

**NOTE**

Session persistence is not required for the API load balancer to function properly.

Configure the following ports on both the front and back of the load balancers:

**Table 14.7. API load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
<b>6443</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the <b>/readyz</b> endpoint for the API server health check probe.	X	X	Kubernetes API server
<b>22623</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server

**NOTE**

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the **/readyz** endpoint to the removal of the API server instance from the pool. Within the time frame after **/readyz** returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application ingress load balancer.** Provides an ingress point for application traffic flowing in from outside the cluster. Configure the following conditions:

- Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the ingress routes.
- A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

**TIP**

If the true IP address of the client can be seen by the application ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

Configure the following ports on both the front and back of the load balancers:

**Table 14.8. Application ingress load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
<b>443</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic

Port	Back-end machines (pool members)	Internal	External	Description
80	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic
1936	The worker nodes that run the Ingress Controller pods, by default. You must configure the <b>/healthz/ready</b> endpoint for the ingress health check probe.	X	X	HTTP traffic

**NOTE**

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

**NOTE**

A working configuration for the Ingress router is required for an OpenShift Container Platform cluster. You must configure the Ingress router after the control plane initializes.

#### 14.2.3.8.1. Example load balancer configuration for user-provisioned clusters

This section provides an example API and application ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an **/etc/haproxy/haproxy.cfg** configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing one load balancing solution over another.

**NOTE**

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

#### Example 14.3. Sample API and application ingress load balancer configuration

```
global
  log      127.0.0.1 local2
  pidfile /var/run/haproxy.pid
  maxconn 4000
  daemon
defaults
  mode      http
  log       global
  option    dontlognull
  option    http-server-close
```

```

option          redispatch
retries         3
timeout http-request 10s
timeout queue   1m
timeout connect 10s
timeout client  1m
timeout server  1m
timeout http-keep-alive 10s
timeout check   10s
maxconn         3000
frontend stats
bind *:1936
mode           http
log            global
maxconn 10
stats enable
stats hide-version
stats refresh 30s
stats show-node
stats show-desc Stats for ocp4 cluster 1
stats auth admin:ocp4
stats uri /stats
listen api-server-6443 2
bind *:6443
mode tcp
server bootstrap bootstrap.ocp4.example.com:6443 check inter 1s backup 3
server master0 master0.ocp4.example.com:6443 check inter 1s
server master1 master1.ocp4.example.com:6443 check inter 1s
server master2 master2.ocp4.example.com:6443 check inter 1s
listen machine-config-server-22623 4
bind *:22623
mode tcp
server bootstrap bootstrap.ocp4.example.com:22623 check inter 1s backup 5
server master0 master0.ocp4.example.com:22623 check inter 1s
server master1 master1.ocp4.example.com:22623 check inter 1s
server master2 master2.ocp4.example.com:22623 check inter 1s
listen ingress-router-443 6
bind *:443
mode tcp
balance source
server worker0 worker0.ocp4.example.com:443 check inter 1s
server worker1 worker1.ocp4.example.com:443 check inter 1s
listen ingress-router-80 7
bind *:80
mode tcp
balance source
server worker0 worker0.ocp4.example.com:80 check inter 1s
server worker1 worker1.ocp4.example.com:80 check inter 1s

```

- 1** In the example, the cluster name is **ocp4**.
- 2** Port **6443** handles the Kubernetes API traffic and points to the control plane machines.
- 3** **5** The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.

- 4 Port **22623** handles the machine config server traffic and points to the control plane machines.
- 6 Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.
- 7 Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



#### NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

#### TIP

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltp** on the HAProxy node.



#### NOTE

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running **setsebool -P haproxy\_connect\_any=1**.

### 14.2.4. Preparing the user-provisioned infrastructure

Before you install OpenShift Container Platform on user-provisioned infrastructure, you must prepare the underlying infrastructure.

This section provides details about the high-level steps required to set up your cluster infrastructure in preparation for an OpenShift Container Platform installation. This includes configuring IP networking and network connectivity for your cluster nodes, enabling the required ports through your firewall, and setting up the required DNS and load balancing infrastructure.

After preparation, your cluster infrastructure must meet the requirements outlined in the *Requirements for a cluster with user-provisioned infrastructure* section.

#### Prerequisites

- You have reviewed the [OpenShift Container Platform 4.x Tested Integrations](#) page.
- You have reviewed the infrastructure requirements detailed in the *Requirements for a cluster with user-provisioned infrastructure* section.

#### Procedure

1. If you are using DHCP to provide the IP networking configuration to your cluster nodes, configure your DHCP service.

- a. Add persistent IP addresses for the nodes to your DHCP server configuration. In your configuration, match the MAC address of the relevant network interface to the intended IP address for each node.
- b. When you use DHCP to configure IP addressing for the cluster machines, the machines also obtain the DNS server information through DHCP. Define the persistent DNS server address that is used by the cluster nodes through your DHCP server configuration.

**NOTE**

If you are not using a DHCP service, you must provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

- c. Define the hostnames of your cluster nodes in your DHCP server configuration. See the *Setting the cluster node hostnames through DHCP* section for details about hostname considerations.

**NOTE**

If you are not using a DHCP service, the cluster nodes obtain their hostname through a reverse DNS lookup.

2. Ensure that your network infrastructure provides the required network connectivity between the cluster components. See the *Networking requirements for user-provisioned infrastructure* section for details about the requirements.
3. Configure your firewall to enable the ports required for the OpenShift Container Platform cluster components to communicate. See *Networking requirements for user-provisioned infrastructure* section for details about the ports that are required.
4. Setup the required DNS infrastructure for your cluster.
  - a. Configure DNS name resolution for the Kubernetes API, the application wildcard, the bootstrap machine, the control plane machines, and the compute machines.
  - b. Configure reverse DNS resolution for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.  
See the *User-provisioned DNS requirements* section for more information about the OpenShift Container Platform DNS requirements.
5. Validate your DNS configuration.
  - a. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses in the responses correspond to the correct components.
  - b. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names in the responses correspond to the correct components.  
See the *Validating DNS resolution for user-provisioned infrastructure* section for detailed DNS validation steps.



6. Provision the required API and application ingress load balancing infrastructure. See the *Load balancing requirements for user-provisioned infrastructure* section for more information about the requirements.



#### NOTE

Some load balancing solutions require the DNS name resolution for the cluster nodes to be in place before the load balancing is initialized.

### 14.2.5. Validating DNS resolution for user-provisioned infrastructure

You can validate your DNS configuration before installing OpenShift Container Platform on user-provisioned infrastructure.



#### IMPORTANT

The validation steps detailed in this section must succeed before you install your cluster.

#### Prerequisites

- You have configured the required DNS records for your user-provisioned infrastructure.

#### Procedure

1. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses contained in the responses correspond to the correct components.
  - a. Perform a lookup against the Kubernetes API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api.<cluster_name>.<base_domain> 1
```

- 1 Replace **<nameserver\_ip>** with the IP address of the nameserver, **<cluster\_name>** with your cluster name, and **<base\_domain>** with your base domain name.

#### Example output

```
api.ocp4.example.com. 0 IN A 192.168.1.5
```

- b. Perform a lookup against the Kubernetes internal API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api-int.<cluster_name>.<base_domain>
```

#### Example output

```
api-int.ocp4.example.com. 0 IN A 192.168.1.5
```

- c. Test an example **\*.apps.<cluster\_name>.<base\_domain>** DNS wildcard lookup. All of the application wildcard lookups must resolve to the IP address of the application ingress load balancer:

```
$ dig +noall +answer @<nameserver_ip> random.apps.<cluster_name>.<base_domain>
```

### Example output

```
random.apps.ocp4.example.com. 0 IN A 192.168.1.5
```



### NOTE

In the example outputs, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

You can replace **random** with another wildcard value. For example, you can query the route to the OpenShift Container Platform console:

```
$ dig +noall +answer @<nameserver_ip> console-openshift-console.apps.<cluster_name>.<base_domain>
```

### Example output

```
console-openshift-console.apps.ocp4.example.com. 0 IN A 192.168.1.5
```

- d. Run a lookup against the bootstrap DNS record name. Check that the result points to the IP address of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> bootstrap.<cluster_name>.<base_domain>
```

### Example output

```
bootstrap.ocp4.example.com. 0 IN A 192.168.1.96
```

- e. Use this method to perform lookups against the DNS record names for the control plane and compute nodes. Check that the results correspond to the IP addresses of each node.
2. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names contained in the responses correspond to the correct components.
    - a. Perform a reverse lookup against the IP address of the API load balancer. Check that the response includes the record names for the Kubernetes API and the Kubernetes internal API:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.5
```

### Example output

```
5.1.168.192.in-addr.arpa. 0 IN PTR api-int.ocp4.example.com. 1  
5.1.168.192.in-addr.arpa. 0 IN PTR api.ocp4.example.com. 2
```

- 1 Provides the record name for the Kubernetes internal API.
- 2 Provides the record name for the Kubernetes API.

**NOTE**

A PTR record is not required for the OpenShift Container Platform application wildcard. No validation step is needed for reverse DNS resolution against the IP address of the application ingress load balancer.

- b. Perform a reverse lookup against the IP address of the bootstrap node. Check that the result points to the DNS record name of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.96
```

**Example output**

```
96.1.168.192.in-addr.arpa. 0 IN PTR bootstrap.ocp4.example.com.
```

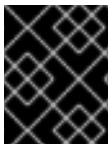
- c. Use this method to perform reverse lookups against the IP addresses for the control plane and compute nodes. Check that the results correspond to the DNS record names of each node.

### 14.2.6. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.

**IMPORTANT**

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

**NOTE**

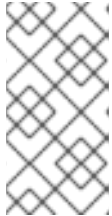
You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

**Procedure**

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.



#### NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.



#### NOTE

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

#### Example output

```
Agent pid 31874
```



#### NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1 Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

### Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

### Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

## 14.2.7. Obtaining the installation program

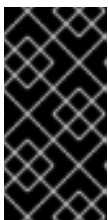
Before you install OpenShift Container Platform, download the installation file on a local computer.

### Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space

### Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



#### IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



#### IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#) . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform

components.

## 14.2.8. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



### IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

### Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

```
$ tar xvf <file>
```

5. Place the **oc** binary in a directory that is on your **PATH**.  
To check your **PATH**, execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

-

```
C:\> path
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

### Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.

To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### 14.2.9. Manually creating the installation configuration file

For user-provisioned installations of OpenShift Container Platform, you manually generate your installation configuration file.

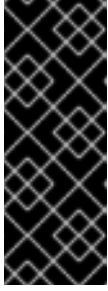
#### Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

#### Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```

**IMPORTANT**

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation\_directory>**.

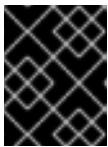
**NOTE**

You must name this configuration file **install-config.yaml**.

**NOTE**

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation\_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

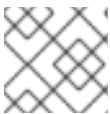
3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

**IMPORTANT**

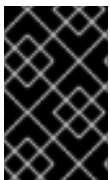
The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

**14.2.9.1. Installation configuration parameters**

Before you deploy an OpenShift Container Platform cluster, you provide a customized **install-config.yaml** installation configuration file that describes the details for your environment.

**NOTE**

After installation, you cannot modify these parameters in the **install-config.yaml** file.

**IMPORTANT**

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

**14.2.9.1.1. Required configuration parameters**

Required installation configuration parameters are described in the following table:

**Table 14.9. Required parameters**



Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;</b> . <b>&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}</b> . <b>{{.baseDomain}}</b> .	String of lowercase letters, hyphens (-), and periods (.), such as <b>dev</b> .
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws</b> , <b>baremetal</b> , <b>azure</b> , <b>gcp</b> , <b>openstack</b> , <b>ovirt</b> , <b>vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object


Parameter	Description	Values
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } }</pre>

#### 14.2.9.1.2. Network configuration parameters


You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

Table 14.10. Network parameters

Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	Object <div style="display: flex; align-items: center; margin-top: 10px;">  <div> <p><b>NOTE</b></p> <p>You cannot modify parameters specified by the <b>networking</b> object after installation.</p> </div> </div>
<b>networking.networkType</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .

Parameter	Description	Values
<b>networking.clusterNetwork</b>	<p>The IP address blocks for pods.</p> <p>The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b>.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   clusterNetwork:     - cidr: 10.128.0.0/14       hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	<p>Required if you use <b>networking.clusterNetwork</b>. An IP address block.</p> <p>An IPv4 network.</p>	<p>An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b>.</p>
<b>networking.clusterNetwork.hostPrefix</b>	<p>The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b>. A <b>hostPrefix</b> value of <b>23</b> provides 510 (<math>2^{(32 - 23)} - 2</math>) pod IP addresses.</p>	<p>A subnet prefix.</p> <p>The default value is <b>23</b>.</p>
<b>networking.serviceNetwork</b>	<p>The IP address block for services. The default value is <b>172.30.0.0/16</b>.</p> <p>The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.</p>	<p>An array with an IP address block in CIDR format. For example:</p> <pre>networking:   serviceNetwork:     - 172.30.0.0/16</pre>
<b>networking.machineNetwork</b>	<p>The IP address blocks for machines.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p> <p>If you specify multiple IP kernel arguments, the <b>machineNetwork.cidr</b> value must be the CIDR of the primary network.</p>	<p>An array of objects. For example:</p> <pre>networking:   machineNetwork:     - cidr: 10.0.0.0/16</pre>


Parameter	Description	Values
<b>networking.machineNetwork.cidr</b>	Required if you use <b>networking.machineNetwork</b> . An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b> .	An IP network block in CIDR notation. For example, <b>10.0.0.0/16</b> .  <b>NOTE</b> Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.

#### 14.2.9.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

Table 14.11. Optional parameters

Parameter	Description	Values
<b>additionalTrustBundle</b>	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
<b>compute</b>	The configuration for the machines that comprise the compute nodes.	Array of <b>MachinePool</b> objects.
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>ppc64le</b> (the default).	String


Parameter	Description	Values
<b>compute.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b>
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>ppc64le</b> (the default).	String

Parameter	Description	Values
<b>controlPlane.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platform</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>controlPlane.replicas</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.

Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.</p> <div data-bbox="485 510 595 864" style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p><b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators</i> reference content.</p> </div> <div data-bbox="485 909 595 1263" style="border: 1px solid black; padding: 5px;"> <p><b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p> </div>	<b>Mint, Passthrough, Manual</b> or an empty string ("").

Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start;"> <div style="width: 30px; height: 30px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 30px; height: 30px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings



Parameter	Description	Values
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<b>Internal</b> or <b>External</b> . The default value is <b>External</b> .  Setting this field to <b>Internal</b> is not supported on non-cloud platforms.
<b>sshKey</b>	The SSH key or keys to authenticate access your cluster machines.   <b>NOTE</b>  For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.	One or more keys. For example:  sshKey: <key1> <key2> <key3>

#### 14.2.9.2. Sample install-config.yaml file for IBM Power

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

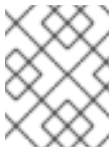
```

apiVersion: v1
baseDomain: example.com 1
compute: 2
- hyperthreading: Enabled 3
  name: worker
  replicas: 0 4
  architecture : ppc64le
controlPlane: 5
  hyperthreading: Enabled 6
  name: master
  replicas: 3 7
  architecture : ppc64le
metadata:
  name: test 8
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14 9
    hostPrefix: 23 10
  networkType: OpenShiftSDN
  serviceNetwork: 11
  - 172.30.0.0/16
platform:
  none: {} 12

```

```
fips: false 13
pullSecret: '{"auths": ...}' 14
sshKey: 'ssh-ed25519 AAAA...' 15
```

- 1** The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.
- 2 5** The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. Only one control plane pool is used.
- 3 6** Specifies whether to enable or disable simultaneous multithreading (SMT), or hyperthreading. By default, SMT is enabled to increase the performance of the cores in your machines. You can disable it by setting the parameter value to **Disabled**. If you disable SMT, you must disable it in all cluster machines; this includes both control plane and compute machines.

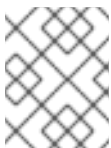
**NOTE**

Simultaneous multithreading (SMT) is enabled by default. If SMT is not enabled in your BIOS settings, the **hyperthreading** parameter has no effect.

**IMPORTANT**

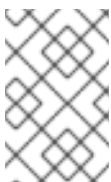
If you disable **hyperthreading**, whether in the BIOS or in the **install-config.yaml** file, ensure that your capacity planning accounts for the dramatically decreased machine performance.

- 4** You must set this value to **0** when you install OpenShift Container Platform on user-provisioned infrastructure. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. In user-provisioned installations, you must manually deploy the compute machines before you finish installing the cluster.

**NOTE**

If you are installing a three-node cluster, do not deploy any compute machines when you install the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

- 7** The number of control plane machines that you add to the cluster. Because the cluster uses these values as the number of etcd endpoints in the cluster, the value must match the number of control plane machines that you deploy.
- 8** The cluster name that you specified in your DNS records.
- 9** A block of IP addresses from which pod IP addresses are allocated. This block must not overlap with existing physical networks. These IP addresses are used for the pod network. If you need to access the pods from an external network, you must configure load balancers and routers to manage the traffic.

**NOTE**

Class E CIDR range is reserved for a future use. To use the Class E CIDR range, you must ensure your networking environment accepts the IP addresses within the Class E CIDR range.

- 10 The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23**, then each node is assigned a **/23** subnet out of the given **cidr**, which allows for 510 ( $2^{(32 - 23)} - 2$ )
- 11 The IP address pool to use for service IP addresses. You can enter only one IP address pool. This block must not overlap with existing physical networks. If you need to access the services from an external network, configure load balancers and routers to manage the traffic.
- 12 You must set the platform to **none**. You cannot provide additional platform configuration variables for IBM Power infrastructure.



### IMPORTANT

Clusters that are installed with the platform type **none** are unable to use some features, such as managing compute machines with the Machine API. This limitation applies even if the compute machines that are attached to the cluster are installed on a platform that would normally support the feature. This parameter cannot be changed after installation.

- 13 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.



### IMPORTANT

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

- 14 The [pull secret from the Red Hat OpenShift Cluster Manager](#) . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.
- 15 The SSH public key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).



### NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

#### 14.2.9.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

#### Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to

hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



## NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

## Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
  additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
...

```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations.
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.



## NOTE

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



#### NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

#### 14.2.9.4. Configuring a three-node cluster

You can optionally deploy zero compute machines in a bare metal cluster that consists of three control plane machines only. This provides smaller, more resource efficient clusters for cluster administrators and developers to use for testing, development, and production.

In three-node OpenShift Container Platform environments, the three control plane machines are schedulable, which means that your application workloads are scheduled to run on them.

#### Prerequisites

- You have an existing **install-config.yaml** file.

#### Procedure

- Ensure that the number of compute replicas is set to **0** in your **install-config.yaml** file, as shown in the following **compute** stanza:

```
compute:
- name: worker
  platform: {}
  replicas: 0
```



#### NOTE

You must set the value of the **replicas** parameter for the compute machines to **0** when you install OpenShift Container Platform on user-provisioned infrastructure, regardless of the number of compute machines you are deploying. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. This does not apply to user-provisioned installations, where the compute machines are deployed manually.

For three-node cluster installations, follow these next steps:

- If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes. See the *Load balancing requirements for user-provisioned infrastructure* section for more information.
- When you create the Kubernetes manifest files in the following procedure, ensure that the **mastersSchedulable** parameter in the **<installation\_directory>/manifests/cluster-**

**scheduler-02-config.yml** file is set to **true**. This enables your application workloads to run on the control plane nodes.

- Do not deploy any compute nodes when you create the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

## 14.2.10. Cluster Network Operator configuration

The configuration for the cluster network is specified as part of the Cluster Network Operator (CNO) configuration and stored in a custom resource (CR) object that is named **cluster**. The CR specifies the fields for the **Network** API in the **operator.openshift.io** API group.

The CNO configuration inherits the following fields during cluster installation from the **Network** API in the **Network.config.openshift.io** API group and these fields cannot be changed:

### **clusterNetwork**

IP address pools from which pod IP addresses are allocated.

### **serviceNetwork**

IP address pool for services.

### **defaultNetwork.type**

Cluster network provider, such as OpenShift SDN or OVN-Kubernetes.

You can specify the cluster network provider configuration for your cluster by setting the fields for the **defaultNetwork** object in the CNO object named **cluster**.

### 14.2.10.1. Cluster Network Operator configuration object

The fields for the Cluster Network Operator (CNO) are described in the following table:

**Table 14.12. Cluster Network Operator configuration object**


Field	Type	Description
<b>metadata.name</b>	<b>string</b>	The name of the CNO object. This name is always <b>cluster</b> .
<b>spec.clusterNetwork</b>	<b>array</b>	<p>A list specifying the blocks of IP addresses from which pod IP addresses are allocated and the subnet prefix length assigned to each individual node in the cluster. For example:</p> <pre>spec:   clusterNetwork:   - cidr: 10.128.0.0/19     hostPrefix: 23   - cidr: 10.128.32.0/19     hostPrefix: 23</pre> <p>You can customize this field only in the <b>install-config.yaml</b> file before you create the manifests. The value is read-only in the manifest file.</p>

Field	Type	Description
<b>spec.serviceNetwork</b>	<b>array</b>	<p>A block of IP addresses for services. The OpenShift SDN and OVN-Kubernetes Container Network Interface (CNI) network providers support only a single IP address block for the service network. For example:</p> <pre>spec:   serviceNetwork:   - 172.30.0.0/14</pre> <p>You can customize this field only in the <b>install-config.yaml</b> file before you create the manifests. The value is read-only in the manifest file.</p>
<b>spec.defaultNetwork</b>	<b>object</b>	Configures the Container Network Interface (CNI) cluster network provider for the cluster network.
<b>spec.kubeProxyConfig</b>	<b>object</b>	The fields for this object specify the kube-proxy configuration. If you are using the OVN-Kubernetes cluster network provider, the kube-proxy configuration has no effect.

#### defaultNetwork object configuration

The values for the **defaultNetwork** object are defined in the following table:

Table 14.13. **defaultNetwork** object

Field	Type	Description
<b>type</b>	<b>string</b>	<p>Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b>. The cluster network provider is selected during installation. This value cannot be changed after cluster installation.</p> <div style="display: flex; align-items: flex-start;"> <div style="flex: 1;">  </div> <div style="flex: 1;"> <p><b>NOTE</b></p> <p>OpenShift Container Platform uses the OpenShift SDN Container Network Interface (CNI) cluster network provider by default.</p> </div> </div>
<b>openshiftSDNConfig</b>	<b>object</b>	This object is only valid for the OpenShift SDN cluster network provider.
<b>ovnKubernetesConfig</b>	<b>object</b>	This object is only valid for the OVN-Kubernetes cluster network provider.

#### Configuration for the OpenShift SDN CNI cluster network provider

The following table lists the fields for the **defaultNetwork** object when you use the OpenShift SDN CNI cluster network provider.

The following table describes the configuration fields for the OpenShift SDN Container Network Interface (CNI) cluster network provider.

**Table 14.14. openshiftSDNConfig object**

Field	Type	Description
<b>mode</b>	<b>string</b>	<p>Configures the network isolation mode for OpenShift SDN. The default value is <b>NetworkPolicy</b>.</p> <p>The values <b>Multitenant</b> and <b>Subnet</b> are available for backwards compatibility with OpenShift Container Platform 3.x but are not recommended. This value cannot be changed after cluster installation.</p>
<b>mtu</b>	<b>integer</b>	<p>The maximum transmission unit (MTU) for the VXLAN overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU.</p> <p>If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes.</p> <p>If your cluster requires different MTU values for different nodes, you must set this value to <b>50</b> less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of <b>9001</b>, and some have an MTU of <b>1500</b>, you must set this value to <b>1450</b>.</p> <p>This value cannot be changed after cluster installation.</p>
<b>vxlanPort</b>	<b>integer</b>	<p>The port to use for all VXLAN packets. The default value is <b>4789</b>. This value cannot be changed after cluster installation.</p> <p>If you are running in a virtualized environment with existing nodes that are part of another VXLAN network, then you might be required to change this. For example, when running an OpenShift SDN overlay on top of VMware NSX-T, you must select an alternate port for the VXLAN, because both SDNs use the same default VXLAN port number.</p> <p>On Amazon Web Services (AWS), you can select an alternate port for the VXLAN between port <b>9000</b> and port <b>9999</b>.</p>

### Example OpenShift SDN configuration

```
defaultNetwork:
  type: OpenShiftSDN
  openshiftSDNConfig:
    mode: NetworkPolicy
    mtu: 1450
    vxlanPort: 4789
```



### Configuration for the OVN-Kubernetes CNI cluster network provider

The following table describes the configuration fields for the OVN-Kubernetes CNI cluster network provider.

Table 14.15. `ovnKubernetesConfig` object

Field	Type	Description
<code>mtu</code>	<code>integer</code>	<p>The maximum transmission unit (MTU) for the Geneve (Generic Network Virtualization Encapsulation) overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU.</p> <p>If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes.</p> <p>If your cluster requires different MTU values for different nodes, you must set this value to <b>100</b> less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of <b>9001</b>, and some have an MTU of <b>1500</b>, you must set this value to <b>1400</b>.</p> <p>This value cannot be changed after cluster installation.</p>
<code>genevePort</code>	<code>integer</code>	The port to use for all Geneve packets. The default value is <b>6081</b> . This value cannot be changed after cluster installation.
<code>ipsecConfig</code>	<code>object</code>	Specify an empty object to enable IPsec encryption. This value cannot be changed after cluster installation.
<code>policyAuditConfig</code>	<code>object</code>	Specify a configuration object for customizing network policy audit logging. If unset, the defaults audit log settings are used.

Table 14.16. `policyAuditConfig` object

Field	Type	Description
<code>rateLimit</code>	<code>integer</code>	The maximum number of messages to generate every second per node. The default value is <b>20</b> messages per second.
<code>maxFileSize</code>	<code>integer</code>	The maximum size for the audit log in bytes. The default value is <b>50000000</b> or 50 MB.

Field	Type	Description
<b>destination</b>	string	<p>One of the following additional audit log targets:</p> <p><b>libc</b> The libc <b>syslog()</b> function of the journald process on the host.</p> <p><b>udp:&lt;host&gt;:&lt;port&gt;</b> A syslog server. Replace <b>&lt;host&gt;:&lt;port&gt;</b> with the host and port of the syslog server.</p> <p><b>unix:&lt;file&gt;</b> A Unix Domain Socket file specified by <b>&lt;file&gt;</b>.</p> <p><b>null</b> Do not send the audit logs to any additional target.</p>
<b>syslogFacility</b>	string	The syslog facility, such as <b>kern</b> , as defined by RFC5424. The default value is <b>local0</b> .

### Example OVN-Kubernetes configuration

```


defaultNetwork:
  type: OVNKubernetes
  ovnKubernetesConfig:
    mtu: 1400
    genevePort: 6081
    ipsecConfig: {}

```

### kubeProxyConfig object configuration

The values for the **kubeProxyConfig** object are defined in the following table:

Table 14.17. **kubeProxyConfig** object

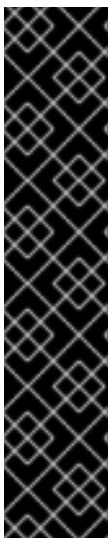
Field	Type	Description
<b>iptablesSyncPeriod</b>	string	<p>The refresh period for <b>iptables</b> rules. The default value is <b>30s</b>. Valid suffixes include <b>s</b>, <b>m</b>, and <b>h</b> and are described in the <a href="#">Go time package</a> documentation.</p> <div style="display: flex; align-items: flex-start;"> <div style="flex: 1;">  </div> <div style="flex: 2;"> <p><b>NOTE</b></p> <p>Because of performance improvements introduced in OpenShift Container Platform 4.3 and greater, adjusting the <b>iptablesSyncPeriod</b> parameter is no longer necessary.</p> </div> </div>

Field	Type	Description
<b>proxyArguments.iptables-min-sync-period</b>	<b>array</b>	<p>The minimum duration before refreshing <b>iptables</b> rules. This field ensures that the refresh does not happen too frequently. Valid suffixes include <b>s</b>, <b>m</b>, and <b>h</b> and are described in the <a href="#">Go time package</a>. The default value is:</p> <pre>kubeProxyConfig:   proxyArguments:     iptables-min-sync-period:       - 0s</pre>

### 14.2.11. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.



#### IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.



#### NOTE

The installation program that generates the manifest and Ignition files is architecture specific and can be obtained from the [client image mirror](#). The Linux version of the installation program runs on ppc64le only. This installer program is also available as a Mac OS version.

#### Prerequisites

- You obtained the OpenShift Container Platform installation program.
- You created the **install-config.yaml** installation configuration file.

## Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

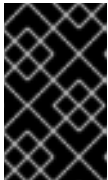
```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

- 1 For **<installation\_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.



### WARNING

If you are installing a three-node cluster, skip the following step to allow the control plane nodes to be schedulable.



### IMPORTANT

When you configure control plane nodes from the default unschedulable to schedulable, additional subscriptions are required. This is because control plane nodes then become worker nodes.

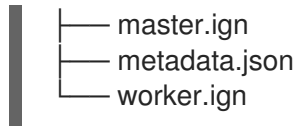
2. Check that the **mastersSchedulable** parameter in the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:
  - a. Open the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** file.
  - b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.
  - c. Save and exit the file.
3. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

- 1 For **<installation\_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation\_directory>/auth** directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
└── bootstrap.ign
```



## 14.2.12. Installing RHCOS and starting the OpenShift Container Platform bootstrap process

To install OpenShift Container Platform on IBM Power infrastructure that you provision, you must install Red Hat Enterprise Linux CoreOS (RHCOS) on the machines. When you install RHCOS, you must provide the Ignition config file that was generated by the OpenShift Container Platform installation program for the type of machine you are installing. If you have configured suitable networking, DNS, and load balancing infrastructure, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS machines have rebooted.

Follow either the steps to use an ISO image or network PXE booting to install RHCOS on the machines.

### 14.2.12.1. Installing RHCOS by using an ISO image

You can use an ISO image to install RHCOS on the machines.

#### Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have an HTTP server that can be accessed from your computer, and from the machines that you create.
- You have reviewed the *Advanced RHCOS installation configuration* section for different ways to configure features, such as networking and disk partitioning.

#### Procedure

1. Obtain the SHA512 digest for each of your Ignition config files. For example, you can use the following on a system running Linux to get the SHA512 digest for your **bootstrap.ign** Ignition config file:

```
$ sha512sum <installation_directory>/bootstrap.ign
```

The digests are provided to the **coreos-installer** in a later step to validate the authenticity of the Ignition config files on the cluster nodes.

2. Upload the bootstrap, control plane, and compute node Ignition config files that the installation program created to your HTTP server. Note the URLs of these files.

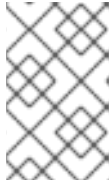


#### IMPORTANT

You can add or change configuration settings in your Ignition configs before saving them to your HTTP server. If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

3. From the installation host, validate that the Ignition config files are available on the URLs. The following example gets the Ignition config file for the bootstrap node:



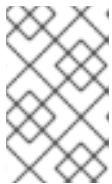
**NOTE**

It is possible to interrupt the RHCOS installation boot process to add kernel arguments. However, for this ISO procedure you should use the **coreos-installer** command as outlined in the following steps, instead of adding kernel arguments.

7. Run the **coreos-installer** command and specify the options that meet your installation requirements. At a minimum, you must specify the URL that points to the Ignition config file for the node type, and the device that you are installing to:

```
$ sudo coreos-installer install --ignition-url=http://<HTTP_server>/<node_type>.ign <device>
--ignition-hash=sha512-<digest> 1 2
```

- 1 1 You must run the **coreos-installer** command by using **sudo**, because the **core** user does not have the required root privileges to perform the installation.
- 2 The **--ignition-hash** option is required when the Ignition config file is obtained through an HTTP URL to validate the authenticity of the Ignition config file on the cluster node. **<digest>** is the Ignition config file SHA512 digest obtained in a preceding step.

**NOTE**

If you want to provide your Ignition config files through an HTTPS server that uses TLS, you can add the internal certificate authority (CA) to the system trust store before running **coreos-installer**.

The following example initializes a bootstrap node installation to the **/dev/sda** device. The Ignition config file for the bootstrap node is obtained from an HTTP web server with the IP address 192.168.1.2:

```
$ sudo coreos-installer install --ignition-
url=http://192.168.1.2:80/installation_directory/bootstrap.ign /dev/sda --ignition-hash=sha512-
a5a2d43879223273c9b60af66b44202a1d1248fc01cf156c46d4a79f552b6bad47bc8cc78ddf011
6e80c59d2ea9e32ba53bc807afbca581aa059311def2c3e3b
```

8. Monitor the progress of the RHCOS installation on the console of the machine.

**IMPORTANT**

Be sure that the installation is successful on each node before commencing with the OpenShift Container Platform installation. Observing the installation process can also help to determine the cause of RHCOS installation issues that might arise.

9. After RHCOS installs, you must reboot the system. During the system reboot, it applies the Ignition config file that you specified.
10. Continue to create the other machines for your cluster.

**IMPORTANT**

You must create the bootstrap and control plane machines at this time. If the control plane machines are not made schedulable, also create at least two compute machines before you install OpenShift Container Platform.

If the required network, DNS, and load balancer infrastructure are in place, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS nodes have rebooted.

**NOTE**

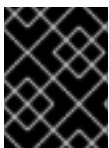
RHCOS nodes do not include a default password for the **core** user. You can access the nodes by running **ssh core@<node>.<cluster\_name>.<base\_domain>** as a user with access to the SSH private key that is paired to the public key that you specified in your **install\_config.yaml** file. OpenShift Container Platform 4 cluster nodes running RHCOS are immutable and rely on Operators to apply cluster changes. Accessing cluster nodes by using SSH is not recommended. However, when investigating installation issues, if the OpenShift Container Platform API is not available, or the kubelet is not properly functioning on a target node, SSH access might be required for debugging or disaster recovery.

**14.2.12.1.1. Advanced RHCOS installation reference**

This section illustrates the networking configuration and other advanced options that allow you to modify the Red Hat Enterprise Linux CoreOS (RHCOS) manual installation process. The following tables describe the kernel arguments and command-line options you can use with the RHCOS live installer and the **coreos-installer** command.

**14.2.12.1.1.1. Networking and bonding options for ISO installations**

If you install RHCOS from an ISO image, you can add kernel arguments manually when you boot the image to configure networking for a node. If no networking arguments are specified, DHCP is activated in the initramfs when RHCOS detects that networking is required to fetch the Ignition config file.

**IMPORTANT**

When adding networking arguments manually, you must also add the **rd.neednet=1** kernel argument to bring the network up in the initramfs.

The following table provides examples for configuring networking and bonding on your RHCOS nodes for ISO installations. The examples describe how to use the **ip=**, **nameserver=**, and **bond=** kernel arguments.

**NOTE**

Ordering is important when adding the kernel arguments: **ip=**, **nameserver=**, and then **bond=**.

The networking options are passed to the **dracut** tool during system boot. For more information about the networking options supported by **dracut**, see the **dracut.cmdline** manual page.



The following information provides examples for configuring networking on your RHCOS nodes for ISO installations. The examples describe how to use the **ip=** and **nameserver=** kernel arguments.



## NOTE

Ordering is important when adding the kernel arguments: **ip=** and **nameserver=**.

The networking options are passed to the **dracut** tool during system boot. For more information about the networking options supported by **dracut**, see the **dracut.cmdline** manual page.

The following examples are the networking options for ISO installation.

Configuring DHCP or static IP addresses

To configure an IP address, either use DHCP (**ip=dhcp**) or set an individual static IP address (**ip=<host\_ip>**). If setting a static IP, you must then identify the DNS server IP address (**nameserver=<dns\_ip>**) on each node. The following example sets:

- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The hostname to **core0.example.com**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
nameserver=4.4.4.41
```



## NOTE

When you use DHCP to configure IP addressing for the RHCOS machines, the machines also obtain the DNS server information through DHCP. For DHCP-based deployments, you can define the DNS server address that is used by the RHCOS nodes through your DHCP server configuration.

Configuring an IP address without a static hostname

You can configure an IP address without assigning a static hostname. If a static hostname is not set by the user, it will be picked up and automatically set by a reverse DNS lookup. To configure an IP address without a static hostname refer to the following example:

- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0::enp1s0:none
nameserver=4.4.4.41
```

#### Specifying multiple network interfaces

You can specify multiple network interfaces by setting multiple **ip=** entries.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=10.10.10.3::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

#### Configuring default gateway and route

Optional: You can configure routes to additional networks by setting an **rd.route=** value.



#### NOTE

When you configure one or multiple networks, one default gateway is required. If the additional network gateway is different from the primary network gateway, the default gateway must be the primary network gateway.

- Run the following command to configure the default gateway:

```
ip=::10.10.10.254:::
```

- Enter the following command to configure the route for the additional network:

```
rd.route=20.20.20.0/24:20.20.20.254:enp2s0
```

#### Disabling DHCP on a single interface

You can disable DHCP on a single interface, such as when there are two or more network interfaces and only one interface is being used. In the example, the **enp1s0** interface has a static networking configuration and DHCP is disabled for **enp2s0**, which is not used:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=::::core0.example.com:enp2s0:none
```

#### Combining DHCP and static IP configurations

You can combine DHCP and static IP configurations on systems with multiple network interfaces, for example:

```
ip=enp1s0:dhcp
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

#### Configuring VLANs on individual interfaces

Optional: You can configure VLANs on individual interfaces by using the **vlan=** parameter.

- To configure a VLAN on a network interface and use a static IP address, run the following command:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0.100:none
vlan=enp2s0.100:enp2s0
```

- To configure a VLAN on a network interface and to use DHCP, run the following command:

```
ip=enp2s0.100:dhcp
vlan=enp2s0.100:enp2s0
```

Providing multiple DNS servers

You can provide multiple DNS servers by adding a **nameserver=** entry for each server, for example:

```
nameserver=1.1.1.1
nameserver=8.8.8.8
```

Bonding multiple network interfaces to a single interface

Optional: You can bond multiple network interfaces to a single interface by using the **bond=** option. Refer to the following examples:

- The syntax for configuring a bonded interface is: **bond=name[:network\_interfaces][:options]** *name* is the bonding device name (**bond0**), *network\_interfaces* represents a comma-separated list of physical (ethernet) interfaces (**em1,em2**), and *options* is a comma-separated list of bonding options. Enter **modinfo bonding** to see available options.
- When you create a bonded interface using **bond=**, you must specify how the IP address is assigned and other information for the bonded interface.
- To configure the bonded interface to use DHCP, set the bond's IP address to **dhcp**. For example:

```
bond=bond0:em1,em2:mode=active-backup
ip=bond0:dhcp
```

- To configure the bonded interface to use a static IP address, enter the specific IP address you want and related information. For example:

```
bond=bond0:em1,em2:mode=active-backup
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0:none
```

Bonding multiple network interfaces to a single interface

Optional: You can configure VLANs on bonded interfaces by using the **vlan=** parameter and to use DHCP, for example:

```
ip=bond0.100:dhcp
bond=bond0:em1,em2:mode=active-backup
vlan=bond0.100:bond0
```

Use the following example to configure the bonded interface with a VLAN and to use a static IP address:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0.100:none
bond=bond0:em1,em2:mode=active-backup
vlan=bond0.100:bond0
```

Using network teaming

Optional: You can use a network teaming as an alternative to bonding by using the **team=** parameter:

- The syntax for configuring a team interface is: **team=name[:network\_interfaces]** *name* is the team device name (**team0**) and *network\_interfaces* represents a comma-separated list of physical (ethernet) interfaces (**em1, em2**).

Teaming is planned to be deprecated when RHCOS switches to an upcoming version of RHEL. For more information, see this [Red Hat Knowledgebase Article](#).

Use the following example to configure a network team:

```
team=team0:em1,em2
ip=team0:dhcp
```

### 14.2.12.2. Installing RHCOS by using PXE booting

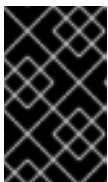
You can use PXE booting to install RHCOS on the machines.

#### Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have configured suitable PXE infrastructure.
- You have an HTTP server that can be accessed from your computer, and from the machines that you create.
- You have reviewed the *Advanced RHCOS installation configuration* section for different ways to configure features, such as networking and disk partitioning.

#### Procedure

1. Upload the bootstrap, control plane, and compute node Ignition config files that the installation program created to your HTTP server. Note the URLs of these files.



#### IMPORTANT

You can add or change configuration settings in your Ignition configs before saving them to your HTTP server. If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

2. From the installation host, validate that the Ignition config files are available on the URLs. The following example gets the Ignition config file for the bootstrap node:

```
$ curl -k http://<HTTP_server>/bootstrap.ign 1
```

#### Example output

```
% Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
           Dload  Upload  Total   Spent    Left    Speed
  0   0   0   0   0   0   0   0  0  --:--:-- --:--:-- --:--:--    0{"ignition":
{"version":"3.2.0"},"passwd":{"users":[{"name":"core","sshAuthorizedKeys":["ssh-rsa...
```

Replace **bootstrap.ign** with **master.ign** or **worker.ign** in the command to validate that the Ignition config files for the control plane and compute nodes are also available.

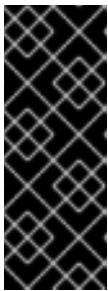
3. Although it is possible to obtain the RHCOS **kernel**, **initramfs** and **rootfs** files that are required

for your preferred method of installing operating system instances from the [RHCOS image mirror](#)[RHCOS image mirror](#) page, the recommended way to obtain the correct version of your RHCOS files are from the output of **openshift-install** command:

```
$ openshift-install coreos print-stream-json | grep -Eo "https.*(kernel-|initramfs.|rootfs.)w+(\.img)?"
```

### Example output

```
"<url>/art/storage/releases/rhcos-4.9-aarch64/<release>/aarch64/rhcos-<release>-live-
kernel-aarch64"
"<url>/art/storage/releases/rhcos-4.9-aarch64/<release>/aarch64/rhcos-<release>-live-
initramfs.aarch64.img"
"<url>/art/storage/releases/rhcos-4.9-aarch64/<release>/aarch64/rhcos-<release>-live-
rootfs.aarch64.img"
"<url>/art/storage/releases/rhcos-4.9-ppc64le/49.84.202110081256-0/ppc64le/rhcos-
<release>-live-kernel-ppc64le"
"<url>/art/storage/releases/rhcos-4.9-ppc64le/<release>/ppc64le/rhcos-<release>-live-
initramfs.ppc64le.img"
"<url>/art/storage/releases/rhcos-4.9-ppc64le/<release>/ppc64le/rhcos-<release>-live-
rootfs.ppc64le.img"
"<url>/art/storage/releases/rhcos-4.9-s390x/<release>/s390x/rhcos-<release>-live-kernel-
s390x"
"<url>/art/storage/releases/rhcos-4.9-s390x/<release>/s390x/rhcos-<release>-live-
initramfs.s390x.img"
"<url>/art/storage/releases/rhcos-4.9-s390x/<release>/s390x/rhcos-<release>-live-
rootfs.s390x.img"
"<url>/art/storage/releases/rhcos-4.9/<release>/x86_64/rhcos-<release>-live-kernel-x86_64"
"<url>/art/storage/releases/rhcos-4.9/<release>/x86_64/rhcos-<release>-live-
initramfs.x86_64.img"
"<url>/art/storage/releases/rhcos-4.9/<release>/x86_64/rhcos-<release>-live-
rootfs.x86_64.img"
```



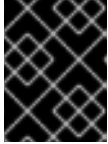
### IMPORTANT

The RHCOS artifacts might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Only use the appropriate **kernel**, **initramfs**, and **rootfs** artifacts described below for this procedure. RHCOS QCOW2 images are not supported for this installation type.

The file names contain the OpenShift Container Platform version number. They resemble the following examples:

- **kernel:** rhcos-<version>-live-kernel-<architecture>
- **initramfs:** rhcos-<version>-live-initramfs.<architecture>.img
- **rootfs:** rhcos-<version>-live-rootfs.<architecture>.img

4. Upload the **rootfs**, **kernel**, and **initramfs** files to your HTTP server.



## IMPORTANT

If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

- Configure the network boot infrastructure so that the machines boot from their local disks after RHCOS is installed on them.
- Configure PXE installation for the RHCOS images and begin the installation. Modify the following example menu entry for your environment and verify that the image and Ignition files are properly accessible:

```

DEFAULT pxeboot
TIMEOUT 20
PROMPT 0
LABEL pxeboot
  KERNEL http://<HTTP_server>/rhcos-<version>-live-kernel-<architecture> 1
  APPEND initrd=http://<HTTP_server>/rhcos-<version>-live-initramfs.<architecture>.img
  coreos.live.rootfs_url=http://<HTTP_server>/rhcos-<version>-live-rootfs.<architecture>.img
  coreos.inst.install_dev=/dev/sda coreos.inst.ignition_url=http://<HTTP_server>/bootstrap.ign
2 3

```

- 1** Specify the location of the live **kernel** file that you uploaded to your HTTP server. The URL must be HTTP, TFTP, or FTP; HTTPS and NFS are not supported.
- 2** If you use multiple NICs, specify a single interface in the **ip** option. For example, to use DHCP on a NIC that is named **eno1**, set **ip=eno1:dhcp**.
- 3** Specify the locations of the RHCOS files that you uploaded to your HTTP server. The **initrd** parameter value is the location of the **initramfs** file, the **coreos.live.rootfs\_url** parameter value is the location of the **rootfs** file, and the **coreos.inst.ignition\_url** parameter value is the location of the bootstrap Ignition config file. You can also add more kernel arguments to the **APPEND** line to configure networking or other boot options.



## NOTE

This configuration does not enable serial console access on machines with a graphical console. To configure a different console, add one or more **console=** arguments to the **APPEND** line. For example, add **console=tty0 console=ttyS0** to set the first PC serial port as the primary console and the graphical console as a secondary console. For more information, see [How does one set up a serial terminal and/or console in Red Hat Enterprise Linux?](#)

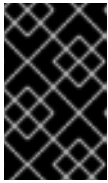
- Monitor the progress of the RHCOS installation on the console of the machine.



## IMPORTANT

Be sure that the installation is successful on each node before commencing with the OpenShift Container Platform installation. Observing the installation process can also help to determine the cause of RHCOS installation issues that might arise.

8. After RHCOS installs, the system reboots. During reboot, the system applies the Ignition config file that you specified.
9. Continue to create the machines for your cluster.



### IMPORTANT

You must create the bootstrap and control plane machines at this time. If the control plane machines are not made schedulable, also create at least two compute machines before you install the cluster.

If the required network, DNS, and load balancer infrastructure are in place, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS nodes have rebooted.



### NOTE

RHCOS nodes do not include a default password for the **core** user. You can access the nodes by running **ssh core@<node>.<cluster\_name>.<base\_domain>** as a user with access to the SSH private key that is paired to the public key that you specified in your **install\_config.yaml** file. OpenShift Container Platform 4 cluster nodes running RHCOS are immutable and rely on Operators to apply cluster changes. Accessing cluster nodes by using SSH is not recommended. However, when investigating installation issues, if the OpenShift Container Platform API is not available, or the kubelet is not properly functioning on a target node, SSH access might be required for debugging or disaster recovery.

#### 14.2.12.3. Enabling multipathing with kernel arguments on RHCOS

In OpenShift Container Platform 4.9 or later, during installation, you can enable multipathing for provisioned nodes. RHCOS supports multipathing on the primary disk. Multipathing provides added benefits of stronger resilience to hardware failure to achieve higher host availability.

During the initial cluster creation, you might want to add kernel arguments to all master or worker nodes. To add kernel arguments to master or worker nodes, you can create a **MachineConfig** object and inject that object into the set of manifest files used by Ignition during cluster setup.

#### Procedure

1. Change to the directory that contains the installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory>
```

2. Decide if you want to add kernel arguments to worker or control plane nodes.
  - Create a machine config file. For example, create a **99-master-kargs-mpath.yaml** that instructs the cluster to add the **master** label and identify the multipath kernel argument:

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: "master"
```

```

name: 99-master-kargs-mpath
spec:
  kernelArguments:
    - 'rd.multipath=default'
    - 'root=/dev/disk/by-label/dm-mpath-root'

```

3. To enable multipathing post-installation on worker nodes:

- Create a machine config file. For example, create a **99-worker-kargs-mpath.yaml** that instructs the cluster to add the **worker** label and identify the multipath kernel argument:

```

apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: "worker"
  name: 99-worker-kargs-mpath
spec:
  kernelArguments:
    - 'rd.multipath=default'
    - 'root=/dev/disk/by-label/dm-mpath-root'

```

You can now continue on to create the cluster.



## IMPORTANT

Additional post-installation steps are required to fully enable multipathing. For more information, see “Enabling multipathing with kernel arguments on RHCOS” in *Post-installation machine configuration tasks*.

In case of MPIO failure, use the `bootlist` command to update the boot device list with alternate logical device names. The command displays a boot list and it designates the possible boot devices for when the system is booted in normal mode.

- To display a boot list and specify the possible boot devices if the system is booted in normal mode, enter the following command:

```

$ bootlist -m normal -o
sda

```

- To update the boot list for normal mode and add alternate device names, enter the following command:

```

$ bootlist -m normal -o /dev/sdc /dev/sdd /dev/sde
sdc
sdd
sde

```

If the original boot disk path is down, the node reboots from the alternate device registered in the normal boot device list.

### 14.2.13. Waiting for the bootstrap process to complete

The OpenShift Container Platform bootstrap process begins after the cluster nodes first boot into the



persistent RHCOS environment that has been installed to disk. The configuration information provided through the Ignition config files is used to initialize the bootstrap process and install OpenShift Container Platform on the machines. You must wait for the bootstrap process to complete.

## Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have obtained the installation program and generated the Ignition config files for your cluster.
- You installed RHCOS on your cluster machines and provided the Ignition config files that the OpenShift Container Platform installation program generated.
- Your machines have direct internet access or have an HTTP or HTTPS proxy available.

## Procedure

1. Monitor the bootstrap process:

```

$ ./openshift-install --dir <installation_directory> wait-for bootstrap-complete \ 1
--log-level=info 2

```

- 1 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

- 2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

## Example output

```

INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...
INFO API v1.22.1 up
INFO Waiting up to 30m0s for bootstrapping to complete...
INFO It is now safe to remove the bootstrap resources

```

The command succeeds when the Kubernetes API server signals that it has been bootstrapped on the control plane machines.

2. After bootstrap process is complete, remove the bootstrap machine from the load balancer.



### IMPORTANT

You must remove the bootstrap machine from the load balancer at this point. You can also remove or reformat the bootstrap machine itself.

## 14.2.14. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

## Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

## Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

### Example output

```
system:admin
```

## 14.2.15. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

## Prerequisites

- You added machines to your cluster.

## Procedure

1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

### Example output

```
NAME      STATUS    ROLES    AGE   VERSION
master-0  Ready     master   63m   v1.22.1
master-1  Ready     master   63m   v1.22.1
master-2  Ready     master   64m   v1.22.1
```

The output lists all of the machines that you created.



### NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

- Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

### Example output

```
NAME          AGE   REQUESTOR                                     CONDITION
csr-8b2br    15m   system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper Pending
csr-8vnps    15m   system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper Pending
...
```

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

- If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:



#### NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.



#### NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{\n"}\n{{end}}\n' | xargs --no-run-if-empty oc adm certificate approve
```

**NOTE**

Some Operators might not become available until some CSRs are approved.

- Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

**Example output**

```
NAME      AGE   REQUESTOR                                     CONDITION
csr-bfd72 5m26s system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv 5m26s system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

- If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

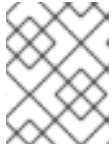
```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{\n"}\n{{end}}\n' | xargs oc adm certificate approve
```

- After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

**Example output**

```
NAME      STATUS  ROLES  AGE  VERSION
master-0  Ready   master 73m  v1.22.1
master-1  Ready   master 73m  v1.22.1
master-2  Ready   master 74m  v1.22.1
worker-0  Ready   worker 11m  v1.22.1
worker-1  Ready   worker 11m  v1.22.1
```

**NOTE**

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

**Additional information**

- For more information on CSRs, see [Certificate Signing Requests](#).

**14.2.16. Initial Operator configuration**

After the control plane initializes, you must immediately configure some Operators so that they all become available.

**Prerequisites**

- Your control plane has initialized.

**Procedure**

1. Watch the cluster components come online:

```
$ watch -n5 oc get clusteroperators
```

**Example output**

```

NAME                               VERSION AVAILABLE PROGRESSING DEGRADED
SINCE
authentication                      4.9.0 True      False      False      19m
baremetal                            4.9.0 True      False      False      37m
cloud-credential                     4.9.0 True      False      False      40m
cluster-autoscaler                   4.9.0 True      False      False      37m
config-operator                      4.9.0 True      False      False      38m
console                              4.9.0 True      False      False      26m
csi-snapshot-controller              4.9.0 True      False      False      37m
dns                                  4.9.0 True      False      False      37m
etcd                                  4.9.0 True      False      False      36m
image-registry                       4.9.0 True      False      False      31m
ingress                              4.9.0 True      False      False      30m
insights                             4.9.0 True      False      False      31m
kube-apiserver                       4.9.0 True      False      False      26m
kube-controller-manager               4.9.0 True      False      False      36m
kube-scheduler                       4.9.0 True      False      False      36m
kube-storage-version-migrator        4.9.0 True      False      False      37m
machine-api                          4.9.0 True      False      False      29m
machine-approver                     4.9.0 True      False      False      37m
machine-config                       4.9.0 True      False      False      36m
marketplace                          4.9.0 True      False      False      37m
monitoring                           4.9.0 True      False      False      29m
network                              4.9.0 True      False      False      38m
node-tuning                          4.9.0 True      False      False      37m
openshift-apiserver                  4.9.0 True      False      False      32m
openshift-controller-manager         4.9.0 True      False      False      30m
openshift-samples                    4.9.0 True      False      False      32m

```

operator-lifecycle-manager	4.9.0	True	False	False	37m
operator-lifecycle-manager-catalog	4.9.0	True	False	False	37m
operator-lifecycle-manager-packageserver	4.9.0	True	False	False	32m
service-ca	4.9.0	True	False	False	38m
storage	4.9.0	True	False	False	37m

2. Configure the Operators that are not available.

### 14.2.16.1. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

#### 14.2.16.1.1. Configuring registry storage for IBM Power

As a cluster administrator, following installation you must configure your registry to use storage.

#### Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.
- You have a cluster on IBM Power.
- You have provisioned persistent storage for your cluster, such as Red Hat OpenShift Container Storage.



#### IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have 100Gi capacity.

#### Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.



#### NOTE

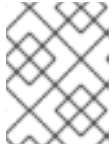
When using shared storage, review your security settings to prevent outside access.

- Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

### Example output

```
No resources found in openshift-image-registry namespace
```



### NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

- Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

### Example output

```
storage:
  pvc:
    claim:
```

Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** PVC.

- Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
image-registry	4.9	True	False	False	6h50m

- Ensure that your registry is set to managed to enable building and pushing of images.

- Run:

```
$ oc edit configs.imageregistry/cluster
```

Then, change the line

```
managementState: Removed
```

to

```
managementState: Managed
```

#### 14.2.16.1.2. Configuring storage for the image registry in non-production clusters

You must configure storage for the Image Registry Operator. For non-production clusters, you can set the image registry to an empty directory. If you do so, all images are lost if you restart the registry.

## Procedure

- To set the image registry storage to an empty directory:

```
$ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec": {"storage":{"emptyDir":{}}}'
```



### WARNING

Configure this option for only non-production clusters.

If you run this command before the Image Registry Operator initializes its components, the **oc patch** command fails with the following error:

```
Error from server (NotFound): configs.imageregistry.operator.openshift.io "cluster" not found
```

Wait a few minutes and run the command again.

## 14.2.17. Completing installation on user-provisioned infrastructure

After you complete the Operator configuration, you can finish installing the cluster on infrastructure that you provide.

### Prerequisites

- Your control plane has initialized.
- You have completed the initial Operator configuration.

### Procedure

- Confirm that all the cluster components are online with the following command:

```
$ watch -n5 oc get clusteroperators
```

### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
authentication	4.9.0	True	False	False	19m
baremetal	4.9.0	True	False	False	37m
cloud-credential	4.9.0	True	False	False	40m
cluster-autoscaler	4.9.0	True	False	False	37m
config-operator	4.9.0	True	False	False	38m
console	4.9.0	True	False	False	26m



csi-snapshot-controller	4.9.0	True	False	False	37m
dns	4.9.0	True	False	False	37m
etcd	4.9.0	True	False	False	36m
image-registry	4.9.0	True	False	False	31m
ingress	4.9.0	True	False	False	30m
insights	4.9.0	True	False	False	31m
kube-apiserver	4.9.0	True	False	False	26m
kube-controller-manager	4.9.0	True	False	False	36m
kube-scheduler	4.9.0	True	False	False	36m
kube-storage-version-migrator	4.9.0	True	False	False	37m
machine-api	4.9.0	True	False	False	29m
machine-approver	4.9.0	True	False	False	37m
machine-config	4.9.0	True	False	False	36m
marketplace	4.9.0	True	False	False	37m
monitoring	4.9.0	True	False	False	29m
network	4.9.0	True	False	False	38m
node-tuning	4.9.0	True	False	False	37m
openshift-apiserver	4.9.0	True	False	False	32m
openshift-controller-manager	4.9.0	True	False	False	30m
openshift-samples	4.9.0	True	False	False	32m
operator-lifecycle-manager	4.9.0	True	False	False	37m
operator-lifecycle-manager-catalog	4.9.0	True	False	False	37m
operator-lifecycle-manager-packageserver	4.9.0	True	False	False	32m
service-ca	4.9.0	True	False	False	38m
storage	4.9.0	True	False	False	37m

Alternatively, the following command notifies you when all of the clusters are available. It also retrieves and displays credentials:

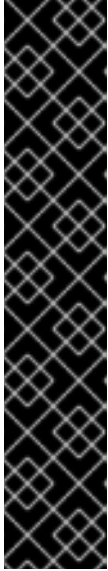
```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

### Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

The command succeeds when the Cluster Version Operator finishes deploying the OpenShift Container Platform cluster from Kubernetes API server.



## IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Confirm that the Kubernetes API server is communicating with the pods.

- a. To view a list of all pods, use the following command:

```
$ oc get pods --all-namespaces
```

### Example output

```

NAMESPACE           NAME                                     READY  STATUS
RESTARTS  AGE
openshift-apiserver-operator  openshift-apiserver-operator-85cb746d55-zqhs8  1/1
Running   1    9m
openshift-apiserver          apiserver-67b9g                                1/1  Running  0
3m
openshift-apiserver          apiserver-ljcmx                                1/1  Running  0
1m
openshift-apiserver          apiserver-z25h4                                1/1  Running  0
2m
openshift-authentication-operator  authentication-operator-69d5d8bf84-vh2n8      1/1
Running   0    5m
...

```

- b. View the logs for a pod that is listed in the output of the previous command by using the following command:

```
$ oc logs <pod_name> -n <namespace> ❶
```

- ❶ Specify the pod name and namespace, as shown in the output of the previous command.

If the pod logs display, the Kubernetes API server can communicate with the cluster machines.

3. Additional steps are required to enable multipathing. Do not enable multipathing during installation.

See "Enabling multipathing with kernel arguments on RHCOS" in the *Post-installation machine configuration tasks* documentation for more information.

### 14.2.18. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

#### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

### 14.2.19. Next steps

- [Enabling multipathing with kernel arguments on RHCOS](#) .
- [Customize your cluster](#) .
- If necessary, you can [opt out of remote health reporting](#) .

## 14.3. INSTALLING A CLUSTER ON IBM POWER IN A RESTRICTED NETWORK

In OpenShift Container Platform version 4.9, you can install a cluster on IBM Power infrastructure that you provision in a restricted network.



#### IMPORTANT

Additional considerations exist for non-bare metal platforms. Review the information in the [guidelines for deploying OpenShift Container Platform on non-tested platforms](#) before you install an OpenShift Container Platform cluster.

### 14.3.1. Prerequisites

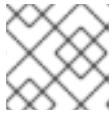
- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You [created a mirror registry for installation in a restricted network](#) and obtained the **imageContentSources** data for your version of OpenShift Container Platform.
- Before you begin the installation process, you must move or remove any existing installation files. This ensures that the required installation files are created and updated during the installation process.



#### IMPORTANT

Ensure that installation steps are performed on a machine with access to the installation media.

- You provisioned [persistent storage](#) for your cluster. To deploy a private image registry, your storage must provide **ReadWriteMany** access modes.
- If you use a firewall and plan to use the Telemetry service, you [configured the firewall to allow the sites](#) that your cluster requires access to.



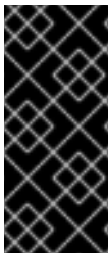
#### NOTE

Be sure to also review this site list if you are configuring a proxy.

### 14.3.2. About installations in restricted networks

In OpenShift Container Platform 4.9, you can perform an installation that does not require an active connection to the internet to obtain software components. Restricted network installations can be completed using installer-provisioned infrastructure or user-provisioned infrastructure, depending on the cloud platform to which you are installing the cluster.

To complete a restricted network installation, you must create a registry that mirrors the contents of the OpenShift Container Platform registry and contains the installation media. You can create this registry on a mirror host, which can access both the internet and your closed network, or by using other methods that meet your restrictions.



#### IMPORTANT

Because of the complexity of the configuration for user-provisioned installations, consider completing a standard user-provisioned infrastructure installation before you attempt a restricted network installation using user-provisioned infrastructure. Completing this test installation might make it easier to isolate and troubleshoot any issues that might arise during your installation in a restricted network.

#### 14.3.2.1. Additional limits

Clusters in restricted networks have the following additional limitations and restrictions:

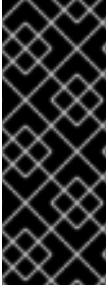
- The **ClusterVersion** status includes an **Unable to retrieve available updates** error.
- By default, you cannot use the contents of the Developer Catalog because you cannot access the required image stream tags.

### 14.3.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to obtain the images that are necessary to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



## IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

### 14.3.4. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

#### 14.3.4.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

**Table 14.18. Minimum required hosts**

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.



## IMPORTANT

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 7.9, or RHEL 8.4.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See [Red Hat Enterprise Linux technology capabilities and limits](#) .

#### 14.3.4.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

**Table 14.19. Minimum resource requirements**

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	2	16 GB	100 GB	300
Control plane	RHCOS	2	16 GB	100 GB	300
Compute	RHCOS	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio:  $(\text{threads per core} \times \text{cores}) \times \text{sockets} = \text{vCPUs}$ .
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.

#### 14.3.4.3. Minimum IBM Power requirements

You can install OpenShift Container Platform version 4.9 on the following IBM hardware:

- IBM Power8, Power9, or Power10 processor-based systems

##### Hardware requirements

- Six IBM Power bare metal servers or six LPARs across multiple PowerVM servers

##### Operating system requirements

- One instance of an IBM Power8, Power9, or Power10 processor-based system

On your IBM Power instance, set up:

- Three guest virtual machines for OpenShift Container Platform control plane machines
- Two guest virtual machines for OpenShift Container Platform compute machines
- One guest virtual machine for the temporary OpenShift Container Platform bootstrap machine

##### Disk storage for the IBM Power guest virtual machines

- Storage provisioned by the Virtual I/O Server using vSCSI, NPIV (N-Port ID Virtualization) or SSP (shared storage pools)

##### Network for the PowerVM guest virtual machines

- Virtualized by the Virtual I/O Server using Shared Ethernet Adapter

- Virtualized by the Virtual I/O Server using IBM vNIC

#### Storage / main memory

- 100 GB / 16 GB for OpenShift Container Platform control plane machines
- 100 GB / 8 GB for OpenShift Container Platform compute machines
- 100 GB / 16 GB for the temporary OpenShift Container Platform bootstrap machine

#### 14.3.4.4. Recommended IBM Power system requirements

##### Hardware requirements

- Six IBM Power bare metal servers or six LPARs across multiple PowerVM servers

##### Operating system requirements

- One instance of an IBM Power8, Power9, or Power10 processor-based system

On your IBM Power instance, set up:

- Three guest virtual machines for OpenShift Container Platform control plane machines
- Two guest virtual machines for OpenShift Container Platform compute machines
- One guest virtual machine for the temporary OpenShift Container Platform bootstrap machine

##### Disk storage for the IBM Power guest virtual machines

- Storage provisioned by the Virtual I/O Server using vSCSI, NPIV (N-Port ID Virtualization) or SSP (shared storage pools)

##### Network for the PowerVM guest virtual machines

- Virtualized by the Virtual I/O Server using Shared Ethernet Adapter
- Virtualized by the Virtual I/O Server using IBM vNIC

#### Storage / main memory

- 120 GB / 32 GB for OpenShift Container Platform control plane machines
- 120 GB / 32 GB for OpenShift Container Platform compute machines
- 120 GB / 16 GB for the temporary OpenShift Container Platform bootstrap machine

#### 14.3.4.5. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

#### 14.3.4.6. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.

It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.



#### NOTE

If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

##### 14.3.4.6.1. Setting the cluster node hostnames through DHCP

On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

##### 14.3.4.6.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.

**Table 14.20. Ports used for all-machine to all-machine communications**



Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	<b>1936</b>	Metrics
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> and the Cluster Version Operator on port <b>9099</b> .
	<b>10250-10259</b>	The default ports that Kubernetes reserves
	<b>10256</b>	openshift-sdn
UDP	<b>4789</b>	VXLAN and Geneve
	<b>6081</b>	VXLAN and Geneve
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> .
	<b>500</b>	IPsec IKE packets
	<b>4500</b>	IPsec NAT-T packets
TCP/UDP	<b>30000-32767</b>	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 14.21. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	<b>6443</b>	Kubernetes API

Table 14.22. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	<b>2379-2380</b>	etcd server and peer ports

### NTP configuration for user-provisioned infrastructure

OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service*.

If a DHCP server provides NTP server information, the chrony time service on the Red Hat Enterprise Linux CoreOS (RHCOS) machines read the information and can sync the clock with the NTP servers.

### Additional resources

- [Configuring chrony time service](#)

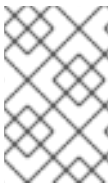
#### 14.3.4.7. User-provisioned DNS requirements

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API
- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines

Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.




### NOTE

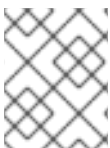
It is recommended to use a DHCP server to provide the hostnames to each cluster node. See the *DHCP recommendations for user-provisioned infrastructure* section for more information.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, **<cluster\_name>** is the cluster name and **<base\_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster\_name>.<base\_domain>..**

**Table 14.23. Required DNS records**

Component	Record	Description
Kubernetes API	<b>api.&lt;cluster_name&gt;.&lt;base_domain&gt;..</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.

Component	Record	Description
	<b>api-int.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	<p>A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>IMPORTANT</b></p> <p>The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.</p> </div> </div>
Routes	<b>*.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	<p>A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.</p> <p>For example, <b>console-openshift-console.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;</b> is used as a wildcard route to the OpenShift Container Platform console.</p>
Bootstrap machine	<b>bootstrap.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.
Control plane machines	<b>&lt;master&gt;&lt;n&gt;.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.
Compute machines	<b>&lt;worker&gt;&lt;n&gt;.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.



#### NOTE

In OpenShift Container Platform 4.4 and later, you do not need to specify etcd host and SRV records in your DNS configuration.

**TIP**

You can use the **dig** command to verify name and reverse name resolution. See the section on *Validating DNS resolution for user-provisioned infrastructure* for detailed validation steps.

**14.3.4.7.1. Example DNS configuration for user-provisioned clusters**

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is **ocp4** and the base domain is **example.com**.

**Example DNS A record configuration for a user-provisioned cluster**

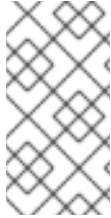
The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

**Example 14.4. Sample DNS zone database**

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H ; refresh (3 hours)
  30M ; retry (30 minutes)
  2W ; expiry (2 weeks)
  1W ) ; minimum (1 week)
IN NS ns1.example.com.
IN MX 10 smtp.example.com.
;
;
ns1.example.com. IN A 192.168.1.5
smtp.example.com. IN A 192.168.1.5
;
helper.example.com. IN A 192.168.1.5
helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com. IN A 192.168.1.5 1
api-int.ocp4.example.com. IN A 192.168.1.5 2
;
*.apps.ocp4.example.com. IN A 192.168.1.5 3
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 4
;
master0.ocp4.example.com. IN A 192.168.1.97 5
master1.ocp4.example.com. IN A 192.168.1.98 6
master2.ocp4.example.com. IN A 192.168.1.99 7
;
worker0.ocp4.example.com. IN A 192.168.1.11 8
worker1.ocp4.example.com. IN A 192.168.1.7 9
;
;EOF
```

- 1 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.

- 2 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.
- 3 Provides name resolution for the wildcard routes. The record refers to the IP address of the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



#### NOTE

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

- 4 Provides name resolution for the bootstrap machine.
- 5 6 7 Provides name resolution for the control plane machines.
- 8 9 Provides name resolution for the compute machines.

### Example DNS PTR record configuration for a user-provisioned cluster

The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

#### Example 14.5. Sample DNS zone database for reverse records

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H ; refresh (3 hours)
  30M ; retry (30 minutes)
  2W ; expiry (2 weeks)
  1W ) ; minimum (1 week)
IN NS ns1.example.com.
;
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. 2
;
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. 3
;
97.1.168.192.in-addr.arpa. IN PTR master0.ocp4.example.com. 4
98.1.168.192.in-addr.arpa. IN PTR master1.ocp4.example.com. 5
99.1.168.192.in-addr.arpa. IN PTR master2.ocp4.example.com. 6
;
11.1.168.192.in-addr.arpa. IN PTR worker0.ocp4.example.com. 7
7.1.168.192.in-addr.arpa. IN PTR worker1.ocp4.example.com. 8
;
;EOF
```

- 1 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.
- 2 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.
- 3 Provides reverse DNS resolution for the bootstrap machine.
- 4 5 6 Provides reverse DNS resolution for the control plane machines.
- 7 8 Provides reverse DNS resolution for the compute machines.

**NOTE**

A PTR record is not required for the OpenShift Container Platform application wildcard.

#### 14.3.4.8. Load balancing requirements for user-provisioned infrastructure

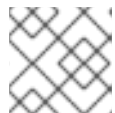
Before you install OpenShift Container Platform, you must provision the API and application ingress load balancing infrastructure. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

**NOTE**

If you want to deploy the API and application ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer.** Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:
  - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the API routes.
  - A stateless load balancing algorithm. The options vary based on the load balancer implementation.

**NOTE**

Session persistence is not required for the API load balancer to function properly.

Configure the following ports on both the front and back of the load balancers:

**Table 14.24. API load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
------	----------------------------------	----------	----------	-------------

Port	Back-end machines (pool members)	Internal	External	Description
<b>6443</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the <b>/readyz</b> endpoint for the API server health check probe.	X	X	Kubernetes API server
<b>22623</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server

**NOTE**

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the **/readyz** endpoint to the removal of the API server instance from the pool. Within the time frame after **/readyz** returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application ingress load balancer.** Provides an ingress point for application traffic flowing in from outside the cluster. Configure the following conditions:
  - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the ingress routes.
  - A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

**TIP**

If the true IP address of the client can be seen by the application ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

Configure the following ports on both the front and back of the load balancers:

**Table 14.25. Application ingress load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
<b>443</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic

Port	Back-end machines (pool members)	Internal	External	Description
80	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic
1936	The worker nodes that run the Ingress Controller pods, by default. You must configure the <b>/healthz/ready</b> endpoint for the ingress health check probe.	X	X	HTTP traffic

**NOTE**

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

**NOTE**

A working configuration for the Ingress router is required for an OpenShift Container Platform cluster. You must configure the Ingress router after the control plane initializes.

#### 14.3.4.8.1. Example load balancer configuration for user-provisioned clusters

This section provides an example API and application ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an **/etc/haproxy/haproxy.cfg** configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing one load balancing solution over another.

**NOTE**

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

#### Example 14.6. Sample API and application ingress load balancer configuration

```
global
  log      127.0.0.1 local2
  pidfile  /var/run/haproxy.pid
  maxconn  4000
  daemon
defaults
  mode      http
  log       global
  option    dontlognull
  option    http-server-close
  option    redispatch
```



```

retries          3
timeout http-request 10s
timeout queue    1m
timeout connect  10s
timeout client   1m
timeout server   1m
timeout http-keep-alive 10s
timeout check    10s
maxconn          3000
frontend stats
bind *:1936
mode            http
log             global
maxconn 10
stats enable
stats hide-version
stats refresh 30s
stats show-node
stats show-desc Stats for ocp4 cluster 1
stats auth admin:ocp4
stats uri /stats
listen api-server-6443 2
bind *:6443
mode tcp
server bootstrap bootstrap.ocp4.example.com:6443 check inter 1s backup 3
server master0 master0.ocp4.example.com:6443 check inter 1s
server master1 master1.ocp4.example.com:6443 check inter 1s
server master2 master2.ocp4.example.com:6443 check inter 1s
listen machine-config-server-22623 4
bind *:22623
mode tcp
server bootstrap bootstrap.ocp4.example.com:22623 check inter 1s backup 5
server master0 master0.ocp4.example.com:22623 check inter 1s
server master1 master1.ocp4.example.com:22623 check inter 1s
server master2 master2.ocp4.example.com:22623 check inter 1s
listen ingress-router-443 6
bind *:443
mode tcp
balance source
server worker0 worker0.ocp4.example.com:443 check inter 1s
server worker1 worker1.ocp4.example.com:443 check inter 1s
listen ingress-router-80 7
bind *:80
mode tcp
balance source
server worker0 worker0.ocp4.example.com:80 check inter 1s
server worker1 worker1.ocp4.example.com:80 check inter 1s

```

- 1** In the example, the cluster name is **ocp4**.
- 2** Port **6443** handles the Kubernetes API traffic and points to the control plane machines.
- 3** **5** The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.

- 4 Port **22623** handles the machine config server traffic and points to the control plane machines.
- 6 Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.
- 7 Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



#### NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

#### TIP

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltp** on the HAProxy node.



#### NOTE

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running **setsebool -P haproxy\_connect\_any=1**.

### 14.3.5. Preparing the user-provisioned infrastructure

Before you install OpenShift Container Platform on user-provisioned infrastructure, you must prepare the underlying infrastructure.

This section provides details about the high-level steps required to set up your cluster infrastructure in preparation for an OpenShift Container Platform installation. This includes configuring IP networking and network connectivity for your cluster nodes, enabling the required ports through your firewall, and setting up the required DNS and load balancing infrastructure.

After preparation, your cluster infrastructure must meet the requirements outlined in the *Requirements for a cluster with user-provisioned infrastructure* section.

#### Prerequisites

- You have reviewed the [OpenShift Container Platform 4.x Tested Integrations](#) page.
- You have reviewed the infrastructure requirements detailed in the *Requirements for a cluster with user-provisioned infrastructure* section.

#### Procedure

1. If you are using DHCP to provide the IP networking configuration to your cluster nodes, configure your DHCP service.

- a. Add persistent IP addresses for the nodes to your DHCP server configuration. In your configuration, match the MAC address of the relevant network interface to the intended IP address for each node.
- b. When you use DHCP to configure IP addressing for the cluster machines, the machines also obtain the DNS server information through DHCP. Define the persistent DNS server address that is used by the cluster nodes through your DHCP server configuration.

**NOTE**

If you are not using a DHCP service, you must provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

- c. Define the hostnames of your cluster nodes in your DHCP server configuration. See the *Setting the cluster node hostnames through DHCP* section for details about hostname considerations.

**NOTE**

If you are not using a DHCP service, the cluster nodes obtain their hostname through a reverse DNS lookup.

2. Ensure that your network infrastructure provides the required network connectivity between the cluster components. See the *Networking requirements for user-provisioned infrastructure* section for details about the requirements.
3. Configure your firewall to enable the ports required for the OpenShift Container Platform cluster components to communicate. See *Networking requirements for user-provisioned infrastructure* section for details about the ports that are required.
4. Setup the required DNS infrastructure for your cluster.
  - a. Configure DNS name resolution for the Kubernetes API, the application wildcard, the bootstrap machine, the control plane machines, and the compute machines.
  - b. Configure reverse DNS resolution for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.  
See the *User-provisioned DNS requirements* section for more information about the OpenShift Container Platform DNS requirements.
5. Validate your DNS configuration.
  - a. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses in the responses correspond to the correct components.
  - b. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names in the responses correspond to the correct components.  
See the *Validating DNS resolution for user-provisioned infrastructure* section for detailed DNS validation steps.

6. Provision the required API and application ingress load balancing infrastructure. See the *Load balancing requirements for user-provisioned infrastructure* section for more information about the requirements.

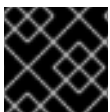


#### NOTE

Some load balancing solutions require the DNS name resolution for the cluster nodes to be in place before the load balancing is initialized.

### 14.3.6. Validating DNS resolution for user-provisioned infrastructure

You can validate your DNS configuration before installing OpenShift Container Platform on user-provisioned infrastructure.



#### IMPORTANT

The validation steps detailed in this section must succeed before you install your cluster.

#### Prerequisites

- You have configured the required DNS records for your user-provisioned infrastructure.

#### Procedure

1. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses contained in the responses correspond to the correct components.
  - a. Perform a lookup against the Kubernetes API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api.<cluster_name>.<base_domain> 1
```

- 1 Replace **<nameserver\_ip>** with the IP address of the nameserver, **<cluster\_name>** with your cluster name, and **<base\_domain>** with your base domain name.

#### Example output

```
api.ocp4.example.com. 0 IN A 192.168.1.5
```

- b. Perform a lookup against the Kubernetes internal API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api-int.<cluster_name>.<base_domain>
```

#### Example output

```
api-int.ocp4.example.com. 0 IN A 192.168.1.5
```

- c. Test an example **\*.apps.<cluster\_name>.<base\_domain>** DNS wildcard lookup. All of the application wildcard lookups must resolve to the IP address of the application ingress load balancer:

```
$ dig +noall +answer @<nameserver_ip> random.apps.<cluster_name>.<base_domain>
```

### Example output

```
random.apps.ocp4.example.com. 0 IN A 192.168.1.5
```



### NOTE

In the example outputs, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

You can replace **random** with another wildcard value. For example, you can query the route to the OpenShift Container Platform console:

```
$ dig +noall +answer @<nameserver_ip> console-openshift-console.apps.<cluster_name>.<base_domain>
```

### Example output

```
console-openshift-console.apps.ocp4.example.com. 0 IN A 192.168.1.5
```

- d. Run a lookup against the bootstrap DNS record name. Check that the result points to the IP address of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> bootstrap.<cluster_name>.<base_domain>
```

### Example output

```
bootstrap.ocp4.example.com. 0 IN A 192.168.1.96
```

- e. Use this method to perform lookups against the DNS record names for the control plane and compute nodes. Check that the results correspond to the IP addresses of each node.
2. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names contained in the responses correspond to the correct components.
    - a. Perform a reverse lookup against the IP address of the API load balancer. Check that the response includes the record names for the Kubernetes API and the Kubernetes internal API:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.5
```

### Example output

```
5.1.168.192.in-addr.arpa. 0 IN PTR api-int.ocp4.example.com. 1  
5.1.168.192.in-addr.arpa. 0 IN PTR api.ocp4.example.com. 2
```

- 1 Provides the record name for the Kubernetes internal API.
- 2 Provides the record name for the Kubernetes API.

**NOTE**

A PTR record is not required for the OpenShift Container Platform application wildcard. No validation step is needed for reverse DNS resolution against the IP address of the application ingress load balancer.

- b. Perform a reverse lookup against the IP address of the bootstrap node. Check that the result points to the DNS record name of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.96
```

**Example output**

```
96.1.168.192.in-addr.arpa. 0 IN PTR bootstrap.ocp4.example.com.
```

- c. Use this method to perform reverse lookups against the IP addresses for the control plane and compute nodes. Check that the results correspond to the DNS record names of each node.

### 14.3.7. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.

**IMPORTANT**

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

**NOTE**

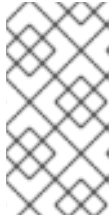
You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

**Procedure**

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.



#### NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.



#### NOTE

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

#### Example output

```
Agent pid 31874
```



#### NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1 Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

### Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

### Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

## 14.3.8. Manually creating the installation configuration file

For user-provisioned installations of OpenShift Container Platform, you manually generate your installation configuration file.

### Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

### Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```



#### IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation\_directory>**.



#### NOTE

You must name this configuration file **install-config.yaml**.

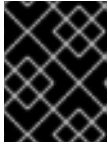


#### NOTE

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation\_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.



3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



### IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

#### 14.3.8.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide a customized **install-config.yaml** installation configuration file that describes the details for your environment.



### NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.



### IMPORTANT

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

##### 14.3.8.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 14.26. Required parameters

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;</b> . <b>&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .

Parameter	Description	Values
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}</b> . <b>{{.baseDomain}}</b> .	String of lowercase letters, hyphens (-), and periods (.), such as <b>dev</b> .
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws</b> , <b>baremetal</b> , <b>azure</b> , <b>gcp</b> , <b>openstack</b> , <b>ovirt</b> , <b>vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } }</pre>


#### 14.3.8.1.2. Network configuration parameters


You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

**Table 14.27. Network parameters**

Parameter	Description	Values
-----------	-------------	--------

Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	Object  <b>NOTE</b> You cannot modify parameters specified by the <b>networking</b> object after installation.
<b>networking.networkType</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .
<b>networking.clusterNetwork</b>	The IP address blocks for pods.  The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b> .  If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example:  <pre>networking:   clusterNetwork:     - cidr: 10.128.0.0/14       hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	Required if you use <b>networking.clusterNetwork</b> . An IP address block.  An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b> .
<b>networking.clusterNetwork.hostPrefix</b>	The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b> . A <b>hostPrefix</b> value of <b>23</b> provides 510 ( $2^{(32 - 23)} - 2$ ) pod IP addresses.	A subnet prefix.  The default value is <b>23</b> .
<b>networking.serviceNetwork</b>	The IP address block for services. The default value is <b>172.30.0.0/16</b> .  The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example:  <pre>networking:   serviceNetwork:     - 172.30.0.0/16</pre>


Parameter	Description	Values
<b>networking.machineNetwork</b>	<p>The IP address blocks for machines.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p> <p>If you specify multiple IP kernel arguments, the <b>machineNetwork.cidr</b> value must be the CIDR of the primary network.</p>	<p>An array of objects. For example:</p> <pre>networking:   machineNetwork:   - cidr: 10.0.0.0/16</pre>
<b>networking.machineNetwork.cidr</b>	<p>Required if you use <b>networking.machineNetwork</b>. An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b>.</p>	<p>An IP network block in CIDR notation.</p> <p>For example, <b>10.0.0.0/16</b>.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p> </div> </div>


#### 14.3.8.1.3. Optional configuration parameters



Optional installation configuration parameters are described in the following table:



Table 14.28. Optional parameters

Parameter	Description	Values
<b>additionalTrustBundle</b>	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
<b>compute</b>	The configuration for the machines that comprise the compute nodes.	Array of <b>MachinePool</b> objects.
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>ppc64le</b> (the default).	String


Parameter	Description	Values
<b>compute.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b>
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>ppc64le</b> (the default).	String

Parameter	Description	Values
<b>controlPlane.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platform</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b>
<b>controlPlane.replicas</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.

Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.</p> <div data-bbox="485 510 595 864" style="border: 1px solid black; padding: 5px; margin-bottom: 10px;">  </div> <p><b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators</i> reference content.</p> <div data-bbox="485 909 595 1263" style="border: 1px solid black; padding: 5px;">  </div> <p><b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p>	<b>Mint, Passthrough, Manual</b> or an empty string ("").

Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start;"> <div style="flex: 1;">  <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> <div style="flex: 1;">  <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<b>Internal</b> or <b>External</b> . The default value is <b>External</b> .  Setting this field to <b>Internal</b> is not supported on non-cloud platforms.



Parameter	Description	Values
<b>sshKey</b>	<p>The SSH key or keys to authenticate access your cluster machines.</p>  <p><b>NOTE</b></p> <p>For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.</p>	<p>One or more keys. For example:</p> <pre>sshKey:   &lt;key1&gt;   &lt;key2&gt;   &lt;key3&gt;</pre>

### 14.3.8.2. Sample install-config.yaml file for IBM Power

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```
apiVersion: v1
baseDomain: example.com 1
compute: 2
- hyperthreading: Enabled 3
  name: worker
  replicas: 0 4
  architecture : ppc64le
controlPlane: 5
  hyperthreading: Enabled 6
  name: master
  replicas: 3 7
  architecture : ppc64le
metadata:
  name: test 8
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14 9
    hostPrefix: 23 10
  networkType: OpenShiftSDN
  serviceNetwork: 11
```



- 8 The cluster name that you specified in your DNS records.
- 9 A block of IP addresses from which pod IP addresses are allocated. This block must not overlap with existing physical networks. These IP addresses are used for the pod network. If you need to access the pods from an external network, you must configure load balancers and routers to manage the traffic.



#### NOTE

Class E CIDR range is reserved for a future use. To use the Class E CIDR range, you must ensure your networking environment accepts the IP addresses within the Class E CIDR range.

- 10 The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23**, then each node is assigned a **/23** subnet out of the given **cidr**, which allows for 510 ( $2^{(32 - 23)} - 2$ ) pod IP addresses. If you are required to provide access to nodes from an external network, configure load balancers and routers to manage the traffic.
- 11 The IP address pool to use for service IP addresses. You can enter only one IP address pool. This block must not overlap with existing physical networks. If you need to access the services from an external network, configure load balancers and routers to manage the traffic.
- 12 You must set the platform to **none**. You cannot provide additional platform configuration variables for IBM Power infrastructure.



#### IMPORTANT

Clusters that are installed with the platform type **none** are unable to use some features, such as managing compute machines with the Machine API. This limitation applies even if the compute machines that are attached to the cluster are installed on a platform that would normally support the feature. This parameter cannot be changed after installation.

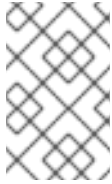
- 13 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.



#### IMPORTANT

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

- 14 For **<local\_registry>**, specify the registry domain name, and optionally the port, that your mirror registry uses to serve content. For example, **registry.example.com** or **registry.example.com:5000**. For **<credentials>**, specify the base64-encoded user name and password for your mirror registry.
- 15 The SSH public key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).

**NOTE**

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

- 16 Provide the contents of the certificate file that you used for your mirror registry.
- 17 Provide the **imageContentSources** section from the output of the command to mirror the repository.

**14.3.8.3. Configuring the cluster-wide proxy during installation**

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

**Prerequisites**

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

**NOTE**

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

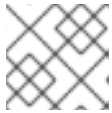
For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

**Procedure**

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
  additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
  ...
```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations.
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

**NOTE**

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

**NOTE**

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

#### 14.3.8.4. Configuring a three-node cluster

You can optionally deploy zero compute machines in a bare metal cluster that consists of three control plane machines only. This provides smaller, more resource efficient clusters for cluster administrators and developers to use for testing, development, and production.

In three-node OpenShift Container Platform environments, the three control plane machines are schedulable, which means that your application workloads are scheduled to run on them.

#### Prerequisites

- You have an existing **install-config.yaml** file.

#### Procedure

- Ensure that the number of compute replicas is set to **0** in your **install-config.yaml** file, as shown in the following **compute** stanza:

```
compute:
- name: worker
```

```
platform: {}
replicas: 0
```



## NOTE

You must set the value of the **replicas** parameter for the compute machines to **0** when you install OpenShift Container Platform on user-provisioned infrastructure, regardless of the number of compute machines you are deploying. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. This does not apply to user-provisioned installations, where the compute machines are deployed manually.

For three-node cluster installations, follow these next steps:

- If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes. See the *Load balancing requirements for user-provisioned infrastructure* section for more information.
- When you create the Kubernetes manifest files in the following procedure, ensure that the **mastersSchedulable** parameter in the `<installation_directory>/manifests/cluster-scheduler-02-config.yml` file is set to **true**. This enables your application workloads to run on the control plane nodes.
- Do not deploy any compute nodes when you create the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

### 14.3.9. Cluster Network Operator configuration

The configuration for the cluster network is specified as part of the Cluster Network Operator (CNO) configuration and stored in a custom resource (CR) object that is named **cluster**. The CR specifies the fields for the **Network** API in the **operator.openshift.io** API group.

The CNO configuration inherits the following fields during cluster installation from the **Network** API in the **Network.config.openshift.io** API group and these fields cannot be changed:

#### **clusterNetwork**

IP address pools from which pod IP addresses are allocated.

#### **serviceNetwork**

IP address pool for services.

#### **defaultNetwork.type**

Cluster network provider, such as OpenShift SDN or OVN-Kubernetes.

You can specify the cluster network provider configuration for your cluster by setting the fields for the **defaultNetwork** object in the CNO object named **cluster**.

#### 14.3.9.1. Cluster Network Operator configuration object

The fields for the Cluster Network Operator (CNO) are described in the following table:

**Table 14.29. Cluster Network Operator configuration object**


Field	Type	Description
<b>metadata.name</b>	<b>string</b>	The name of the CNO object. This name is always <b>cluster</b> .
<b>spec.clusterNetwork</b>	<b>array</b>	<p>A list specifying the blocks of IP addresses from which pod IP addresses are allocated and the subnet prefix length assigned to each individual node in the cluster. For example:</p> <pre>spec:   clusterNetwork:   - cidr: 10.128.0.0/19     hostPrefix: 23   - cidr: 10.128.32.0/19     hostPrefix: 23</pre> <p>You can customize this field only in the <b>install-config.yaml</b> file before you create the manifests. The value is read-only in the manifest file.</p>
<b>spec.serviceNetwork</b>	<b>array</b>	<p>A block of IP addresses for services. The OpenShift SDN and OVN-Kubernetes Container Network Interface (CNI) network providers support only a single IP address block for the service network. For example:</p> <pre>spec:   serviceNetwork:   - 172.30.0.0/14</pre> <p>You can customize this field only in the <b>install-config.yaml</b> file before you create the manifests. The value is read-only in the manifest file.</p>
<b>spec.defaultNetwork</b>	<b>object</b>	Configures the Container Network Interface (CNI) cluster network provider for the cluster network.
<b>spec.kubeProxy</b> <b>Config</b>	<b>object</b>	The fields for this object specify the kube-proxy configuration. If you are using the OVN-Kubernetes cluster network provider, the kube-proxy configuration has no effect.

### defaultNetwork object configuration

The values for the **defaultNetwork** object are defined in the following table:

Table 14.30. **defaultNetwork** object

Field	Type	Description
-------	------	-------------

Field	Type	Description
<b>type</b>	<b>string</b>	<p>Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b>. The cluster network provider is selected during installation. This value cannot be changed after cluster installation.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>OpenShift Container Platform uses the OpenShift SDN Container Network Interface (CNI) cluster network provider by default.</p> </div> </div>
<b>openshiftSDNConfig</b>	<b>object</b>	This object is only valid for the OpenShift SDN cluster network provider.
<b>ovnKubernetesConfig</b>	<b>object</b>	This object is only valid for the OVN-Kubernetes cluster network provider.

### Configuration for the OpenShift SDN CNI cluster network provider

The following table describes the configuration fields for the OpenShift SDN Container Network Interface (CNI) cluster network provider.

**Table 14.31. openshiftSDNConfig object**

Field	Type	Description
<b>mode</b>	<b>string</b>	<p>Configures the network isolation mode for OpenShift SDN. The default value is <b>NetworkPolicy</b>.</p> <p>The values <b>Multitenant</b> and <b>Subnet</b> are available for backwards compatibility with OpenShift Container Platform 3.x but are not recommended. This value cannot be changed after cluster installation.</p>



Field	Type	Description
<b>mtu</b>	<b>integer</b>	<p>The maximum transmission unit (MTU) for the VXLAN overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU.</p> <p>If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes.</p> <p>If your cluster requires different MTU values for different nodes, you must set this value to <b>50</b> less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of <b>9001</b>, and some have an MTU of <b>1500</b>, you must set this value to <b>1450</b>.</p> <p>This value cannot be changed after cluster installation.</p>
<b>vxlanPort</b>	<b>integer</b>	<p>The port to use for all VXLAN packets. The default value is <b>4789</b>. This value cannot be changed after cluster installation.</p> <p>If you are running in a virtualized environment with existing nodes that are part of another VXLAN network, then you might be required to change this. For example, when running an OpenShift SDN overlay on top of VMware NSX-T, you must select an alternate port for the VXLAN, because both SDNs use the same default VXLAN port number.</p> <p>On Amazon Web Services (AWS), you can select an alternate port for the VXLAN between port <b>9000</b> and port <b>9999</b>.</p>

### Example OpenShift SDN configuration

```
defaultNetwork:
  type: OpenShiftSDN
openshiftSDNConfig:
  mode: NetworkPolicy
  mtu: 1450
  vxlanPort: 4789
```

### Configuration for the OVN-Kubernetes CNI cluster network provider

The following table describes the configuration fields for the OVN-Kubernetes CNI cluster network provider.

Table 14.32. `ovnKubernetesConfig` object

Field	Type	Description
-------	------	-------------

Field	Type	Description
<b>mtu</b>	<b>integer</b>	<p>The maximum transmission unit (MTU) for the Geneve (Generic Network Virtualization Encapsulation) overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU.</p> <p>If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes.</p> <p>If your cluster requires different MTU values for different nodes, you must set this value to <b>100</b> less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of <b>9001</b>, and some have an MTU of <b>1500</b>, you must set this value to <b>1400</b>.</p> <p>This value cannot be changed after cluster installation.</p>
<b>genevePort</b>	<b>integer</b>	The port to use for all Geneve packets. The default value is <b>6081</b> . This value cannot be changed after cluster installation.
<b>ipsecConfig</b>	<b>object</b>	Specify an empty object to enable IPsec encryption. This value cannot be changed after cluster installation.
<b>policyAuditConfig</b>	<b>object</b>	Specify a configuration object for customizing network policy audit logging. If unset, the defaults audit log settings are used.

Table 14.33. **policyAuditConfig** object

Field	Type	Description
<b>rateLimit</b>	integer	The maximum number of messages to generate every second per node. The default value is <b>20</b> messages per second.
<b>maxFileSize</b>	integer	The maximum size for the audit log in bytes. The default value is <b>50000000</b> or 50 MB.

Field	Type	Description
<b>destination</b>	string	<p>One of the following additional audit log targets:</p> <p><b>libc</b> The libc <b>syslog()</b> function of the journald process on the host.</p> <p><b>udp:&lt;host&gt;:&lt;port&gt;</b> A syslog server. Replace <b>&lt;host&gt;:&lt;port&gt;</b> with the host and port of the syslog server.</p> <p><b>unix:&lt;file&gt;</b> A Unix Domain Socket file specified by <b>&lt;file&gt;</b>.</p> <p><b>null</b> Do not send the audit logs to any additional target.</p>
<b>syslogFacility</b>	string	The syslog facility, such as <b>kern</b> , as defined by RFC5424. The default value is <b>local0</b> .


### Example OVN-Kubernetes configuration

```
defaultNetwork:
  type: OVNKubernetes
  ovnKubernetesConfig:
    mtu: 1400
    genevePort: 6081
    ipsecConfig: {}
```

### kubeProxyConfig object configuration

The values for the **kubeProxyConfig** object are defined in the following table:

Table 14.34. **kubeProxyConfig** object

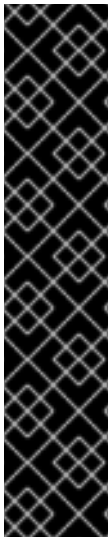
Field	Type	Description
<b>iptablesSyncPeriod</b>	<b>string</b>	<p>The refresh period for <b>iptables</b> rules. The default value is <b>30s</b>. Valid suffixes include <b>s</b>, <b>m</b>, and <b>h</b> and are described in the <a href="#">Go time package</a> documentation.</p> <div style="display: flex; align-items: flex-start;"> <div style="flex: 1;">  </div> <div style="flex: 2;"> <p><b>NOTE</b></p> <p>Because of performance improvements introduced in OpenShift Container Platform 4.3 and greater, adjusting the <b>iptablesSyncPeriod</b> parameter is no longer necessary.</p> </div> </div>

Field	Type	Description
<b>proxyArguments.iptables-min-sync-period</b>	<b>array</b>	<p>The minimum duration before refreshing <b>iptables</b> rules. This field ensures that the refresh does not happen too frequently. Valid suffixes include <b>s</b>, <b>m</b>, and <b>h</b> and are described in the <a href="#">Go time package</a>. The default value is:</p> <pre>kubeProxyConfig:   proxyArguments:     iptables-min-sync-period:       - 0s</pre>

### 14.3.10. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.



#### IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.



#### NOTE

The installation program that generates the manifest and Ignition files is architecture specific and can be obtained from the [client image mirror](#). The Linux version of the installation program runs on ppc64le only. This installer program is also available as a Mac OS version.

#### Prerequisites

- You obtained the OpenShift Container Platform installation program. For a restricted network installation, these files are on your mirror host.

- You created the **install-config.yaml** installation configuration file.

## Procedure

- Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

- For **<installation\_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.



### WARNING

If you are installing a three-node cluster, skip the following step to allow the control plane nodes to be schedulable.



### IMPORTANT

When you configure control plane nodes from the default unschedulable to schedulable, additional subscriptions are required. This is because control plane nodes then become worker nodes.

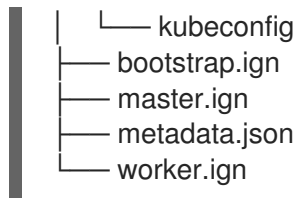
- Check that the **mastersSchedulable** parameter in the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:
  - Open the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** file.
  - Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.
  - Save and exit the file.
- To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

- For **<installation\_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation\_directory>/auth** directory:

```
.
├── auth
│   ├── kubeadmin-password
```



### 14.3.11. Installing RHCOS and starting the OpenShift Container Platform bootstrap process

To install OpenShift Container Platform on IBM Power infrastructure that you provision, you must install Red Hat Enterprise Linux CoreOS (RHCOS) on the machines. When you install RHCOS, you must provide the Ignition config file that was generated by the OpenShift Container Platform installation program for the type of machine you are installing. If you have configured suitable networking, DNS, and load balancing infrastructure, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS machines have rebooted.

Follow either the steps to use an ISO image or network PXE booting to install RHCOS on the machines.

#### 14.3.11.1. Installing RHCOS by using an ISO image

You can use an ISO image to install RHCOS on the machines.

#### Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have an HTTP server that can be accessed from your computer, and from the machines that you create.
- You have reviewed the *Advanced RHCOS installation configuration* section for different ways to configure features, such as networking and disk partitioning.

#### Procedure

1. Obtain the SHA512 digest for each of your Ignition config files. For example, you can use the following on a system running Linux to get the SHA512 digest for your **bootstrap.ign** Ignition config file:

```
$ sha512sum <installation_directory>/bootstrap.ign
```

The digests are provided to the **coreos-installer** in a later step to validate the authenticity of the Ignition config files on the cluster nodes.

2. Upload the bootstrap, control plane, and compute node Ignition config files that the installation program created to your HTTP server. Note the URLs of these files.



#### IMPORTANT

You can add or change configuration settings in your Ignition configs before saving them to your HTTP server. If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

- From the installation host, validate that the Ignition config files are available on the URLs. The following example gets the Ignition config file for the bootstrap node:

```
$ curl -k http://<HTTP_server>/bootstrap.ign 1
```

### Example output

```
% Total % Received % Xferd Average Speed Time Time Time Current
          Dload Upload Total Spent Left Speed
 0  0  0  0  0  0  0 --:--:-- --:--:-- --:--:-- 0{"ignition":
{"version":"3.2.0"},"passwd":{"users":[{"name":"core","sshAuthorizedKeys":["ssh-rsa...
```

Replace **bootstrap.ign** with **master.ign** or **worker.ign** in the command to validate that the Ignition config files for the control plane and compute nodes are also available.

- Although it is possible to obtain the RHCOS images that are required for your preferred method of installing operating system instances from the [RHCOS image mirror](#) [RHCOS image mirror](#) page, the recommended way to obtain the correct version of your RHCOS images are from the output of **openshift-install** command:

```
$ openshift-install coreos print-stream-json | grep '\.iso[^\.]'
```

### Example output

```
"location": "<url>/art/storage/releases/rhcos-4.9-aarch64/<release>/aarch64/rhcos-
<release>-live.aarch64.iso",
"location": "<url>/art/storage/releases/rhcos-4.9-ppc64le/<release>/ppc64le/rhcos-<release>-
live.ppc64le.iso",
"location": "<url>/art/storage/releases/rhcos-4.9-s390x/<release>/s390x/rhcos-<release>-
live.s390x.iso",
"location": "<url>/art/storage/releases/rhcos-4.9/<release>/x86_64/rhcos-<release>-
live.x86_64.iso",
```



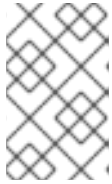
### IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image versions that match your OpenShift Container Platform version if they are available. Use only ISO images for this procedure. RHCOS qcow2 images are not supported for this installation type.

ISO file names resemble the following example:

**rhcos-<version>-live.<architecture>.iso**

- Use the ISO to start the RHCOS installation. Use one of the following installation options:
  - Burn the ISO image to a disk and boot it directly.
  - Use ISO redirection by using a lights-out management (LOM) interface.
- Boot the RHCOS ISO image without specifying any options or interrupting the live boot sequence. Wait for the installer to boot into a shell prompt in the RHCOS live environment.

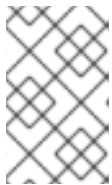
**NOTE**

It is possible to interrupt the RHCOS installation boot process to add kernel arguments. However, for this ISO procedure you should use the **coreos-installer** command as outlined in the following steps, instead of adding kernel arguments.

7. Run the **coreos-installer** command and specify the options that meet your installation requirements. At a minimum, you must specify the URL that points to the Ignition config file for the node type, and the device that you are installing to:

```
$ sudo coreos-installer install --ignition-url=http://<HTTP_server>/<node_type>.ign <device>
--ignition-hash=sha512-<digest> 1 2
```

- 1 You must run the **coreos-installer** command by using **sudo**, because the **core** user does not have the required root privileges to perform the installation.
- 2 The **--ignition-hash** option is required when the Ignition config file is obtained through an HTTP URL to validate the authenticity of the Ignition config file on the cluster node. **<digest>** is the Ignition config file SHA512 digest obtained in a preceding step.

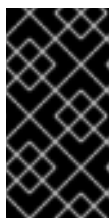
**NOTE**

If you want to provide your Ignition config files through an HTTPS server that uses TLS, you can add the internal certificate authority (CA) to the system trust store before running **coreos-installer**.

The following example initializes a bootstrap node installation to the **/dev/sda** device. The Ignition config file for the bootstrap node is obtained from an HTTP web server with the IP address 192.168.1.2:

```
$ sudo coreos-installer install --ignition-
url=http://192.168.1.2:80/installation_directory/bootstrap.ign /dev/sda --ignition-hash=sha512-
a5a2d43879223273c9b60af66b44202a1d1248fc01cf156c46d4a79f552b6bad47bc8cc78ddf011
6e80c59d2ea9e32ba53bc807afbca581aa059311def2c3e3b
```

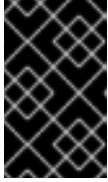
8. Monitor the progress of the RHCOS installation on the console of the machine.

**IMPORTANT**

Be sure that the installation is successful on each node before commencing with the OpenShift Container Platform installation. Observing the installation process can also help to determine the cause of RHCOS installation issues that might arise.

9. After RHCOS installs, you must reboot the system. During the system reboot, it applies the Ignition config file that you specified.
10. Continue to create the other machines for your cluster.





## IMPORTANT

You must create the bootstrap and control plane machines at this time. If the control plane machines are not made schedulable, also create at least two compute machines before you install OpenShift Container Platform.

If the required network, DNS, and load balancer infrastructure are in place, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS nodes have rebooted.



## NOTE

RHCOS nodes do not include a default password for the **core** user. You can access the nodes by running **ssh core@<node>.<cluster\_name>.<base\_domain>** as a user with access to the SSH private key that is paired to the public key that you specified in your **install\_config.yaml** file. OpenShift Container Platform 4 cluster nodes running RHCOS are immutable and rely on Operators to apply cluster changes. Accessing cluster nodes by using SSH is not recommended. However, when investigating installation issues, if the OpenShift Container Platform API is not available, or the kubelet is not properly functioning on a target node, SSH access might be required for debugging or disaster recovery.

### 14.3.11.1.1. Advanced RHCOS installation reference

This section illustrates the networking configuration and other advanced options that allow you to modify the Red Hat Enterprise Linux CoreOS (RHCOS) manual installation process. The following tables describe the kernel arguments and command-line options you can use with the RHCOS live installer and the **coreos-installer** command.

#### 14.3.11.1.1.1. Networking and bonding options for ISO installations

If you install RHCOS from an ISO image, you can add kernel arguments manually when you boot the image to configure networking for a node. If no networking arguments are specified, DHCP is activated in the initramfs when RHCOS detects that networking is required to fetch the Ignition config file.



## IMPORTANT

When adding networking arguments manually, you must also add the **rd.neednet=1** kernel argument to bring the network up in the initramfs.

The following table provides examples for configuring networking and bonding on your RHCOS nodes for ISO installations. The examples describe how to use the **ip=**, **nameserver=**, and **bond=** kernel arguments.

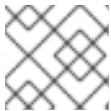


## NOTE

Ordering is important when adding the kernel arguments: **ip=**, **nameserver=**, and then **bond=**.

The networking options are passed to the **dracut** tool during system boot. For more information about the networking options supported by **dracut**, see the **dracut.cmdline** manual page.

The following information provides examples for configuring networking on your RHCOS nodes for ISO installations. The examples describe how to use the **ip=** and **nameserver=** kernel arguments.



## NOTE

Ordering is important when adding the kernel arguments: **ip=** and **nameserver=**.

The networking options are passed to the **dracut** tool during system boot. For more information about the networking options supported by **dracut**, see the **dracut.cmdline** manual page.

The following examples are the networking options for ISO installation.

### Configuring DHCP or static IP addresses

To configure an IP address, either use DHCP (**ip=dhcp**) or set an individual static IP address (**ip=<host\_ip>**). If setting a static IP, you must then identify the DNS server IP address (**nameserver=<dns\_ip>**) on each node. The following example sets:

- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The hostname to **core0.example.com**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none  
nameserver=4.4.4.41
```



## NOTE

When you use DHCP to configure IP addressing for the RHCOS machines, the machines also obtain the DNS server information through DHCP. For DHCP-based deployments, you can define the DNS server address that is used by the RHCOS nodes through your DHCP server configuration.

### Configuring an IP address without a static hostname

You can configure an IP address without assigning a static hostname. If a static hostname is not set by the user, it will be picked up and automatically set by a reverse DNS lookup. To configure an IP address without a static hostname refer to the following example:

- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0::enp1s0:none
nameserver=4.4.4.41
```

#### Specifying multiple network interfaces

You can specify multiple network interfaces by setting multiple **ip=** entries.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=10.10.10.3::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

#### Configuring default gateway and route

Optional: You can configure routes to additional networks by setting an **rd.route=** value.



#### NOTE

When you configure one or multiple networks, one default gateway is required. If the additional network gateway is different from the primary network gateway, the default gateway must be the primary network gateway.

- Run the following command to configure the default gateway:

```
ip=::10.10.10.254:::
```

- Enter the following command to configure the route for the additional network:

```
rd.route=20.20.20.0/24:20.20.20.254:enp2s0
```

#### Disabling DHCP on a single interface

You can disable DHCP on a single interface, such as when there are two or more network interfaces and only one interface is being used. In the example, the **enp1s0** interface has a static networking configuration and DHCP is disabled for **enp2s0**, which is not used:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=::::core0.example.com:enp2s0:none
```

#### Combining DHCP and static IP configurations

You can combine DHCP and static IP configurations on systems with multiple network interfaces, for example:

```
ip=enp1s0:dhcp
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

#### Configuring VLANs on individual interfaces

Optional: You can configure VLANs on individual interfaces by using the **vlan=** parameter.

- To configure a VLAN on a network interface and use a static IP address, run the following command:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0.100:none
vlan=enp2s0.100:enp2s0
```

- To configure a VLAN on a network interface and to use DHCP, run the following command:

```
ip=enp2s0.100:dhcp
vlan=enp2s0.100:enp2s0
```

Providing multiple DNS servers

You can provide multiple DNS servers by adding a **nameserver=** entry for each server, for example:

```
nameserver=1.1.1.1
nameserver=8.8.8.8
```

Bonding multiple network interfaces to a single interface

Optional: You can bond multiple network interfaces to a single interface by using the **bond=** option. Refer to the following examples:

- The syntax for configuring a bonded interface is: **bond=name[:network\_interfaces][:options]** *name* is the bonding device name (**bond0**), *network\_interfaces* represents a comma-separated list of physical (ethernet) interfaces (**em1,em2**), and *options* is a comma-separated list of bonding options. Enter **modinfo bonding** to see available options.
- When you create a bonded interface using **bond=**, you must specify how the IP address is assigned and other information for the bonded interface.
- To configure the bonded interface to use DHCP, set the bond's IP address to **dhcp**. For example:

```
bond=bond0:em1,em2:mode=active-backup
ip=bond0:dhcp
```

- To configure the bonded interface to use a static IP address, enter the specific IP address you want and related information. For example:

```
bond=bond0:em1,em2:mode=active-backup
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0:none
```

Bonding multiple network interfaces to a single interface

Optional: You can configure VLANs on bonded interfaces by using the **vlan=** parameter and to use DHCP, for example:

```
ip=bond0.100:dhcp
bond=bond0:em1,em2:mode=active-backup
vlan=bond0.100:bond0
```

Use the following example to configure the bonded interface with a VLAN and to use a static IP address:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0.100:none
bond=bond0:em1,em2:mode=active-backup
vlan=bond0.100:bond0
```

Using network teaming

Optional: You can use a network teaming as an alternative to bonding by using the **team=** parameter:

- The syntax for configuring a team interface is: **team=name[:network\_interfaces]** *name* is the team device name (**team0**) and *network\_interfaces* represents a comma-separated list of physical (ethernet) interfaces (**em1, em2**).

Teaming is planned to be deprecated when RHCOS switches to an upcoming version of RHEL. For more information, see this [Red Hat Knowledgebase Article](#).

Use the following example to configure a network team:

```
team=team0:em1,em2
ip=team0:dhcp
```

### 14.3.11.2. Installing RHCOS by using PXE booting

You can use PXE booting to install RHCOS on the machines.

#### Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have configured suitable PXE infrastructure.
- You have an HTTP server that can be accessed from your computer, and from the machines that you create.
- You have reviewed the *Advanced RHCOS installation configuration* section for different ways to configure features, such as networking and disk partitioning.

#### Procedure

1. Upload the bootstrap, control plane, and compute node Ignition config files that the installation program created to your HTTP server. Note the URLs of these files.



#### IMPORTANT

You can add or change configuration settings in your Ignition configs before saving them to your HTTP server. If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

2. From the installation host, validate that the Ignition config files are available on the URLs. The following example gets the Ignition config file for the bootstrap node:

```
$ curl -k http://<HTTP_server>/bootstrap.ign 1
```

#### Example output

```
% Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
           Dload  Upload  Total   Spent    Left    Speed
  0   0   0   0   0   0   0   0  0  --:--:-- --:--:-- --:--:--    0{"ignition":
{"version":"3.2.0"},"passwd":{"users":[{"name":"core","sshAuthorizedKeys":["ssh-rsa...
```

Replace **bootstrap.ign** with **master.ign** or **worker.ign** in the command to validate that the Ignition config files for the control plane and compute nodes are also available.

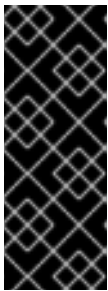
3. Although it is possible to obtain the RHCOS **kernel**, **initramfs** and **rootfs** files that are required

for your preferred method of installing operating system instances from the [RHCOS image mirror](#) page, the recommended way to obtain the correct version of your RHCOS files are from the output of **openshift-install** command:

```
$ openshift-install coreos print-stream-json | grep -Eo "'https.*(kernel-|initramfs.|rootfs.)w+(\.img)?"'
```

### Example output

```
"<url>/art/storage/releases/rhcos-4.9-aarch64/<release>/aarch64/rhcos-<release>-live-
kernel-aarch64"
"<url>/art/storage/releases/rhcos-4.9-aarch64/<release>/aarch64/rhcos-<release>-live-
initramfs.aarch64.img"
"<url>/art/storage/releases/rhcos-4.9-aarch64/<release>/aarch64/rhcos-<release>-live-
rootfs.aarch64.img"
"<url>/art/storage/releases/rhcos-4.9-ppc64le/49.84.202110081256-0/ppc64le/rhcos-
<release>-live-kernel-ppc64le"
"<url>/art/storage/releases/rhcos-4.9-ppc64le/<release>/ppc64le/rhcos-<release>-live-
initramfs.ppc64le.img"
"<url>/art/storage/releases/rhcos-4.9-ppc64le/<release>/ppc64le/rhcos-<release>-live-
rootfs.ppc64le.img"
"<url>/art/storage/releases/rhcos-4.9-s390x/<release>/s390x/rhcos-<release>-live-kernel-
s390x"
"<url>/art/storage/releases/rhcos-4.9-s390x/<release>/s390x/rhcos-<release>-live-
initramfs.s390x.img"
"<url>/art/storage/releases/rhcos-4.9-s390x/<release>/s390x/rhcos-<release>-live-
rootfs.s390x.img"
"<url>/art/storage/releases/rhcos-4.9/<release>/x86_64/rhcos-<release>-live-kernel-x86_64"
"<url>/art/storage/releases/rhcos-4.9/<release>/x86_64/rhcos-<release>-live-
initramfs.x86_64.img"
"<url>/art/storage/releases/rhcos-4.9/<release>/x86_64/rhcos-<release>-live-
rootfs.x86_64.img"
```



### IMPORTANT

The RHCOS artifacts might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Only use the appropriate **kernel**, **initramfs**, and **rootfs** artifacts described below for this procedure. RHCOS QCOW2 images are not supported for this installation type.

The file names contain the OpenShift Container Platform version number. They resemble the following examples:

- **kernel:** rhcos-<version>-live-kernel-<architecture>
- **initramfs:** rhcos-<version>-live-initramfs.<architecture>.img
- **rootfs:** rhcos-<version>-live-rootfs.<architecture>.img

4. Upload the **rootfs**, **kernel**, and **initramfs** files to your HTTP server.



## IMPORTANT

If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

- Configure the network boot infrastructure so that the machines boot from their local disks after RHCOS is installed on them.
- Configure PXE installation for the RHCOS images and begin the installation. Modify the following example menu entry for your environment and verify that the image and Ignition files are properly accessible:

```

DEFAULT pxeboot
TIMEOUT 20
PROMPT 0
LABEL pxeboot
  KERNEL http://<HTTP_server>/rhcos-<version>-live-kernel-<architecture> 1
  APPEND initrd=http://<HTTP_server>/rhcos-<version>-live-initramfs.<architecture>.img
  coreos.live.rootfs_url=http://<HTTP_server>/rhcos-<version>-live-rootfs.<architecture>.img
  coreos.inst.install_dev=/dev/sda coreos.inst.ignition_url=http://<HTTP_server>/bootstrap.ign
2 3

```

- 1** Specify the location of the live **kernel** file that you uploaded to your HTTP server. The URL must be HTTP, TFTP, or FTP; HTTPS and NFS are not supported.
- 2** If you use multiple NICs, specify a single interface in the **ip** option. For example, to use DHCP on a NIC that is named **eno1**, set **ip=eno1:dhcp**.
- 3** Specify the locations of the RHCOS files that you uploaded to your HTTP server. The **initrd** parameter value is the location of the **initramfs** file, the **coreos.live.rootfs\_url** parameter value is the location of the **rootfs** file, and the **coreos.inst.ignition\_url** parameter value is the location of the bootstrap Ignition config file. You can also add more kernel arguments to the **APPEND** line to configure networking or other boot options.



## NOTE

This configuration does not enable serial console access on machines with a graphical console. To configure a different console, add one or more **console=** arguments to the **APPEND** line. For example, add **console=tty0 console=ttyS0** to set the first PC serial port as the primary console and the graphical console as a secondary console. For more information, see [How does one set up a serial terminal and/or console in Red Hat Enterprise Linux?](#).

- Monitor the progress of the RHCOS installation on the console of the machine.



## IMPORTANT

Be sure that the installation is successful on each node before commencing with the OpenShift Container Platform installation. Observing the installation process can also help to determine the cause of RHCOS installation issues that might arise.

8. After RHCOS installs, the system reboots. During reboot, the system applies the Ignition config file that you specified.
9. Continue to create the machines for your cluster.



### IMPORTANT

You must create the bootstrap and control plane machines at this time. If the control plane machines are not made schedulable, also create at least two compute machines before you install the cluster.

If the required network, DNS, and load balancer infrastructure are in place, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS nodes have rebooted.



### NOTE

RHCOS nodes do not include a default password for the **core** user. You can access the nodes by running **ssh core@<node>.<cluster\_name>.<base\_domain>** as a user with access to the SSH private key that is paired to the public key that you specified in your **install\_config.yaml** file. OpenShift Container Platform 4 cluster nodes running RHCOS are immutable and rely on Operators to apply cluster changes. Accessing cluster nodes by using SSH is not recommended. However, when investigating installation issues, if the OpenShift Container Platform API is not available, or the kubelet is not properly functioning on a target node, SSH access might be required for debugging or disaster recovery.

#### 14.3.11.3. Enabling multipathing with kernel arguments on RHCOS

In OpenShift Container Platform 4.9 or later, during installation, you can enable multipathing for provisioned nodes. RHCOS supports multipathing on the primary disk. Multipathing provides added benefits of stronger resilience to hardware failure to achieve higher host availability.

During the initial cluster creation, you might want to add kernel arguments to all master or worker nodes. To add kernel arguments to master or worker nodes, you can create a **MachineConfig** object and inject that object into the set of manifest files used by Ignition during cluster setup.

#### Procedure

1. Change to the directory that contains the installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory>
```

2. Decide if you want to add kernel arguments to worker or control plane nodes.
  - Create a machine config file. For example, create a **99-master-kargs-mpath.yaml** that instructs the cluster to add the **master** label and identify the multipath kernel argument:

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: "master"
```



```

name: 99-master-kargs-mpath
spec:
  kernelArguments:
    - 'rd.multipath=default'
    - 'root=/dev/disk/by-label/dm-mpath-root'

```

3. To enable multipathing post-installation on worker nodes:

- Create a machine config file. For example, create a **99-worker-kargs-mpath.yaml** that instructs the cluster to add the **worker** label and identify the multipath kernel argument:

```

apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: "worker"
  name: 99-worker-kargs-mpath
spec:
  kernelArguments:
    - 'rd.multipath=default'
    - 'root=/dev/disk/by-label/dm-mpath-root'

```

You can now continue on to create the cluster.



### IMPORTANT

Additional post-installation steps are required to fully enable multipathing. For more information, see “Enabling multipathing with kernel arguments on RHCOS” in *Post-installation machine configuration tasks*.

In case of MPIO failure, use the `bootlist` command to update the boot device list with alternate logical device names. The command displays a boot list and it designates the possible boot devices for when the system is booted in normal mode.

- To display a boot list and specify the possible boot devices if the system is booted in normal mode, enter the following command:

```

$ bootlist -m normal -o
sda

```

- To update the boot list for normal mode and add alternate device names, enter the following command:

```

$ bootlist -m normal -o /dev/sdc /dev/sdd /dev/sde
sdc
sdd
sde

```

If the original boot disk path is down, the node reboots from the alternate device registered in the normal boot device list.

### 14.3.12. Waiting for the bootstrap process to complete

The OpenShift Container Platform bootstrap process begins after the cluster nodes first boot into the

persistent RHCOS environment that has been installed to disk. The configuration information provided through the Ignition config files is used to initialize the bootstrap process and install OpenShift Container Platform on the machines. You must wait for the bootstrap process to complete.

## Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have obtained the installation program and generated the Ignition config files for your cluster.
- You installed RHCOS on your cluster machines and provided the Ignition config files that the OpenShift Container Platform installation program generated.

## Procedure

1. Monitor the bootstrap process:

```
$ ./openshift-install --dir <installation_directory> wait-for bootstrap-complete \ 1  
--log-level=info 2
```

- 1 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

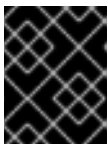
- 2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

## Example output

```
INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...  
INFO API v1.22.1 up  
INFO Waiting up to 30m0s for bootstrapping to complete...  
INFO It is now safe to remove the bootstrap resources
```

The command succeeds when the Kubernetes API server signals that it has been bootstrapped on the control plane machines.

2. After bootstrap process is complete, remove the bootstrap machine from the load balancer.



### IMPORTANT

You must remove the bootstrap machine from the load balancer at this point. You can also remove or reformat the bootstrap machine itself.

## 14.3.13. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

## Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

### Example output

```
system:admin
```

## 14.3.14. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

### Prerequisites

- You added machines to your cluster.

### Procedure

1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

### Example output

```
NAME      STATUS   ROLES    AGE   VERSION
master-0  Ready    master   63m   v1.22.1
master-1  Ready    master   63m   v1.22.1
master-2  Ready    master   64m   v1.22.1
```

The output lists all of the machines that you created.



### NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

- Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

### Example output

```
NAME      AGE   REQUESTOR                                     CONDITION
csr-8b2br 15m   system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper Pending
csr-8vnps 15m   system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper Pending
...
```

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

- If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:



#### NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.



#### NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{\n"}\n{{end}}\n' | xargs --no-run-if-empty oc adm certificate approve
```

**NOTE**

Some Operators might not become available until some CSRs are approved.

- Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

**Example output**

```
NAME      AGE   REQUESTOR                                     CONDITION
csr-bfd72 5m26s system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv 5m26s system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

- If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{\n"}\n{{end}}\n' | xargs oc adm certificate approve
```

- After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

**Example output**

```
NAME      STATUS  ROLES  AGE  VERSION
master-0  Ready   master 73m  v1.22.1
master-1  Ready   master 73m  v1.22.1
master-2  Ready   master 74m  v1.22.1
worker-0  Ready   worker 11m  v1.22.1
worker-1  Ready   worker 11m  v1.22.1
```

**NOTE**

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

**Additional information**

- For more information on CSRs, see [Certificate Signing Requests](#).

**14.3.15. Initial Operator configuration**

After the control plane initializes, you must immediately configure some Operators so that they all become available.

**Prerequisites**

- Your control plane has initialized.

**Procedure**

1. Watch the cluster components come online:

```
$ watch -n5 oc get clusteroperators
```

**Example output**

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
authentication	4.9.0	True	False	False	19m
baremetal	4.9.0	True	False	False	37m
cloud-credential	4.9.0	True	False	False	40m
cluster-autoscaler	4.9.0	True	False	False	37m
config-operator	4.9.0	True	False	False	38m
console	4.9.0	True	False	False	26m
csi-snapshot-controller	4.9.0	True	False	False	37m
dns	4.9.0	True	False	False	37m
etcd	4.9.0	True	False	False	36m
image-registry	4.9.0	True	False	False	31m
ingress	4.9.0	True	False	False	30m
insights	4.9.0	True	False	False	31m
kube-apiserver	4.9.0	True	False	False	26m
kube-controller-manager	4.9.0	True	False	False	36m
kube-scheduler	4.9.0	True	False	False	36m
kube-storage-version-migrator	4.9.0	True	False	False	37m
machine-api	4.9.0	True	False	False	29m
machine-approver	4.9.0	True	False	False	37m
machine-config	4.9.0	True	False	False	36m
marketplace	4.9.0	True	False	False	37m
monitoring	4.9.0	True	False	False	29m
network	4.9.0	True	False	False	38m
node-tuning	4.9.0	True	False	False	37m
openshift-apiserver	4.9.0	True	False	False	32m
openshift-controller-manager	4.9.0	True	False	False	30m
openshift-samples	4.9.0	True	False	False	32m

operator-lifecycle-manager	4.9.0	True	False	False	37m
operator-lifecycle-manager-catalog	4.9.0	True	False	False	37m
operator-lifecycle-manager-packageserver	4.9.0	True	False	False	32m
service-ca	4.9.0	True	False	False	38m
storage	4.9.0	True	False	False	37m

2. Configure the Operators that are not available.

### 14.3.15.1. Disabling the default OperatorHub sources

Operator catalogs that source content provided by Red Hat and community projects are configured for OperatorHub by default during an OpenShift Container Platform installation. In a restricted network environment, you must disable the default catalogs as a cluster administrator.

#### Procedure

- Disable the sources for the default catalogs by adding **disableAllDefaultSources: true** to the **OperatorHub** object:

```
$ oc patch OperatorHub cluster --type json \
  -p '[{"op": "add", "path": "/spec/disableAllDefaultSources", "value": true}]'
```

#### TIP

Alternatively, you can use the web console to manage catalog sources. From the **Administration** → **Cluster Settings** → **Configuration** → **OperatorHub** page, click the **Sources** tab, where you can create, delete, disable, and enable individual sources.

### 14.3.15.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

#### 14.3.15.2.1. Changing the image registry's management state

To start the image registry, you must change the Image Registry Operator configuration's **managementState** from **Removed** to **Managed**.

#### Procedure

- Change **managementState** Image Registry Operator configuration from **Removed** to **Managed**. For example:

```
$ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec": {"managementState": "Managed"}}'
```

### 14.3.15.2.2. Configuring registry storage for IBM Power

As a cluster administrator, following installation you must configure your registry to use storage.

#### Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.
- You have a cluster on IBM Power.
- You have provisioned persistent storage for your cluster, such as Red Hat OpenShift Container Storage.



#### IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have 100Gi capacity.

#### Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.



#### NOTE

When using shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

#### Example output

```
No resources found in openshift-image-registry namespace
```



#### NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

#### Example output



```
storage:
  pvc:
    claim:
```

Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** PVC.

4. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

#### Example output

```
NAME          VERSION      AVAILABLE  PROGRESSING  DEGRADED  SINCE
MESSAGE
image-registry 4.9          True       False        False     6h50m
```

5. Ensure that your registry is set to managed to enable building and pushing of images.

- Run:

```
$ oc edit configs.imageregistry/cluster
```

Then, change the line

```
managementState: Removed
```

to

```
managementState: Managed
```

#### 14.3.15.2.3. Configuring storage for the image registry in non-production clusters

You must configure storage for the Image Registry Operator. For non-production clusters, you can set the image registry to an empty directory. If you do so, all images are lost if you restart the registry.

#### Procedure

- To set the image registry storage to an empty directory:

```
$ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec": {"storage":{"emptyDir":{}}}}'
```



#### WARNING

Configure this option for only non-production clusters.

If you run this command before the Image Registry Operator initializes its components, the **oc patch** command fails with the following error:

```
Error from server (NotFound): configs.imageregistry.operator.openshift.io "cluster" not found
```

Wait a few minutes and run the command again.

### 14.3.16. Completing installation on user-provisioned infrastructure

After you complete the Operator configuration, you can finish installing the cluster on infrastructure that you provide.

#### Prerequisites

- Your control plane has initialized.
- You have completed the initial Operator configuration.

#### Procedure

1. Confirm that all the cluster components are online with the following command:

```
$ watch -n5 oc get clusteroperators
```

#### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
authentication	4.9.0	True	False	False	19m
baremetal	4.9.0	True	False	False	37m
cloud-credential	4.9.0	True	False	False	40m
cluster-autoscaler	4.9.0	True	False	False	37m
config-operator	4.9.0	True	False	False	38m
console	4.9.0	True	False	False	26m
csi-snapshot-controller	4.9.0	True	False	False	37m
dns	4.9.0	True	False	False	37m
etcd	4.9.0	True	False	False	36m
image-registry	4.9.0	True	False	False	31m
ingress	4.9.0	True	False	False	30m
insights	4.9.0	True	False	False	31m
kube-apiserver	4.9.0	True	False	False	26m
kube-controller-manager	4.9.0	True	False	False	36m
kube-scheduler	4.9.0	True	False	False	36m
kube-storage-version-migrator	4.9.0	True	False	False	37m
machine-api	4.9.0	True	False	False	29m
machine-approver	4.9.0	True	False	False	37m
machine-config	4.9.0	True	False	False	36m
marketplace	4.9.0	True	False	False	37m
monitoring	4.9.0	True	False	False	29m
network	4.9.0	True	False	False	38m
node-tuning	4.9.0	True	False	False	37m
openshift-apiserver	4.9.0	True	False	False	32m
openshift-controller-manager	4.9.0	True	False	False	30m
openshift-samples	4.9.0	True	False	False	32m

operator-lifecycle-manager	4.9.0	True	False	False	37m
operator-lifecycle-manager-catalog	4.9.0	True	False	False	37m
operator-lifecycle-manager-packageserver	4.9.0	True	False	False	32m
service-ca	4.9.0	True	False	False	38m
storage	4.9.0	True	False	False	37m

Alternatively, the following command notifies you when all of the clusters are available. It also retrieves and displays credentials:

```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

### Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

The command succeeds when the Cluster Version Operator finishes deploying the OpenShift Container Platform cluster from Kubernetes API server.

### IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Confirm that the Kubernetes API server is communicating with the pods.

- a. To view a list of all pods, use the following command:

```
$ oc get pods --all-namespaces
```

### Example output

NAMESPACE	NAME	READY	STATUS
openshift-apiserver-operator	openshift-apiserver-operator-85cb746d55-zqhs8	1/1	Running
openshift-apiserver	apiserver-67b9g	1/1	Running
openshift-apiserver	apiserver-ljcmx	1/1	Running

```

1m
openshift-apiserver          apiserver-z25h4           1/1   Running   0
2m
openshift-authentication-operator authentication-operator-69d5d8bf84-vh2n8 1/1
Running   0       5m
...

```

- b. View the logs for a pod that is listed in the output of the previous command by using the following command:

```
$ oc logs <pod_name> -n <namespace> 1
```

- 1 Specify the pod name and namespace, as shown in the output of the previous command.

If the pod logs display, the Kubernetes API server can communicate with the cluster machines.

- Additional steps are required to enable multipathing. Do not enable multipathing during installation.  
See "Enabling multipathing with kernel arguments on RHCOS" in the *Post-installation machine configuration tasks* documentation for more information.
- Register your cluster on the [Cluster registration](#) page.

### 14.3.17. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

#### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

### 14.3.18. Next steps

- [Enabling multipathing with kernel arguments on RHCOS](#) .
- [Customize your cluster](#) .
- If the mirror registry that you used to install your cluster has a trusted CA, add it to the cluster by [configuring additional trust stores](#) .

# CHAPTER 15. INSTALLING ON OPENSTACK

## 15.1. PREPARING TO INSTALL ON OPENSTACK

You can install OpenShift Container Platform on Red Hat OpenStack Platform (RHOSP).

### 15.1.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).

### 15.1.2. Choosing a method to install OpenShift Container Platform on OpenStack

You can install OpenShift Container Platform on installer-provisioned or user-provisioned infrastructure. The default installation type uses installer-provisioned infrastructure, where the installation program provisions the underlying infrastructure for the cluster. You can also install OpenShift Container Platform on infrastructure that you provision. If you do not use infrastructure that the installation program provisions, you must manage and maintain the cluster resources yourself.

See [Installation process](#) for more information about installer-provisioned and user-provisioned installation processes.

#### 15.1.2.1. Installing a cluster on installer-provisioned infrastructure

You can install a cluster on Red Hat OpenStack Platform (RHOSP) infrastructure that is provisioned by the OpenShift Container Platform installation program, by using one of the following methods:

- **Installing a cluster on OpenStack with customizations** You can install a customized cluster on RHOSP. The installation program allows for some customization to be applied at the installation stage. Many other customization options are available [post-installation](#).
- **Installing a cluster on OpenStack with Kuryr** You can install a customized OpenShift Container Platform cluster on RHOSP that uses Kuryr SDN. Kuryr and OpenShift Container Platform integration is primarily designed for OpenShift Container Platform clusters running on RHOSP VMs. Kuryr improves the network performance by plugging OpenShift Container Platform pods into RHOSP SDN. In addition, it provides interconnectivity between pods and RHOSP virtual instances.
- **Installing a cluster on OpenStack in a restricted network** You can install OpenShift Container Platform on RHOSP in a restricted or disconnected network by creating an internal mirror of the installation release content. You can use this method to install a cluster that does not require an active internet connection to obtain the software components. You can also use this installation method to ensure that your clusters only use container images that satisfy your organizational controls on external content.

#### 15.1.2.2. Installing a cluster on user-provisioned infrastructure

You can install a cluster on RHOSP infrastructure that you provision, by using one of the following methods:

- **Installing a cluster on OpenStack on your own infrastructure** You can install OpenShift

Container Platform on user-provisioned RHOSP infrastructure. By using this installation method, you can integrate your cluster with existing infrastructure and modifications. For installations on user-provisioned infrastructure, you must create all RHOSP resources, like Nova servers, Neutron ports, and security groups. You can use the provided Ansible playbooks to assist with the deployment process.

- [Installing a cluster on OpenStack with Kuryr on your own infrastructure](#) You can install OpenShift Container Platform on user-provisioned RHOSP infrastructure that uses Kuryr SDN.
- [Installing a cluster on OpenStack on your own SR-IOV infrastructure](#) You can install OpenShift Container Platform on user-provisioned RHOSP infrastructure that uses single-root input/output virtualization (SR-IOV) networks to run compute machines.

## 15.2. INSTALLING A CLUSTER ON OPENSTACK WITH CUSTOMIZATIONS

In OpenShift Container Platform version 4.9, you can install a customized cluster on Red Hat OpenStack Platform (RHOSP). To customize the installation, modify parameters in the `install-config.yaml` before you install the cluster.

### 15.2.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You verified that OpenShift Container Platform 4.9 is compatible with your RHOSP version by using the [Supported platforms for OpenShift clusters](#) section. You can also compare platform support across different versions by viewing the [OpenShift Container Platform on RHOSP support matrix](#).
- You have a storage service installed in RHOSP, such as block storage (Cinder) or object storage (Swift). Object storage is the recommended storage technology for OpenShift Container Platform registry cluster deployment. For more information, see [Optimizing storage](#).
- You have the metadata service enabled in RHOSP.

### 15.2.2. Resource guidelines for installing OpenShift Container Platform on RHOSP

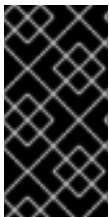
To support an OpenShift Container Platform installation, your Red Hat OpenStack Platform (RHOSP) quota must meet the following requirements:

**Table 15.1. Recommended resources for a default OpenShift Container Platform cluster on RHOSP**

Resource	Value
Floating IP addresses	3
Ports	15
Routers	1

Resource	Value
Subnets	1
RAM	88 GB
vCPUs	22
Volume storage	275 GB
Instances	7
Security groups	3
Security group rules	60

A cluster might function with fewer than recommended resources, but its performance is not guaranteed.



### IMPORTANT

If RHOSP object storage (Swift) is available and operated by a user account with the **swiftoperator** role, it is used as the default backend for the OpenShift Container Platform image registry. In this case, the volume storage requirement is 175 GB. Swift space requirements vary depending on the size of the image registry.



### NOTE

By default, your security group and security group rule quotas might be low. If you encounter problems, run **openstack quota set --secgroups 3 --secgroup-rules 60 <project>** as an administrator to increase them.

An OpenShift Container Platform deployment comprises control plane machines, compute machines, and a bootstrap machine.

#### 15.2.2.1. Control plane machines

By default, the OpenShift Container Platform installation process creates three control plane machines.

Each machine requires:

- An instance from the RHOSP quota
- A port from the RHOSP quota
- A flavor with at least 16 GB memory and 4 vCPUs
- At least 100 GB storage space from the RHOSP quota

#### 15.2.2.2. Compute machines

By default, the OpenShift Container Platform installation process creates three compute machines.

Each machine requires:

- An instance from the RHOSP quota
- A port from the RHOSP quota
- A flavor with at least 8 GB memory and 2 vCPUs
- At least 100 GB storage space from the RHOSP quota

## TIP

Compute machines host the applications that you run on OpenShift Container Platform; aim to run as many as you can.

### 15.2.2.3. Bootstrap machine

During installation, a bootstrap machine is temporarily provisioned to stand up the control plane. After the production control plane is ready, the bootstrap machine is deprovisioned.

The bootstrap machine requires:

- An instance from the RHOSP quota
- A port from the RHOSP quota
- A flavor with at least 16 GB memory and 4 vCPUs
- At least 100 GB storage space from the RHOSP quota

### 15.2.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



## IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.



## 15.2.4. Enabling Swift on RHOSP

Swift is operated by a user account with the **swiftoperator** role. Add the role to an account before you run the installation program.



### IMPORTANT

If [the Red Hat OpenStack Platform \(RHOSP\) object storage service](#), commonly known as Swift, is available, OpenShift Container Platform uses it as the image registry storage. If it is unavailable, the installation program relies on the RHOSP block storage service, commonly known as Cinder.

If Swift is present and you want to use it, you must enable access to it. If it is not present, or if you do not want to use it, skip this section.

### Prerequisites

- You have a RHOSP administrator account on the target environment.
- The Swift service is installed.
- On [Ceph RGW](#), the **account in url** option is enabled.

### Procedure

To enable Swift on RHOSP:

1. As an administrator in the RHOSP CLI, add the **swiftoperator** role to the account that will access Swift:

```
$ openstack role add --user <user> --project <project> swiftoperator
```

Your RHOSP deployment can now use Swift for the image registry.

## 15.2.5. Configuring an image registry with custom storage on clusters that run on RHOSP

After you install a cluster on Red Hat OpenStack Platform (RHOSP), you can use a Cinder volume that is in a specific availability zone for registry storage.

### Procedure

1. Create a YAML file that specifies the storage class and availability zone to use. For example:

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: custom-csi-storageclass
provisioner: cinder.csi.openstack.org
volumeBindingMode: WaitForFirstConsumer
allowVolumeExpansion: true
parameters:
  availability: <availability_zone_name>
```

**NOTE**

OpenShift Container Platform does not verify the existence of the availability zone you choose. Verify the name of the availability zone before you apply the configuration.

- From a command line, apply the configuration:

```
$ oc apply -f <storage_class_file_name>
```

**Example output**

```
storageclass.storage.k8s.io/custom-csi-storageclass created
```

- Create a YAML file that specifies a persistent volume claim (PVC) that uses your storage class and the **openshift-image-registry** namespace. For example:

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: csi-pvc-imageregistry
  namespace: openshift-image-registry 1
  annotations:
    imageregistry.openshift.io: "true"
spec:
  accessModes:
  - ReadWriteOnce
  volumeMode: Filesystem
  resources:
    requests:
      storage: 100Gi 2
  storageClassName: <your_custom_storage_class> 3
```

- Enter the namespace **openshift-image-registry**. This namespace allows the Cluster Image Registry Operator to consume the PVC.
- Optional: Adjust the volume size.
- Enter the name of the storage class that you created.

- From a command line, apply the configuration:

```
$ oc apply -f <pvc_file_name>
```

**Example output**

```
persistentvolumeclaim/csi-pvc-imageregistry created
```

- Replace the original persistent volume claim in the image registry configuration with the new claim:

```
$ oc patch configs.imageregistry.operator.openshift.io/cluster --type 'json' -p='[{"op":
"replace", "path": "/spec/storage/pvc/claim", "value": "csi-pvc-imageregistry"}]'
```

### Example output

```
config.imageregistry.operator.openshift.io/cluster patched
```

Over the next several minutes, the configuration is updated.

## Verification

To confirm that the registry is using the resources that you defined:

1. Verify that the PVC claim value is identical to the name that you provided in your PVC definition:

```
$ oc get configs.imageregistry.operator.openshift.io/cluster -o yaml
```

### Example output

```
...
status:
  ...
  managementState: Managed
  pvc:
    claim: csi-pvc-imageregistry
  ...
```

2. Verify that the status of the PVC is **Bound**:

```
$ oc get pvc -n openshift-image-registry csi-pvc-imageregistry
```

### Example output

NAME	STATUS	VOLUME	CAPACITY	ACCESS MODES
STORAGECLASS	AGE			
csi-pvc-imageregistry	Bound	pvc-72a8f9c9-f462-11e8-b6b6-fa163e18b7b5	100Gi	
RWO		custom-csi-storageclass	11m	

## 15.2.6. Verifying external network access

The OpenShift Container Platform installation process requires external network access. You must provide an external network value to it, or deployment fails. Before you begin the process, verify that a network with the external router type exists in Red Hat OpenStack Platform (RHOSP).

### Prerequisites

- [Configure OpenStack's networking service to have DHCP agents forward instances' DNS queries](#)

### Procedure

1. Using the RHOSP CLI, verify the name and ID of the 'External' network:

■

```
$ openstack network list --long -c ID -c Name -c "Router Type"
```

### Example output

```
+-----+-----+-----+
| ID                | Name          | Router Type |
+-----+-----+-----+
| 148a8023-62a7-4672-b018-003462f8d7dc | public_network | External    |
+-----+-----+-----+
```

A network with an external router type appears in the network list. If at least one does not, see [Creating a default floating IP network](#) and [Creating a default provider network](#).

### IMPORTANT

If the external network's CIDR range overlaps one of the default network ranges, you must change the matching network ranges in the **install-config.yaml** file before you start the installation process.

The default network ranges are:

Network	Range
<b>machineNetwork</b>	10.0.0.0/16
<b>serviceNetwork</b>	172.30.0.0/16
<b>clusterNetwork</b>	10.128.0.0/14



### WARNING

If the installation program finds multiple networks with the same name, it sets one of them at random. To avoid this behavior, create unique names for resources in RHOSP.



### NOTE

If the Neutron trunk service plugin is enabled, a trunk port is created by default. For more information, see [Neutron trunk port](#).

## 15.2.7. Defining parameters for the installation program

The OpenShift Container Platform installation program relies on a file that is called **clouds.yaml**. The file describes Red Hat OpenStack Platform (RHOSP) configuration parameters, including the project name, log in information, and authorization service URLs.

### Procedure

1. Create the **clouds.yaml** file:

- If your RHOSP distribution includes the Horizon web UI, generate a **clouds.yaml** file in it.

**IMPORTANT**

Remember to add a password to the **auth** field. You can also keep secrets in [a separate file](#) from **clouds.yaml**.

- If your RHOSP distribution does not include the Horizon web UI, or you do not want to use Horizon, create the file yourself. For detailed information about **clouds.yaml**, see [Config files](#) in the RHOSP documentation.

```
clouds:
  shiftstack:
    auth:
      auth_url: http://10.10.14.42:5000/v3
      project_name: shiftstack
      username: shiftstack_user
      password: XXX
      user_domain_name: Default
      project_domain_name: Default
    dev-env:
      region_name: RegionOne
      auth:
        username: 'devuser'
        password: XXX
        project_name: 'devonly'
        auth_url: 'https://10.10.14.22:5001/v2.0'
```

## 2. If your RHOSP installation uses self-signed certificate authority (CA) certificates for endpoint authentication:

- a. Copy the certificate authority file to your machine.
- b. Add the **cacerts** key to the **clouds.yaml** file. The value must be an absolute, non-root-accessible path to the CA certificate:

```
clouds:
  shiftstack:
    ...
    cacert: "/etc/pki/ca-trust/source/anchors/ca.crt.pem"
```

**TIP**

After you run the installer with a custom CA certificate, you can update the certificate by editing the value of the **ca-cert.pem** key in the **cloud-provider-config** keymap. On a command line, run:

```
$ oc edit configmap -n openshift-config cloud-provider-config
```

3. Place the **clouds.yaml** file in one of the following locations:

- a. The value of the **OS\_CLIENT\_CONFIG\_FILE** environment variable
  - b. The current directory
  - c. A Unix-specific user configuration directory, for example `~/.config/openstack/clouds.yaml`
  - d. A Unix-specific site configuration directory, for example `/etc/openstack/clouds.yaml`
- The installation program searches for **clouds.yaml** in that order.

### 15.2.8. Setting cloud provider options

Optionally, you can edit the cloud provider configuration for your cluster. The cloud provider configuration controls how OpenShift Container Platform interacts with Red Hat OpenStack Platform (RHOSP).

For a complete list of cloud provider configuration parameters, see the "OpenStack cloud configuration reference guide" page in the "Installing on OpenStack" documentation.

#### Procedure

1. If you have not already generated manifest files for your cluster, generate them by running the following command:

```
$ openshift-install --dir <destination_directory> create manifests
```

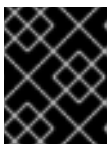
2. In a text editor, open the cloud-provider configuration manifest file. For example:

```
$ vi openshift/manifests/cloud-provider-config.yaml
```

3. Modify the options based on the cloud configuration specification. Configuring Octavia for load balancing is a common case for clusters that do not use Kuryr. For example:

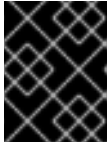
```
#...
[LoadBalancer]
use-octavia=true 1
lb-provider = "amphora" 2
floating-network-id="d3deb660-4190-40a3-91f1-37326fe6ec4a" 3
#...
```

- 1 This property enables Octavia integration.
- 2 This property sets the Octavia provider that your load balancer uses. It accepts **"ovn"** or **"amphora"** as values. If you choose to use OVN, you must also set **lb-method** to **SOURCE\_IP\_PORT**.
- 3 This property is required if you want to use multiple external networks with your cluster. The cloud provider creates floating IP addresses on the network that is specified here.



#### IMPORTANT

Prior to saving your changes, verify that the file is structured correctly. Clusters might fail if properties are not placed in the appropriate section.



### IMPORTANT

For installations that use Kuryr, Kuryr handles relevant services. There is no need to configure Octavia load balancing in the cloud provider.

4. Save the changes to the file and proceed with installation.

### TIP

You can update your cloud provider configuration after you run the installer. On a command line, run:

```
$ oc edit configmap -n openshift-config cloud-provider-config
```

After you save your changes, your cluster will take some time to reconfigure itself. The process is complete if none of your nodes have a **SchedulingDisabled** status.

### Additional resources

- For more information about cloud provider configuration, see [OpenStack cloud provider options](#).

## 15.2.9. Obtaining the installation program

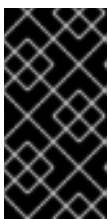
Before you install OpenShift Container Platform, download the installation file on a local computer.

### Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space

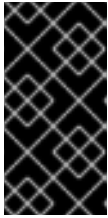
### Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



### IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



## IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#). This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

### 15.2.10. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Red Hat OpenStack Platform (RHOSP).

#### Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

#### Procedure

1. Create the **install-config.yaml** file.
  - a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

- 1** For **<installation\_directory>**, specify the directory name to store the files that the installation program creates.



## IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

- b. At the prompts, provide the configuration details for your cloud:



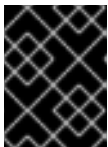
- i. Optional: Select an SSH key to use to access your cluster machines.



#### NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

- ii. Select **openstack** as the platform to target.
  - iii. Specify the Red Hat OpenStack Platform (RHOSP) external network name to use for installing the cluster.
  - iv. Specify the floating IP address to use for external access to the OpenShift API.
  - v. Specify a RHOSP flavor with at least 16 GB RAM to use for control plane nodes and 8 GB RAM for compute nodes.
  - vi. Select the base domain to deploy the cluster to. All DNS records will be sub-domains of this base and will also include the cluster name.
  - vii. Enter a name for your cluster. The name must be 14 or fewer characters long.
  - viii. Paste the [pull secret from the Red Hat OpenShift Cluster Manager](#) .
2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.
  3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



#### IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

#### Additional resources

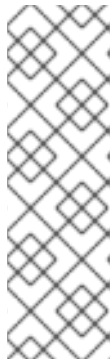
See [Installation configuration parameters section](#) for more information about the available parameters.

#### 15.2.10.1. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

#### Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



## NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

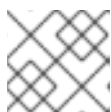
For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

## Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
  additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
  ...
```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations.
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.



## NOTE

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



#### NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

### 15.2.11. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.



#### NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.



#### IMPORTANT

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

#### 15.2.11.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 15.2. Required parameters

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String


Parameter	Description	Values
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;.&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}</b> . <b>{{.baseDomain}}</b> .	String of lowercase letters, hyphens (-), and periods (.), such as <b>dev</b> . The string must be 14 characters or fewer long.
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws, baremetal, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b> . For additional information about <b>platform.&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre> {   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } } </pre>


### 15.2.11.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

Table 15.3. Network parameters

Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	Object   <b>NOTE</b> You cannot modify parameters specified by the <b>networking</b> object after installation.
<b>networking.networkType</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .
<b>networking.clusterNetwork</b>	The IP address blocks for pods.  The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b> .  If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example:  <pre>networking:   clusterNetwork:     - cidr: 10.128.0.0/14       hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	Required if you use <b>networking.clusterNetwork</b> . An IP address block.  An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b> .
<b>networking.clusterNetwork.hostPrefix</b>	The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b> . A <b>hostPrefix</b> value of <b>23</b> provides 510 ( $2^{(32 - 23)} - 2$ ) pod IP addresses.	A subnet prefix.  The default value is <b>23</b> .


Parameter	Description	Values
<b>networking.serviceNetwork</b>	<p>The IP address block for services. The default value is <b>172.30.0.0/16</b>.</p> <p>The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.</p>	<p>An array with an IP address block in CIDR format. For example:</p> <pre>networking:   serviceNetwork:   - 172.30.0.0/16</pre>
<b>networking.machineNetwork</b>	<p>The IP address blocks for machines.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   machineNetwork:   - cidr: 10.0.0.0/16</pre>
<b>networking.machineNetwork.cidr</b>	<p>Required if you use <b>networking.machineNetwork</b>. An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b>.</p>	<p>An IP network block in CIDR notation.</p> <p>For example, <b>10.0.0.0/16</b>.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p> </div> </div>


### 15.2.11.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:



Table 15.4. Optional parameters

Parameter	Description	Values
<b>additionalTrustBundle</b>	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
<b>compute</b>	The configuration for the machines that comprise the compute nodes.	Array of <b>MachinePool</b> objects.


Parameter	Description	Values
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String
<b>compute.hyperthreading</b>	Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b> , on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.   <b>IMPORTANT</b>  If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b>
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String

Parameter	Description	Values
<b>controlPlane.hypert hreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hypert hreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platfor m</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>controlPlane.replica s</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.



Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.</p> <div data-bbox="485 510 595 864" style="border: 1px solid black; padding: 5px; margin-bottom: 10px;">  </div> <p><b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators reference content</i>.</p> <div data-bbox="485 909 595 1263" style="border: 1px solid black; padding: 5px;">  </div> <p><b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p>	<b>Mint, Passthrough, Manual</b> or an empty string ("").

Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start;"> <div style="width: 60px; height: 60px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 60px; height: 60px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<p><b>Internal</b> or <b>External</b>. The default value is <b>External</b>.</p> <p>Setting this field to <b>Internal</b> is not supported on non-cloud platforms.</p>

Parameter	Description	Values
<b>sshKey</b>	<p>The SSH key or keys to authenticate access your cluster machines.</p>  <p><b>NOTE</b></p> <p>For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.</p>	<p>One or more keys. For example:</p> <pre>sshKey:   &lt;key1&gt;   &lt;key2&gt;   &lt;key3&gt;</pre>

#### 15.2.11.4. Additional Red Hat OpenStack Platform (RHOSP) configuration parameters

Additional RHOSP configuration parameters are described in the following table:

Table 15.5. Additional RHOSP parameters

Parameter	Description	Values
<b>compute.platform.openstack.rootVolume.size</b>	For compute machines, the size in gigabytes of the root volume. If you do not set this value, machines use ephemeral storage.	Integer, for example <b>30</b> .
<b>compute.platform.openstack.rootVolume.type</b>	For compute machines, the root volume's type.	String, for example <b>performance</b> .
<b>controlPlane.platform.openstack.rootVolume.size</b>	For control plane machines, the size in gigabytes of the root volume. If you do not set this value, machines use ephemeral storage.	Integer, for example <b>30</b> .
<b>controlPlane.platform.openstack.rootVolume.type</b>	For control plane machines, the root volume's type.	String, for example <b>performance</b> .

Parameter	Description	Values
<b>platform.openstack.cloud</b>	The name of the RHOSP cloud to use from the list of clouds in the <b>clouds.yaml</b> file.	String, for example <b>MyCloud</b> .
<b>platform.openstack.externalNetwork</b>	The RHOSP external network name to be used for installation.	String, for example <b>external</b> .
<b>platform.openstack.computeFlavor</b>	<p>The RHOSP flavor to use for control plane and compute machines.</p> <p>This property is deprecated. To use a flavor as the default for all machine pools, add it as the value of the <b>type</b> key in the <b>platform.openstack.defaultMachinePlatform</b> property. You can also set a flavor value for each machine pool individually.</p>	String, for example <b>m1.xlarge</b> .

### 15.2.11.5. Optional RHOSP configuration parameters

Optional RHOSP configuration parameters are described in the following table:

Table 15.6. Optional RHOSP parameters

Parameter	Description	Values
<b>compute.platform.openstack.additionalNetworkIDs</b>	Additional networks that are associated with compute machines. Allowed address pairs are not created for additional networks.	A list of one or more UUIDs as strings. For example, <b>fa806b2f-ac49-4bce-b9db-124bc64209bf</b> .
<b>compute.platform.openstack.additionalSecurityGroupIDs</b>	Additional security groups that are associated with compute machines.	A list of one or more UUIDs as strings. For example, <b>7ee219f3-d2e9-48a1-96c2-e7429f1b0da7</b> .

Parameter	Description	Values
<b>compute.platform.openstack.zones</b>	<p>RHOSP Compute (Nova) availability zones (AZs) to install machines on. If this parameter is not set, the installer relies on the default settings for Nova that the RHOSP administrator configured.</p> <p>On clusters that use Kuryr, RHOSP Octavia does not support availability zones. Load balancers and, if you are using the Amphora provider driver, OpenShift Container Platform services that rely on Amphora VMs, are not created according to the value of this property.</p>	A list of strings. For example, <b>["zone-1", "zone-2"]</b> .
<b>compute.platform.openstack.rootVolume.zones</b>	For compute machines, the availability zone to install root volumes on. If you do not set a value for this parameter, the installer selects the default availability zone.	A list of strings, for example <b>["zone-1", "zone-2"]</b> .
<b>controlPlane.platform.openstack.additionalNetworkIDs</b>	Additional networks that are associated with control plane machines. Allowed address pairs are not created for additional networks.	A list of one or more UUIDs as strings. For example, <b>fa806b2f-ac49-4bce-b9db-124bc64209bf</b> .
<b>controlPlane.platform.openstack.additionalSecurityGroupIDs</b>	Additional security groups that are associated with control plane machines.	A list of one or more UUIDs as strings. For example, <b>7ee219f3-d2e9-48a1-96c2-e7429f1b0da7</b> .

Parameter	Description	Values
<b>controlPlane.platform.openstack.zones</b>	<p>RHOSP Compute (Nova) availability zones (AZs) to install machines on. If this parameter is not set, the installer relies on the default settings for Nova that the RHOSP administrator configured.</p> <p>On clusters that use Kuryr, RHOSP Octavia does not support availability zones. Load balancers and, if you are using the Amphora provider driver, OpenShift Container Platform services that rely on Amphora VMs, are not created according to the value of this property.</p>	A list of strings. For example, <b>["zone-1", "zone-2"]</b> .
<b>controlPlane.platform.openstack.rootVolume.zones</b>	For control plane machines, the availability zone to install root volumes on. If you do not set this value, the installer selects the default availability zone.	A list of strings, for example <b>["zone-1", "zone-2"]</b> .
<b>platform.openstack.clusterOSImage</b>	<p>The location from which the installer downloads the RHCOS image.</p> <p>You must set this parameter to perform an installation in a restricted network.</p>	<p>An HTTP or HTTPS URL, optionally with an SHA-256 checksum.</p> <p>For example,  <b>http://mirror.example.com/images/rhcos-43.81.201912131630.0-openstack.x86_64.qcow2.gz?sha256=ffebbd68e8a1f2a245ca19522c16c86f67f9ac8e4e0c1f0a812b068b16f7265d</b>. The value can also be the name of an existing Glance image, for example <b>my-rhcos</b>.</p>

Parameter	Description	Values
<b>platform.openstack.clusterOSImageProperties</b>	<p>Properties to add to the installer-uploaded ClusterOSImage in Glance. This property is ignored if <b>platform.openstack.clusterOSImage</b> is set to an existing Glance image.</p> <p>You can use this property to exceed the default persistent volume (PV) limit for RHOSP of 26 PVs per node. To exceed the limit, set the <b>hw_scsi_model</b> property value to <b>virtio-scsi</b> and the <b>hw_disk_bus</b> value to <b>scsi</b>.</p> <p>You can also use this property to enable the QEMU guest agent by including the <b>hw_qemu_guest_agent</b> property with a value of <b>yes</b>.</p>	A list of key-value string pairs. For example, <b>["hw_scsi_model": "virtio-scsi", "hw_disk_bus": "scsi"]</b> .
<b>platform.openstack.defaultMachinePlatform</b>	The default machine pool platform configuration.	<pre>{   "type": "ml.large",   "rootVolume": {     "size": 30,     "type": "performance"   } }</pre>
<b>platform.openstack.ingressFloatingIP</b>	An existing floating IP address to associate with the Ingress port. To use this property, you must also define the <b>platform.openstack.externalNetwork</b> property.	An IP address, for example <b>128.0.0.1</b> .
<b>platform.openstack.apiFloatingIP</b>	An existing floating IP address to associate with the API load balancer. To use this property, you must also define the <b>platform.openstack.externalNetwork</b> property.	An IP address, for example <b>128.0.0.1</b> .
<b>platform.openstack.externalDNS</b>	IP addresses for external DNS servers that cluster instances use for DNS resolution.	A list of IP addresses as strings. For example, <b>["8.8.8.8", "192.168.1.12"]</b> .

Parameter	Description	Values
<b>platform.openstack.machinesSubnet</b>	<p>The UUID of a RHOSP subnet that the cluster's nodes use. Nodes and virtual IP (VIP) ports are created on this subnet.</p> <p>The first item in <b>networking.machineNetwork</b> must match the value of <b>machinesSubnet</b>.</p> <p>If you deploy to a custom subnet, you cannot specify an external DNS server to the OpenShift Container Platform installer. Instead, <a href="#">add DNS to the subnet in RHOSP</a>.</p>	A UUID as a string. For example, <b>fa806b2f-ac49-4bce-b9db-124bc64209bf</b> .

#### 15.2.11.6. Custom subnets in RHOSP deployments

Optionally, you can deploy a cluster on a Red Hat OpenStack Platform (RHOSP) subnet of your choice. The subnet's GUID is passed as the value of **platform.openstack.machinesSubnet** in the **install-config.yaml** file.

This subnet is used as the cluster's primary subnet. By default, nodes and ports are created on it. You can create nodes and ports on a different RHOSP subnet by setting the value of the **platform.openstack.machinesSubnet** property to the subnet's UUID.

Before you run the OpenShift Container Platform installer with a custom subnet, verify that your configuration meets the following requirements:

- The subnet that is used by **platform.openstack.machinesSubnet** has DHCP enabled.
- The CIDR of **platform.openstack.machinesSubnet** matches the CIDR of **networking.machineNetwork**.
- The installation program user has permission to create ports on this network, including ports with fixed IP addresses.

Clusters that use custom subnets have the following limitations:

- If you plan to install a cluster that uses floating IP addresses, the **platform.openstack.machinesSubnet** subnet must be attached to a router that is connected to the **externalNetwork** network.
- If the **platform.openstack.machinesSubnet** value is set in the **install-config.yaml** file, the installation program does not create a private network or subnet for your RHOSP machines.
- You cannot use the **platform.openstack.externalDNS** property at the same time as a custom subnet. To add DNS to a cluster that uses a custom subnet, configure DNS on the RHOSP network.



**NOTE**

By default, the API VIP takes x.x.x.5 and the Ingress VIP takes x.x.x.7 from your network's CIDR block. To override these default values, set values for **platform.openstack.apiVIP** and **platform.openstack.ingressVIP** that are outside of the DHCP allocation pool.

### 15.2.11.7. Deploying a cluster with bare metal machines

If you want your cluster to use bare metal machines, modify the **install-config.yaml** file. Your cluster can have both control plane and compute machines running on bare metal, or just compute machines.

Bare-metal compute machines are not supported on clusters that use Kuryr.

**NOTE**

Be sure that your **install-config.yaml** file reflects whether the RHOSP network that you use for bare metal workers supports floating IP addresses or not.

#### Prerequisites

- The RHOSP [Bare Metal service \(Ironic\)](#) is enabled and accessible via the RHOSP Compute API.
- Bare metal is available as [a RHOSP flavor](#).
- The RHOSP network supports both VM and bare metal server attachment.
- Your network configuration does not rely on a provider network. Provider networks are not supported.
- If you want to deploy the machines on a pre-existing network, a RHOSP subnet is provisioned.
- If you want to deploy the machines on an installer-provisioned network, the RHOSP Bare Metal service (Ironic) is able to listen for and interact with Preboot eXecution Environment (PXE) boot machines that run on tenant networks.
- You created an **install-config.yaml** file as part of the OpenShift Container Platform installation process.

#### Procedure

1. In the **install-config.yaml** file, edit the flavors for machines:
  - a. If you want to use bare-metal control plane machines, change the value of **controlPlane.platform.openstack.type** to a bare metal flavor.
  - b. Change the value of **compute.platform.openstack.type** to a bare metal flavor.
  - c. If you want to deploy your machines on a pre-existing network, change the value of **platform.openstack.machinesSubnet** to the RHOSP subnet UUID of the network. Control plane and compute machines must use the same subnet.

#### An example bare metal **install-config.yaml** file

```
controlPlane:
  platform:
    openstack:
```

```

    type: <bare_metal_control_plane_flavor> 1
    ...
compute:
  - architecture: amd64
    hyperthreading: Enabled
    name: worker
    platform:
      openstack:
        type: <bare_metal_compute_flavor> 2
        replicas: 3
    ...
platform:
  openstack:
    machinesSubnet: <subnet_UUID> 3
    ...

```

- 1** If you want to have bare-metal control plane machines, change this value to a bare metal flavor.
- 2** Change this value to a bare metal flavor to use for compute machines.
- 3** If you want to use a pre-existing network, change this value to the UUID of the RHOSP subnet.

Use the updated **install-config.yaml** file to complete the installation process. The compute machines that are created during deployment use the flavor that you added to the file.



#### NOTE

The installer may time out while waiting for bare metal machines to boot.

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

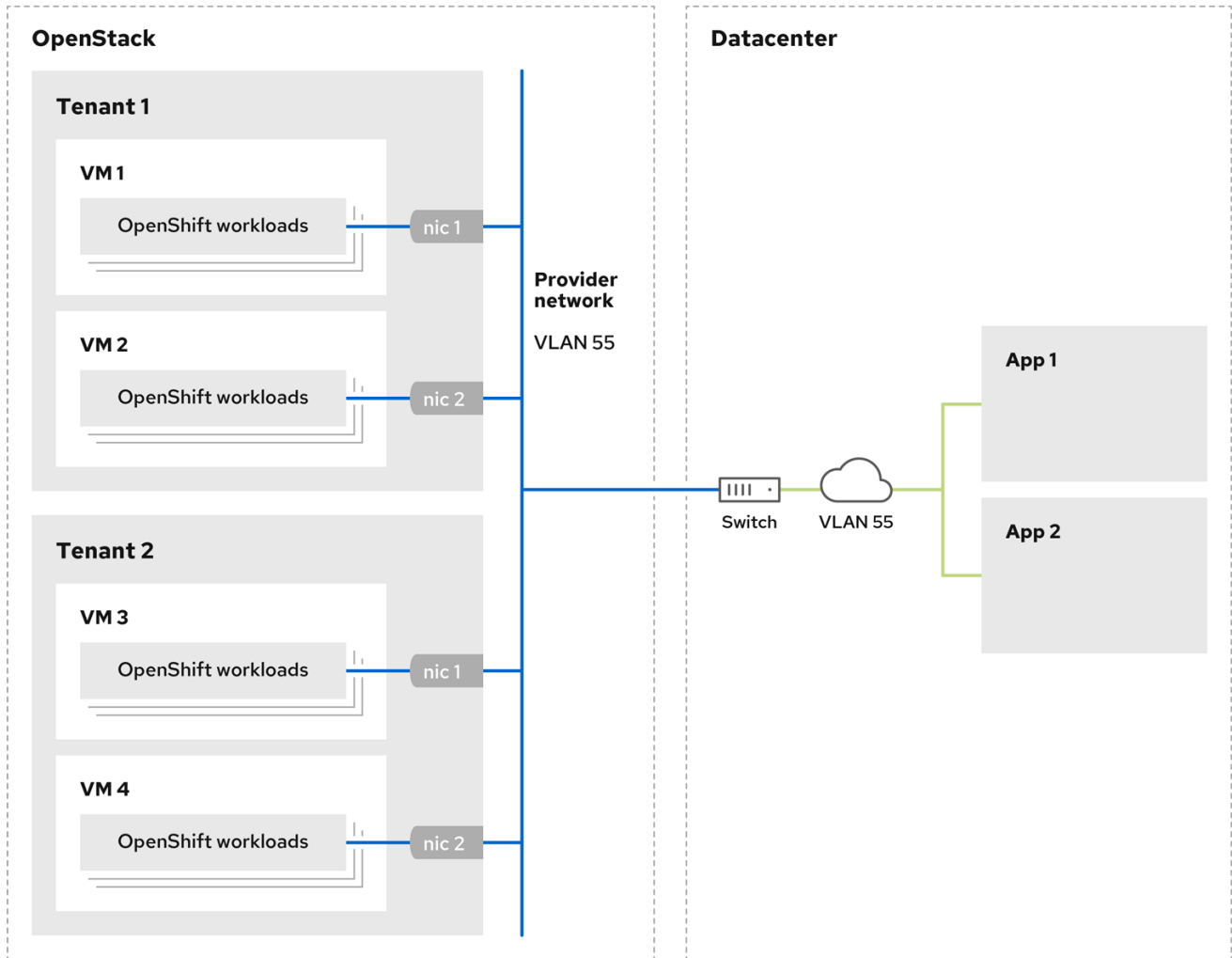
```
./openshift-install wait-for install-complete --log-level debug
```

#### 15.2.11.8. Cluster deployment on RHOSP provider networks

You can deploy your OpenShift Container Platform clusters on Red Hat OpenStack Platform (RHOSP) with a primary network interface on a provider network. Provider networks are commonly used to give projects direct access to a public network that can be used to reach the internet. You can also share provider networks among projects as part of the network creation process.

RHOSP provider networks map directly to an existing physical network in the data center. A RHOSP administrator must create them.

In the following example, OpenShift Container Platform workloads are connected to a data center by using a provider network:



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OpenShift Container Platform clusters that are installed on provider networks do not require tenant networks or floating IP addresses. The installer does not create these resources during installation.

Example provider network types include flat (untagged) and VLAN (802.1Q tagged).



## NOTE

A cluster can support as many provider network connections as the network type allows. For example, VLAN networks typically support up to 4096 connections.

You can learn more about provider and tenant networks in [the RHOSP documentation](#).

### 15.2.11.8.1. RHOSP provider network requirements for cluster installation

Before you install an OpenShift Container Platform cluster, your Red Hat OpenStack Platform (RHOSP) deployment and provider network must meet a number of conditions:

- The [RHOSP networking service \(Neutron\) is enabled](#) and accessible through the RHOSP networking API.
- The RHOSP networking service has the [port security and allowed address pairs extensions enabled](#).

- The provider network can be shared with other tenants.

### TIP

Use the **openstack network create** command with the **--share** flag to create a network that can be shared.

- The RHOSP project that you use to install the cluster must own the provider network, as well as an appropriate subnet.

### TIP

To create a network for a project that is named "openshift," enter the following command

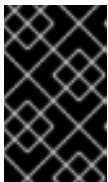
```
$ openstack network create --project openshift
```

To create a subnet for a project that is named "openshift," enter the following command

```
$ openstack subnet create --project openshift
```

To learn more about creating networks on RHOSP, read [the provider networks documentation](#).

If the cluster is owned by the **admin** user, you must run the installer as that user to create ports on the network.



### IMPORTANT

Provider networks must be owned by the RHOSP project that is used to create the cluster. If they are not, the RHOSP Compute service (Nova) cannot request a port from that network.

- Verify that the provider network can reach the RHOSP metadata service IP address, which is **169.254.169.254** by default.

Depending on your RHOSP SDN and networking service configuration, you might need to provide the route when you create the subnet. For example:

```
$ openstack subnet create --dhcp --host-route
destination=169.254.169.254/32,gateway=192.0.2.2 ...
```

- Optional: To secure the network, create [role-based access control \(RBAC\)](#) rules that limit network access to a single project.

#### 15.2.11.8.2. Deploying a cluster that has a primary interface on a provider network

You can deploy an OpenShift Container Platform cluster that has its primary network interface on an Red Hat OpenStack Platform (RHOSP) provider network. .Prerequisites

- Your Red Hat OpenStack Platform (RHOSP) deployment is configured as described by "RHOSP provider network requirements for cluster installation".

### Procedure

1. In a text editor, open the **install-config.yaml** file.
2. Set the value of the **platform.openstack.apiVIP** property to the IP address for the API VIP.
3. Set the value of the **platform.openstack.ingressVIP** property to the IP address for the Ingress VIP.
4. Set the value of the **platform.openstack.machinesSubnet** property to the UUID of the provider network subnet.
5. Set the value of the **networking.machineNetwork.cidr** property to the CIDR block of the provider network subnet.



### IMPORTANT

The **platform.openstack.apiVIP** and **platform.openstack.ingressVIP** properties must both be unassigned IP addresses from the **networking.machineNetwork.cidr** block.

### Section of an installation configuration file for a cluster that relies on a RHOSP provider network

```
...
platform:
  openstack:
    apiVIP: 192.0.2.13
    ingressVIP: 192.0.2.23
    machinesSubnet: fa806b2f-ac49-4bce-b9db-124bc64209bf
    # ...
networking:
  machineNetwork:
    - cidr: 192.0.2.0/24
```



### WARNING

You cannot set the **platform.openstack.externalNetwork** or **platform.openstack.externalDNS** parameters while using a provider network for the primary network interface.

When you deploy the cluster, the installer uses the **install-config.yaml** file to deploy the cluster on the provider network.

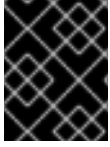
### TIP

You can add additional networks, including provider networks, to the **platform.openstack.additionalNetworkIDs** list.

After you deploy your cluster, you can attach pods to additional networks. For more information, see [Understanding multiple networks](#).

### 15.2.11.9. Sample customized `install-config.yaml` file for RHOSP

This sample **`install-config.yaml`** demonstrates all of the possible Red Hat OpenStack Platform (RHOSP) customization options.



#### IMPORTANT

This sample file is provided for reference only. You must obtain your **`install-config.yaml`** file by using the installation program.

```
apiVersion: v1
baseDomain: example.com
controlPlane:
  name: master
  platform: {}
  replicas: 3
compute:
- name: worker
  platform:
    openstack:
      type: m1.large
    replicas: 3
metadata:
  name: example
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  serviceNetwork:
  - 172.30.0.0/16
  networkType: OpenShiftSDN
platform:
  openstack:
    cloud: mycloud
    externalNetwork: external
    computeFlavor: m1.xlarge
    apiFloatingIP: 128.0.0.1
fips: false
pullSecret: '{"auths": ...}'
sshKey: ssh-ed25519 AAAA...
```

### 15.2.12. Setting compute machine affinity

Optionally, you can set the affinity policy for compute machines during installation. The installer does not select an affinity policy for compute machines by default.

You can also create machine sets that use particular RHOSP server groups after installation.



#### NOTE

Control plane machines are created with a **`soft-anti-affinity`** policy.

**TIP**

You can learn more about [RHOSP instance scheduling and placement](#) in the RHOSP documentation.

**Prerequisites**

- Create the **install-config.yaml** file and complete any modifications to it.

**Procedure**

1. Using the RHOSP command-line interface, create a server group for your compute machines. For example:

```
$ openstack \
  --os-compute-api-version=2.15 \
  server group create \
  --policy anti-affinity \
  my-openshift-worker-group
```

For more information, see the [server group create command documentation](#).

2. Change to the directory that contains the installation program and create the manifests:

```
$ ./openshift-install create manifests --dir <installation_directory>
```

where:

**installation\_directory**

Specifies the name of the directory that contains the **install-config.yaml** file for your cluster.

3. Open **manifests/99\_openshift-cluster-api\_worker-machineset-0.yaml**, the **MachineSet** definition file.
4. Add the property **serverGroupID** to the definition beneath the **spec.template.spec.providerSpec.value** property. For example:

```
apiVersion: machine.openshift.io/v1beta1
kind: MachineSet
metadata:
  labels:
    machine.openshift.io/cluster-api-cluster: <infrastructure_ID>
    machine.openshift.io/cluster-api-machine-role: <node_role>
    machine.openshift.io/cluster-api-machine-type: <node_role>
  name: <infrastructure_ID>-<node_role>
  namespace: openshift-machine-api
spec:
  replicas: <number_of_replicas>
  selector:
    matchLabels:
      machine.openshift.io/cluster-api-cluster: <infrastructure_ID>
      machine.openshift.io/cluster-api-machineset: <infrastructure_ID>-<node_role>
  template:
    metadata:
      labels:
```

```

machine.openshift.io/cluster-api-cluster: <infrastructure_ID>
machine.openshift.io/cluster-api-machine-role: <node_role>
machine.openshift.io/cluster-api-machine-type: <node_role>
machine.openshift.io/cluster-api-machineset: <infrastructure_ID>-<node_role>
spec:
  providerSpec:
    value:
      apiVersion: openstackproviderconfig.openshift.io/v1alpha1
      cloudName: openstack
      cloudsSecret:
        name: openstack-cloud-credentials
        namespace: openshift-machine-api
      flavor: <nova_flavor>
      image: <glance_image_name_or_location>
      serverGroupID: aaaaaaaa-bbbb-cccc-dddd-eeeeeeeeeeee 1
      kind: OpenstackProviderSpec
      networks:
        - filter: {}
          subnets:
            - filter:
                name: <subnet_name>
                tags: openshiftClusterID=<infrastructure_ID>
      securityGroups:
        - filter: {}
          name: <infrastructure_ID>-<node_role>
      serverMetadata:
        Name: <infrastructure_ID>-<node_role>
        openshiftClusterID: <infrastructure_ID>
      tags:
        - openshiftClusterID=<infrastructure_ID>
      trunk: true
      userDataSecret:
        name: <node_role>-user-data
      availabilityZone: <optional_openstack_availability_zone>

```

1 Add the UUID of your server group here.

- Optional: Back up the **manifests/99\_openshift-cluster-api\_worker-machineset-0.yaml** file. The installation program deletes the **manifests/** directory when creating the cluster.

When you install the cluster, the installer uses the **MachineSet** definition that you modified to create compute machines within your RHOSP server group.

### 15.2.13. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized\_keys** list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.



If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.



### IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

### Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> ❶
```

- ❶ Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.



### NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.



### NOTE

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

### Example output

```
Agent pid 31874
```

**NOTE**

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1** Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

**Example output**

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

**Next steps**

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

**15.2.14. Enabling access to the environment**

At deployment, all OpenShift Container Platform machines are created in a Red Hat OpenStack Platform (RHOSP)-tenant network. Therefore, they are not accessible directly in most RHOSP deployments.

You can configure OpenShift Container Platform API and application access by using floating IP addresses (FIPs) during installation. You can also complete an installation without configuring FIPs, but the installer will not configure a way to reach the API or applications externally.

**15.2.14.1. Enabling access with floating IP addresses**

Create floating IP (FIP) addresses for external access to the OpenShift Container Platform API and cluster applications.

**Procedure**

1. Using the Red Hat OpenStack Platform (RHOSP) CLI, create the API FIP:

```
$ openstack floating ip create --description "API <cluster_name>.<base_domain>"
<external_network>
```

2. Using the Red Hat OpenStack Platform (RHOSP) CLI, create the apps, or Ingress, FIP:

```
$ openstack floating ip create --description "Ingress <cluster_name>.<base_domain>"
<external_network>
```

3. Add records that follow these patterns to your DNS server for the API and Ingress FIPs:

```
api.<cluster_name>.<base_domain>. IN A <API_FIP>
*.apps.<cluster_name>.<base_domain>. IN A <apps_FIP>
```



## NOTE

If you do not control the DNS server, you can access the cluster by adding the cluster domain names such as the following to your `/etc/hosts` file:

- `<api_floating_ip> api.<cluster_name>.<base_domain>`
- `<application_floating_ip> grafana-openshift-monitoring.apps.<cluster_name>.<base_domain>`
- `<application_floating_ip> prometheus-k8s-openshift-monitoring.apps.<cluster_name>.<base_domain>`
- `<application_floating_ip> oauth-openshift.apps.<cluster_name>.<base_domain>`
- `<application_floating_ip> console-openshift-console.apps.<cluster_name>.<base_domain>`
- `application_floating_ip integrated-oauth-server-openshift-authentication.apps.<cluster_name>.<base_domain>`

The cluster domain names in the `/etc/hosts` file grant access to the web console and the monitoring interface of your cluster locally. You can also use the **kubectl** or **oc**. You can access the user applications by using the additional entries pointing to the `<application_floating_ip>`. This action makes the API and applications accessible to only you, which is not suitable for production deployment, but does allow installation for development and testing.

4. Add the FIPs to the `install-config.yaml` file as the values of the following parameters:

- `platform.openstack.ingressFloatingIP`
- `platform.openstack.apiFloatingIP`

If you use these values, you must also enter an external network as the value of the `platform.openstack.externalNetwork` parameter in the `install-config.yaml` file.

## TIP

You can make OpenShift Container Platform resources available outside of the cluster by assigning a floating IP address and updating your firewall configuration.

### 15.2.14.2. Completing installation without floating IP addresses

You can install OpenShift Container Platform on Red Hat OpenStack Platform (RHOSP) without providing floating IP addresses.

In the `install-config.yaml` file, do not define the following parameters:

- `platform.openstack.ingressFloatingIP`

- **platform.openstack.apiFloatingIP**

If you cannot provide an external network, you can also leave **platform.openstack.externalNetwork** blank. If you do not provide a value for **platform.openstack.externalNetwork**, a router is not created for you, and, without additional action, the installer will fail to retrieve an image from Glance. You must configure external connectivity on your own.

If you run the installer from a system that cannot reach the cluster API due to a lack of floating IP addresses or name resolution, installation fails. To prevent installation failure in these cases, you can use a proxy network or run the installer from a system that is on the same network as your machines.



#### NOTE

You can enable name resolution by creating DNS records for the API and Ingress ports. For example:

```
api.<cluster_name>.<base_domain>. IN A <api_port_IP>
*.apps.<cluster_name>.<base_domain>. IN A <ingress_port_IP>
```

If you do not control the DNS server, you can add the record to your **/etc/hosts** file. This action makes the API accessible to only you, which is not suitable for production deployment but does allow installation for development and testing.

## 15.2.15. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



#### IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

#### Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

#### Procedure

1. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
--log-level=info 2
```

- 1 For **<installation\_directory>**, specify the location of your customized **./install-config.yaml** file.
- 2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

**NOTE**

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

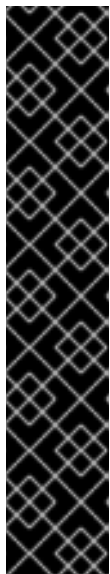
When the cluster deployment completes, directions for accessing your cluster, including a link to its web console and credentials for the **kubeadmin** user, display in your terminal.

**Example output**

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Ee6gm-ymBZj-
Wt5AL"
INFO Time elapsed: 36m22s
```

**NOTE**

The cluster access and credential information also outputs to **<installation\_directory>/openshift\_install.log** when an installation succeeds.

**IMPORTANT**

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

**IMPORTANT**

You must not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

**15.2.16. Verifying cluster status**

You can verify your OpenShift Container Platform cluster's status during or after installation.

**Procedure**

1. In the cluster environment, export the administrator's kubeconfig file:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server.

2. View the control plane and compute machines created after a deployment:

```
$ oc get nodes
```

3. View your cluster's version:

```
$ oc get clusterversion
```

4. View your Operators' status:

```
$ oc get clusteroperator
```

5. View all running pods in the cluster:

```
$ oc get pods -A
```

### 15.2.17. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

#### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

#### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

## Example output

```
system:admin
```

### Additional resources

- See [Accessing the web console](#) for more details about accessing and understanding the OpenShift Container Platform web console.

## 15.2.18. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

## 15.2.19. Next steps

- [Customize your cluster](#).
- If necessary, you can [opt out of remote health reporting](#).
- If you need to enable external access to node ports, [configure ingress cluster traffic by using a node port](#).
- If you did not configure RHOSP to accept application traffic over floating IP addresses, [configure RHOSP access with floating IP addresses](#).

## 15.3. INSTALLING A CLUSTER ON OPENSTACK WITH KURYR

In OpenShift Container Platform version 4.9, you can install a customized cluster on Red Hat OpenStack Platform (RHOSP) that uses Kuryr SDN. To customize the installation, modify parameters in the **install-config.yaml** before you install the cluster.

### 15.3.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You verified that OpenShift Container Platform 4.9 is compatible with your RHOSP version by using the [Supported platforms for OpenShift clusters](#) section. You can also compare platform support across different versions by viewing the [OpenShift Container Platform on RHOSP support matrix](#).

- You have a storage service installed in RHOSP, such as block storage (Cinder) or object storage (Swift). Object storage is the recommended storage technology for OpenShift Container Platform registry cluster deployment. For more information, see [Optimizing storage](#).

### 15.3.2. About Kuryr SDN

[Kuryr](#) is a container network interface (CNI) plugin solution that uses the [Neutron](#) and [Octavia](#) Red Hat OpenStack Platform (RHOSP) services to provide networking for pods and Services.

Kuryr and OpenShift Container Platform integration is primarily designed for OpenShift Container Platform clusters running on RHOSP VMs. Kuryr improves the network performance by plugging OpenShift Container Platform pods into RHOSP SDN. In addition, it provides interconnectivity between pods and RHOSP virtual instances.

Kuryr components are installed as pods in OpenShift Container Platform using the **openshift-kuryr** namespace:

- **kuryr-controller** - a single service instance installed on a **master** node. This is modeled in OpenShift Container Platform as a **Deployment** object.
- **kuryr-cni** - a container installing and configuring Kuryr as a CNI driver on each OpenShift Container Platform node. This is modeled in OpenShift Container Platform as a **DaemonSet** object.

The Kuryr controller watches the OpenShift Container Platform API server for pod, service, and namespace create, update, and delete events. It maps the OpenShift Container Platform API calls to corresponding objects in Neutron and Octavia. This means that every network solution that implements the Neutron trunk port functionality can be used to back OpenShift Container Platform via Kuryr. This includes open source solutions such as Open vSwitch (OVS) and Open Virtual Network (OVN) as well as Neutron-compatible commercial SDNs.

Kuryr is recommended for OpenShift Container Platform deployments on encapsulated RHOSP tenant networks to avoid double encapsulation, such as running an encapsulated OpenShift Container Platform SDN over an RHOSP network.

If you use provider networks or tenant VLANs, you do not need to use Kuryr to avoid double encapsulation. The performance benefit is negligible. Depending on your configuration, though, using Kuryr to avoid having two overlays might still be beneficial.

Kuryr is not recommended in deployments where all of the following criteria are true:

- The RHOSP version is less than 16.
- The deployment uses UDP services, or a large number of TCP services on few hypervisors.

or

- The **ovn-octavia** Octavia driver is disabled.
- The deployment uses a large number of TCP services on few hypervisors.

### 15.3.3. Resource guidelines for installing OpenShift Container Platform on RHOSP with Kuryr



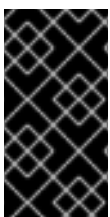
When using Kuryr SDN, the pods, services, namespaces, and network policies are using resources from the RHOSP quota; this increases the minimum requirements. Kuryr also has some additional requirements on top of what a default install requires.

Use the following quota to satisfy a default cluster's minimum requirements:

**Table 15.7. Recommended resources for a default OpenShift Container Platform cluster on RHOSP with Kuryr**

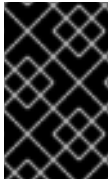
Resource	Value
Floating IP addresses	3 - plus the expected number of Services of LoadBalancer type
Ports	1500 - 1 needed per Pod
Routers	1
Subnets	250 - 1 needed per Namespace/Project
Networks	250 - 1 needed per Namespace/Project
RAM	112 GB
vCPUs	28
Volume storage	275 GB
Instances	7
Security groups	250 - 1 needed per Service and per NetworkPolicy
Security group rules	1000
Load balancers	100 - 1 needed per Service
Load balancer listeners	500 - 1 needed per Service-exposed port
Load balancer pools	500 - 1 needed per Service-exposed port

A cluster might function with fewer than recommended resources, but its performance is not guaranteed.



### IMPORTANT

If RHOSP object storage (Swift) is available and operated by a user account with the **swiftoperator** role, it is used as the default backend for the OpenShift Container Platform image registry. In this case, the volume storage requirement is 175 GB. Swift space requirements vary depending on the size of the image registry.



## IMPORTANT

If you are using Red Hat OpenStack Platform (RHOSP) version 16 with the Amphora driver rather than the OVN Octavia driver, security groups are associated with service accounts instead of user projects.

Take the following notes into consideration when setting resources:

- The number of ports that are required is larger than the number of pods. Kuryr uses ports pools to have pre-created ports ready to be used by pods and speed up the pods' booting time.
- Each network policy is mapped into an RHOSP security group, and depending on the **NetworkPolicy** spec, one or more rules are added to the security group.
- Each service is mapped to an RHOSP load balancer. Consider this requirement when estimating the number of security groups required for the quota.  
If you are using RHOSP version 15 or earlier, or the **ovn-octavia driver**, each load balancer has a security group with the user project.
- The quota does not account for load balancer resources (such as VM resources), but you must consider these resources when you decide the RHOSP deployment's size. The default installation will have more than 50 load balancers; the clusters must be able to accommodate them.  
If you are using RHOSP version 16 with the OVN Octavia driver enabled, only one load balancer VM is generated; services are load balanced through OVN flows.

An OpenShift Container Platform deployment comprises control plane machines, compute machines, and a bootstrap machine.

To enable Kuryr SDN, your environment must meet the following requirements:

- Run RHOSP 13+.
- Have Overcloud with Octavia.
- Use Neutron Trunk ports extension.
- Use **openvswitch** firewall driver if ML2/OVS Neutron driver is used instead of **ovs-hybrid**.

### 15.3.3.1. Increasing quota

When using Kuryr SDN, you must increase quotas to satisfy the Red Hat OpenStack Platform (RHOSP) resources used by pods, services, namespaces, and network policies.

#### Procedure

- Increase the quotas for a project by running the following command:

```
$ sudo openstack quota set --secgroups 250 --secgroup-rules 1000 --ports 1500 --subnets 250 --networks 250 <project>
```

### 15.3.3.2. Configuring Neutron

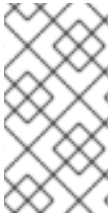
Kuryr CNI leverages the Neutron Trunks extension to plug containers into the Red Hat OpenStack Platform (RHOSP) SDN, so you must use the **trunks** extension for Kuryr to properly work.

In addition, if you leverage the default ML2/OVS Neutron driver, the firewall must be set to **openvswitch** instead of **ovs\_hybrid** so that security groups are enforced on trunk subports and Kuryr can properly handle network policies.

### 15.3.3.3. Configuring Octavia

Kuryr SDN uses Red Hat OpenStack Platform (RHOSP)'s Octavia LBaaS to implement OpenShift Container Platform services. Thus, you must install and configure Octavia components in RHOSP to use Kuryr SDN.

To enable Octavia, you must include the Octavia service during the installation of the RHOSP Overcloud, or upgrade the Octavia service if the Overcloud already exists. The following steps for enabling Octavia apply to both a clean install of the Overcloud or an Overcloud update.



#### NOTE

The following steps only capture the key pieces required during the [deployment of RHOSP](#) when dealing with Octavia. It is also important to note that [registry methods](#) vary.

This example uses the local registry method.

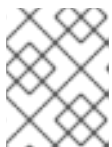
#### Procedure

1. If you are using the local registry, create a template to upload the images to the registry. For example:

```
(undercloud) $ openstack overcloud container image prepare \
-e /usr/share/openstack-tripleo-heat-templates/environments/services-docker/octavia.yaml \
--namespace=registry.access.redhat.com/rhosp13 \
--push-destination=<local-ip-from-undercloud.conf>:8787 \
--prefix=openstack- \
--tag-from-label {version}-{product-version} \
--output-env-file=/home/stack/templates/overcloud_images.yaml \
--output-images-file /home/stack/local_registry_images.yaml
```

2. Verify that the **local\_registry\_images.yaml** file contains the Octavia images. For example:

```
...
- imagename: registry.access.redhat.com/rhosp13/openstack-octavia-api:13.0-43
  push_destination: <local-ip-from-undercloud.conf>:8787
- imagename: registry.access.redhat.com/rhosp13/openstack-octavia-health-manager:13.0-45
  push_destination: <local-ip-from-undercloud.conf>:8787
- imagename: registry.access.redhat.com/rhosp13/openstack-octavia-housekeeping:13.0-45
  push_destination: <local-ip-from-undercloud.conf>:8787
- imagename: registry.access.redhat.com/rhosp13/openstack-octavia-worker:13.0-44
  push_destination: <local-ip-from-undercloud.conf>:8787
```



#### NOTE

The Octavia container versions vary depending upon the specific RHOSP release installed.

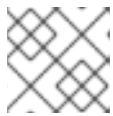
3. Pull the container images from **registry.redhat.io** to the Undercloud node:

```
(undercloud) $ sudo openstack overcloud container image upload \
--config-file /home/stack/local_registry_images.yaml \
--verbose
```

This may take some time depending on the speed of your network and Undercloud disk.

4. Since an Octavia load balancer is used to access the OpenShift Container Platform API, you must increase their listeners' default timeouts for the connections. The default timeout is 50 seconds. Increase the timeout to 20 minutes by passing the following file to the Overcloud deploy command:

```
(undercloud) $ cat octavia_timeouts.yaml
parameter_defaults:
  OctaviaTimeoutClientData: 1200000
  OctaviaTimeoutMemberData: 1200000
```



#### NOTE

This is not needed for RHOSP 13.0.13+.

5. Install or update your Overcloud environment with Octavia:

```
$ openstack overcloud deploy --templates \
-e /usr/share/openstack-tripleo-heat-templates/environments/services-docker/octavia.yaml \
-e octavia_timeouts.yaml
```



#### NOTE

This command only includes the files associated with Octavia; it varies based on your specific installation of RHOSP. See the RHOSP documentation for further information. For more information on customizing your Octavia installation, see [installation of Octavia using Director](#).



#### NOTE

When leveraging Kuryr SDN, the Overcloud installation requires the Neutron **trunk** extension. This is available by default on director deployments. Use the **openvswitch** firewall instead of the default **ovs-hybrid** when the Neutron backend is ML2/OVS. There is no need for modifications if the backend is ML2/OVN.

6. In RHOSP versions earlier than 13.0.13, add the project ID to the **octavia.conf** configuration file after you create the project.
  - To enforce network policies across services, like when traffic goes through the Octavia load balancer, you must ensure Octavia creates the Amphora VM security groups on the user project. This change ensures that required load balancer security groups belong to that project, and that they can be updated to enforce services isolation.

**NOTE**

This task is unnecessary in RHOSP version 13.0.13 or later.

Octavia implements a new ACL API that restricts access to the load balancers VIP.

- a. Get the project ID

```
$ openstack project show <project>
```

**Example output**

```
+-----+-----+
| Field  | Value                |
+-----+-----+
| description |                    |
| domain_id | default              |
| enabled   | True                 |
| id       | PROJECT_ID          |
| is_domain | False                |
| name     | *<project>*         |
| parent_id | default              |
| tags     | []                   |
+-----+-----+
```

- b. Add the project ID to **octavia.conf** for the controllers.
  - i. Source the **stackrc** file:

```
$ source stackrc # Undercloud credentials
```

- ii. List the Overcloud controllers:

```
$ openstack server list
```

**Example output**

```
+-----+-----+-----+-----+-----+
| ID                | Name          | Status | Networks |
| Image            | Flavor       |        |           |
+-----+-----+-----+-----+-----+
| 6bef8e73-2ba5-4860-a0b1-3937f8ca7e01 | controller-0 | ACTIVE |          |
|ctlplane=192.168.24.8 | overcloud-full | controller |
|
| dda3173a-ab26-47f8-a2dc-8473b4a67ab9 | compute-0    | ACTIVE |          |
|ctlplane=192.168.24.6 | overcloud-full | compute  |
```

```
|
+-----+-----+-----+-----+
-----+
```

- iii. SSH into the controller(s).

```
$ ssh heat-admin@192.168.24.8
```

- iv. Edit the **octavia.conf** file to add the project into the list of projects where Amphora security groups are on the user's account.

```
# List of project IDs that are allowed to have Load balancer security groups
# belonging to them.
amp_secgroup_allowed_projects = PROJECT_ID
```

- c. Restart the Octavia worker so the new configuration loads.

```
controller-0$ sudo docker restart octavia_worker
```



#### NOTE

Depending on your RHOSP environment, Octavia might not support UDP listeners. If you use Kuryr SDN on RHOSP version 13.0.13 or earlier, UDP services are not supported. RHOSP version 16 or later support UDP.

#### 15.3.3.3.1. The Octavia OVN Driver

Octavia supports multiple provider drivers through the Octavia API.

To see all available Octavia provider drivers, on a command line, enter:

```
$ openstack loadbalancer provider list
```

#### Example output

```
+-----+-----+-----+
| name | description |
+-----+-----+
| amphora | The Octavia Amphora driver. |
| octavia | Deprecated alias of the Octavia Amphora driver. |
| ovn | Octavia OVN driver. |
+-----+-----+-----+

```

Beginning with RHOSP version 16, the Octavia OVN provider driver (**ovn**) is supported on OpenShift Container Platform on RHOSP deployments.

**ovn** is an integration driver for the load balancing that Octavia and OVN provide. It supports basic load balancing capabilities, and is based on OpenFlow rules. The driver is automatically enabled in Octavia by Director on deployments that use OVN Neutron ML2.

The Amphora provider driver is the default driver. If **ovn** is enabled, however, Kuryr uses it.

If Kuryr uses **ovn** instead of Amphora, it offers the following benefits:

- Decreased resource requirements. Kuryr does not require a load balancer VM for each service.
- Reduced network latency.
- Increased service creation speed by using OpenFlow rules instead of a VM for each service.
- Distributed load balancing actions across all nodes instead of centralized on Amphora VMs.

You can [configure your cluster to use the Octavia OVN driver](#) after your RHOSP cloud is upgraded from version 13 to version 16.

#### 15.3.3.4. Known limitations of installing with Kuryr

Using OpenShift Container Platform with Kuryr SDN has several known limitations.

##### RHOSP general limitations

Using OpenShift Container Platform with Kuryr SDN has several limitations that apply to all versions and environments:

- **Service** objects with the **NodePort** type are not supported.
- Clusters that use the OVN Octavia provider driver support **Service** objects for which the **.spec.selector** property is unspecified only if the **.subsets.addresses** property of the **Endpoints** object includes the subnet of the nodes or pods.
- If the subnet on which machines are created is not connected to a router, or if the subnet is connected, but the router has no external gateway set, Kuryr cannot create floating IPs for **Service** objects with type **LoadBalancer**.
- Configuring the **sessionAffinity=ClientIP** property on **Service** objects does not have an effect. Kuryr does not support this setting.

##### RHOSP version limitations

Using OpenShift Container Platform with Kuryr SDN has several limitations that depend on the RHOSP version.

- RHOSP versions before 16 use the default Octavia load balancer driver (Amphora). This driver requires that one Amphora load balancer VM is deployed per OpenShift Container Platform service. Creating too many services can cause you to run out of resources. Deployments of later versions of RHOSP that have the OVN Octavia driver disabled also use the Amphora driver. They are subject to the same resource concerns as earlier versions of RHOSP.
- Octavia RHOSP versions before 13.0.13 do not support UDP listeners. Therefore, OpenShift Container Platform UDP services are not supported.
- Octavia RHOSP versions before 13.0.13 cannot listen to multiple protocols on the same port. Services that expose the same port to different protocols, like TCP and UDP, are not supported.
- Kuryr SDN does not support automatic unidling by a service.

##### RHOSP environment limitations

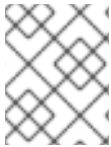
There are limitations when using Kuryr SDN that depend on your deployment environment.

Because of Octavia's lack of support for the UDP protocol and multiple listeners, if the RHOSP version is earlier than 13.0.13, Kuryr forces pods to use TCP for DNS resolution.

In Go versions 1.12 and earlier, applications that are compiled with CGO support disabled use UDP only. In this case, the native Go resolver does not recognize the **use-vc** option in **resolv.conf**, which controls whether TCP is forced for DNS resolution. As a result, UDP is still used for DNS resolution, which fails.

To ensure that TCP forcing is allowed, compile applications either with the environment variable **CGO\_ENABLED** set to **1**, i.e. **CGO\_ENABLED=1**, or ensure that the variable is absent.

In Go versions 1.13 and later, TCP is used automatically if DNS resolution using UDP fails.



#### NOTE

musl-based containers, including Alpine-based containers, do not support the **use-vc** option.

#### RHOSP upgrade limitations

As a result of the RHOSP upgrade process, the Octavia API might be changed, and upgrades to the Amphora images that are used for load balancers might be required.

You can address API changes on an individual basis.

If the Amphora image is upgraded, the RHOSP operator can handle existing load balancer VMs in two ways:

- Upgrade each VM by triggering a [load balancer failover](#).
- Leave responsibility for upgrading the VMs to users.

If the operator takes the first option, there might be short downtimes during failovers.

If the operator takes the second option, the existing load balancers will not support upgraded Octavia API features, like UDP listeners. In this case, users must recreate their Services to use these features.



#### IMPORTANT

If OpenShift Container Platform detects a new Octavia version that supports UDP load balancing, it recreates the DNS service automatically. The service recreation ensures that the service default supports UDP load balancing.

The recreation causes the DNS service approximately one minute of downtime.

#### 15.3.3.5. Control plane machines

By default, the OpenShift Container Platform installation process creates three control plane machines.

Each machine requires:

- An instance from the RHOSP quota
- A port from the RHOSP quota
- A flavor with at least 16 GB memory and 4 vCPUs
- At least 100 GB storage space from the RHOSP quota

#### 15.3.3.6. Compute machines



By default, the OpenShift Container Platform installation process creates three compute machines.

Each machine requires:

- An instance from the RHOSP quota
- A port from the RHOSP quota
- A flavor with at least 8 GB memory and 2 vCPUs
- At least 100 GB storage space from the RHOSP quota

## TIP

Compute machines host the applications that you run on OpenShift Container Platform; aim to run as many as you can.

### 15.3.3.7. Bootstrap machine

During installation, a bootstrap machine is temporarily provisioned to stand up the control plane. After the production control plane is ready, the bootstrap machine is deprovisioned.

The bootstrap machine requires:

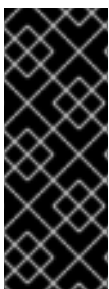
- An instance from the RHOSP quota
- A port from the RHOSP quota
- A flavor with at least 16 GB memory and 4 vCPUs
- At least 100 GB storage space from the RHOSP quota

### 15.3.4. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

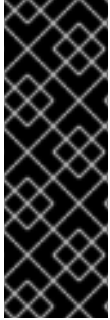


## IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

### 15.3.5. Enabling Swift on RHOSP

Swift is operated by a user account with the **swiftoperator** role. Add the role to an account before you run the installation program.



#### IMPORTANT

If [the Red Hat OpenStack Platform \(RHOSP\) object storage service](#), commonly known as Swift, is available, OpenShift Container Platform uses it as the image registry storage. If it is unavailable, the installation program relies on the RHOSP block storage service, commonly known as Cinder.

If Swift is present and you want to use it, you must enable access to it. If it is not present, or if you do not want to use it, skip this section.

#### Prerequisites

- You have a RHOSP administrator account on the target environment.
- The Swift service is installed.
- On [Ceph RGW](#), the **account in url** option is enabled.

#### Procedure

To enable Swift on RHOSP:

1. As an administrator in the RHOSP CLI, add the **swiftoperator** role to the account that will access Swift:

```
$ openstack role add --user <user> --project <project> swiftoperator
```

Your RHOSP deployment can now use Swift for the image registry.

### 15.3.6. Verifying external network access

The OpenShift Container Platform installation process requires external network access. You must provide an external network value to it, or deployment fails. Before you begin the process, verify that a network with the external router type exists in Red Hat OpenStack Platform (RHOSP).

#### Prerequisites

- [Configure OpenStack's networking service to have DHCP agents forward instances' DNS queries](#)

#### Procedure

1. Using the RHOSP CLI, verify the name and ID of the 'External' network:

```
$ openstack network list --long -c ID -c Name -c "Router Type"
```

#### Example output

```
+-----+-----+-----+
```

ID	Name	Router Type
148a8023-62a7-4672-b018-003462f8d7dc	public_network	External

A network with an external router type appears in the network list. If at least one does not, see [Creating a default floating IP network](#) and [Creating a default provider network](#).

### IMPORTANT

If the external network's CIDR range overlaps one of the default network ranges, you must change the matching network ranges in the **install-config.yaml** file before you start the installation process.

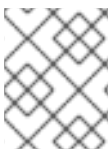
The default network ranges are:

Network	Range
<b>machineNetwork</b>	10.0.0.0/16
<b>serviceNetwork</b>	172.30.0.0/16
<b>clusterNetwork</b>	10.128.0.0/14



### WARNING

If the installation program finds multiple networks with the same name, it sets one of them at random. To avoid this behavior, create unique names for resources in RHOSP.



### NOTE

If the Neutron trunk service plugin is enabled, a trunk port is created by default. For more information, see [Neutron trunk port](#).

## 15.3.7. Defining parameters for the installation program

The OpenShift Container Platform installation program relies on a file that is called **clouds.yaml**. The file describes Red Hat OpenStack Platform (RHOSP) configuration parameters, including the project name, log in information, and authorization service URLs.

### Procedure

1. Create the **clouds.yaml** file:
  - If your RHOSP distribution includes the Horizon web UI, generate a **clouds.yaml** file in it.



## IMPORTANT

Remember to add a password to the **auth** field. You can also keep secrets in a [separate file](#) from **clouds.yaml**.

- If your RHOSP distribution does not include the Horizon web UI, or you do not want to use Horizon, create the file yourself. For detailed information about **clouds.yaml**, see [Config files](#) in the RHOSP documentation.

```
clouds:
  shiftstack:
    auth:
      auth_url: http://10.10.14.42:5000/v3
      project_name: shiftstack
      username: shiftstack_user
      password: XXX
      user_domain_name: Default
      project_domain_name: Default
  dev-env:
    region_name: RegionOne
    auth:
      username: 'devuser'
      password: XXX
      project_name: 'devonly'
      auth_url: 'https://10.10.14.22:5001/v2.0'
```

2. If your RHOSP installation uses self-signed certificate authority (CA) certificates for endpoint authentication:
  - a. Copy the certificate authority file to your machine.
  - b. Add the **cacerts** key to the **clouds.yaml** file. The value must be an absolute, non-root-accessible path to the CA certificate:

```
clouds:
  shiftstack:
    ...
    cacert: "/etc/pki/ca-trust/source/anchors/ca.crt.pem"
```

## TIP

After you run the installer with a custom CA certificate, you can update the certificate by editing the value of the **ca-cert.pem** key in the **cloud-provider-config** keymap. On a command line, run:

```
$ oc edit configmap -n openshift-config cloud-provider-config
```

3. Place the **clouds.yaml** file in one of the following locations:
  - a. The value of the **OS\_CLIENT\_CONFIG\_FILE** environment variable
  - b. The current directory
  - c. A Unix-specific user configuration directory, for example **~/.config/openstack/clouds.yaml**

- d. A Unix-specific site configuration directory, for example `/etc/openstack/clouds.yaml`  
The installation program searches for **clouds.yaml** in that order.

### 15.3.8. Setting cloud provider options

Optionally, you can edit the cloud provider configuration for your cluster. The cloud provider configuration controls how OpenShift Container Platform interacts with Red Hat OpenStack Platform (RHOSP).

For a complete list of cloud provider configuration parameters, see the "OpenStack cloud configuration reference guide" page in the "Installing on OpenStack" documentation.

#### Procedure

1. If you have not already generated manifest files for your cluster, generate them by running the following command:

```
$ openshift-install --dir <destination_directory> create manifests
```

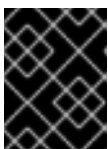
2. In a text editor, open the cloud-provider configuration manifest file. For example:

```
$ vi openshift/manifests/cloud-provider-config.yaml
```

3. Modify the options based on the cloud configuration specification.  
Configuring Octavia for load balancing is a common case for clusters that do not use Kuryr. For example:

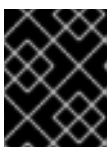
```
#...
[LoadBalancer]
use-octavia=true 1
lb-provider = "amphora" 2
floating-network-id="d3deb660-4190-40a3-91f1-37326fe6ec4a" 3
#...
```

- 1 This property enables Octavia integration.
- 2 This property sets the Octavia provider that your load balancer uses. It accepts "ovn" or "amphora" as values. If you choose to use OVN, you must also set **lb-method** to **SOURCE\_IP\_PORT**.
- 3 This property is required if you want to use multiple external networks with your cluster. The cloud provider creates floating IP addresses on the network that is specified here.



#### IMPORTANT

Prior to saving your changes, verify that the file is structured correctly. Clusters might fail if properties are not placed in the appropriate section.



#### IMPORTANT

For installations that use Kuryr, Kuryr handles relevant services. There is no need to configure Octavia load balancing in the cloud provider.

4. Save the changes to the file and proceed with installation.

### TIP

You can update your cloud provider configuration after you run the installer. On a command line, run:

```
$ oc edit configmap -n openshift-config cloud-provider-config
```

After you save your changes, your cluster will take some time to reconfigure itself. The process is complete if none of your nodes have a **SchedulingDisabled** status.

### Additional resources

- For more information about cloud provider configuration, see [OpenStack cloud provider options](#).

## 15.3.9. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

### Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space

### Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



### IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



### IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#) . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

### 15.3.10. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Red Hat OpenStack Platform (RHOSP).

#### Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

#### Procedure

1. Create the **install-config.yaml** file.
  - a. Change to the directory that contains the installation program and run the following command:

```
./openshift-install create install-config --dir <installation_directory> 1
```

- 1** For **<installation\_directory>**, specify the directory name to store the files that the installation program creates.



#### IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

- b. At the prompts, provide the configuration details for your cloud:
  - i. Optional: Select an SSH key to use to access your cluster machines.

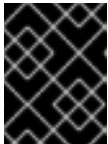


#### NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

- ii. Select **openstack** as the platform to target.

- iii. Specify the Red Hat OpenStack Platform (RHOSP) external network name to use for installing the cluster.
  - iv. Specify the floating IP address to use for external access to the OpenShift API.
  - v. Specify a RHOSP flavor with at least 16 GB RAM to use for control plane nodes and 8 GB RAM for compute nodes.
  - vi. Select the base domain to deploy the cluster to. All DNS records will be sub-domains of this base and will also include the cluster name.
  - vii. Enter a name for your cluster. The name must be 14 or fewer characters long.
  - viii. Paste the [pull secret from the Red Hat OpenShift Cluster Manager](#) .
2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.
  3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



### IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

#### 15.3.10.1. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.



### NOTE

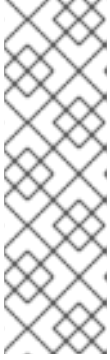
Kuryr installations default to HTTP proxies.

#### Prerequisites

- For Kuryr installations on restricted networks that use the **Proxy** object, the proxy must be able to reply to the router that the cluster uses. To add a static route for the proxy configuration, from a command line as the root user, enter:
 

```
$ ip route add <cluster_network_cidr> via <installer_subnet_gateway>
```
- The restricted subnet must have a gateway that is defined and available to be linked to the **Router** resource that Kuryr creates.
- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.





## NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

## Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
  additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
  ...
```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations.
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.



## NOTE

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



#### NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

### 15.3.11. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.



#### NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.



#### IMPORTANT

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

#### 15.3.11.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 15.8. Required parameters

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String


Parameter	Description	Values
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;.&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}</b> . <b>{{.baseDomain}}</b> .	String of lowercase letters, hyphens (-), and periods (.), such as <b>dev</b> . The string must be 14 characters or fewer long.
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws, baremetal, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b> . For additional information about <b>platform.&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre> {   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } } </pre>

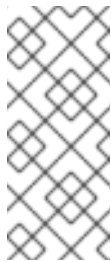
### 15.3.11.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

Table 15.9. Network parameters

Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	Object   <b>NOTE</b> You cannot modify parameters specified by the <b>networking</b> object after installation.
<b>networking.networkType</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .
<b>networking.clusterNetwork</b>	The IP address blocks for pods.  The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b> .  If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example:  <pre>networking:   clusterNetwork:   - cidr: 10.128.0.0/14     hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	Required if you use <b>networking.clusterNetwork</b> . An IP address block.  An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b> .
<b>networking.clusterNetwork.hostPrefix</b>	The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b> . A <b>hostPrefix</b> value of <b>23</b> provides 510 ( $2^{(32 - 23)} - 2$ ) pod IP addresses.	A subnet prefix.  The default value is <b>23</b> .


Parameter	Description	Values
<b>networking.serviceNetwork</b>	<p>The IP address block for services. The default value is <b>172.30.0.0/16</b>.</p> <p>The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.</p>	<p>An array with an IP address block in CIDR format. For example:</p> <pre>networking:   serviceNetwork:     - 172.30.0.0/16</pre>
<b>networking.machineNetwork</b>	<p>The IP address blocks for machines.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   machineNetwork:     - cidr: 10.0.0.0/16</pre>
<b>networking.machineNetwork.cidr</b>	<p>Required if you use <b>networking.machineNetwork</b>. An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b>.</p>	<p>An IP network block in CIDR notation.</p> <p>For example, <b>10.0.0.0/16</b>.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p> </div> </div>


### 15.3.11.3. Optional configuration parameters



Optional installation configuration parameters are described in the following table:

Table 15.10. Optional parameters

Parameter	Description	Values
<b>additionalTrustBundle</b>	<p>A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.</p>	String
<b>compute</b>	<p>The configuration for the machines that comprise the compute nodes.</p>	Array of <b>MachinePool</b> objects.


Parameter	Description	Values
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String
<b>compute.hyperthreading</b>	Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b> , on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.   <b>IMPORTANT</b>  If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b>
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String

Parameter	Description	Values
<b>controlPlane.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platform</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>controlPlane.replicas</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.

Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.</p> <div data-bbox="485 510 595 862" style="border: 1px solid black; padding: 5px; margin-bottom: 10px;">  </div> <p><b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators reference content</i>.</p> <div data-bbox="485 907 595 1258" style="border: 1px solid black; padding: 5px;">  </div> <p><b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p>	<b>Mint, Passthrough, Manual</b> or an empty string ("").



Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 60px; height: 60px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 60px; height: 60px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<p><b>Internal</b> or <b>External</b>. The default value is <b>External</b>.</p> <p>Setting this field to <b>Internal</b> is not supported on non-cloud platforms.</p>

Parameter	Description	Values
<b>sshKey</b>	<p>The SSH key or keys to authenticate access your cluster machines.</p>  <p><b>NOTE</b></p> <p>For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.</p>	<p>One or more keys. For example:</p> <pre>sshKey:   &lt;key1&gt;   &lt;key2&gt;   &lt;key3&gt;</pre>

#### 15.3.11.4. Additional Red Hat OpenStack Platform (RHOSP) configuration parameters

Additional RHOSP configuration parameters are described in the following table:

Table 15.11. Additional RHOSP parameters

Parameter	Description	Values
<b>compute.platform.openstack.rootVolume.size</b>	For compute machines, the size in gigabytes of the root volume. If you do not set this value, machines use ephemeral storage.	Integer, for example <b>30</b> .
<b>compute.platform.openstack.rootVolume.type</b>	For compute machines, the root volume's type.	String, for example <b>performance</b> .
<b>controlPlane.platform.openstack.rootVolume.size</b>	For control plane machines, the size in gigabytes of the root volume. If you do not set this value, machines use ephemeral storage.	Integer, for example <b>30</b> .
<b>controlPlane.platform.openstack.rootVolume.type</b>	For control plane machines, the root volume's type.	String, for example <b>performance</b> .

Parameter	Description	Values
<b>platform.openstack.cloud</b>	The name of the RHOSP cloud to use from the list of clouds in the <b>clouds.yaml</b> file.	String, for example <b>MyCloud</b> .
<b>platform.openstack.externalNetwork</b>	The RHOSP external network name to be used for installation.	String, for example <b>external</b> .
<b>platform.openstack.computeFlavor</b>	<p>The RHOSP flavor to use for control plane and compute machines.</p> <p>This property is deprecated. To use a flavor as the default for all machine pools, add it as the value of the <b>type</b> key in the <b>platform.openstack.defaultMachinePlatform</b> property. You can also set a flavor value for each machine pool individually.</p>	String, for example <b>m1.xlarge</b> .

### 15.3.11.5. Optional RHOSP configuration parameters

Optional RHOSP configuration parameters are described in the following table:

Table 15.12. Optional RHOSP parameters

Parameter	Description	Values
<b>compute.platform.openstack.additionalNetworkIDs</b>	Additional networks that are associated with compute machines. Allowed address pairs are not created for additional networks.	A list of one or more UUIDs as strings. For example, <b>fa806b2f-ac49-4bce-b9db-124bc64209bf</b> .
<b>compute.platform.openstack.additionalSecurityGroupIDs</b>	Additional security groups that are associated with compute machines.	A list of one or more UUIDs as strings. For example, <b>7ee219f3-d2e9-48a1-96c2-e7429f1b0da7</b> .

Parameter	Description	Values
<b>compute.platform.openstack.zones</b>	<p>RHOSP Compute (Nova) availability zones (AZs) to install machines on. If this parameter is not set, the installer relies on the default settings for Nova that the RHOSP administrator configured.</p> <p>On clusters that use Kuryr, RHOSP Octavia does not support availability zones. Load balancers and, if you are using the Amphora provider driver, OpenShift Container Platform services that rely on Amphora VMs, are not created according to the value of this property.</p>	A list of strings. For example, <b>["zone-1", "zone-2"]</b> .
<b>compute.platform.openstack.rootVolume.zones</b>	For compute machines, the availability zone to install root volumes on. If you do not set a value for this parameter, the installer selects the default availability zone.	A list of strings, for example <b>["zone-1", "zone-2"]</b> .
<b>controlPlane.platform.openstack.additionalNetworkIDs</b>	Additional networks that are associated with control plane machines. Allowed address pairs are not created for additional networks.	A list of one or more UUIDs as strings. For example, <b>fa806b2f-ac49-4bce-b9db-124bc64209bf</b> .
<b>controlPlane.platform.openstack.additionalSecurityGroupIDs</b>	Additional security groups that are associated with control plane machines.	A list of one or more UUIDs as strings. For example, <b>7ee219f3-d2e9-48a1-96c2-e7429f1b0da7</b> .

Parameter	Description	Values
<b>controlPlane.platform.openstack.zones</b>	<p>RHOSP Compute (Nova) availability zones (AZs) to install machines on. If this parameter is not set, the installer relies on the default settings for Nova that the RHOSP administrator configured.</p> <p>On clusters that use Kuryr, RHOSP Octavia does not support availability zones. Load balancers and, if you are using the Amphora provider driver, OpenShift Container Platform services that rely on Amphora VMs, are not created according to the value of this property.</p>	A list of strings. For example, <b>["zone-1", "zone-2"]</b> .
<b>controlPlane.platform.openstack.rootVolume.zones</b>	For control plane machines, the availability zone to install root volumes on. If you do not set this value, the installer selects the default availability zone.	A list of strings, for example <b>["zone-1", "zone-2"]</b> .
<b>platform.openstack.clusterOSImage</b>	<p>The location from which the installer downloads the RHCOS image.</p> <p>You must set this parameter to perform an installation in a restricted network.</p>	<p>An HTTP or HTTPS URL, optionally with an SHA-256 checksum.</p> <p>For example,  <b>http://mirror.example.com/images/rhcos-43.81.201912131630.0-openstack.x86_64.qcow2.gz?sha256=ffebbd68e8a1f2a245ca19522c16c86f67f9ac8e4e0c1f0a812b068b16f7265d</b>. The value can also be the name of an existing Glance image, for example <b>my-rhcos</b>.</p>

Parameter	Description	Values
<b>platform.openstack.clusterOSImageProperties</b>	<p>Properties to add to the installer-uploaded ClusterOSImage in Glance. This property is ignored if <b>platform.openstack.clusterOSImage</b> is set to an existing Glance image.</p> <p>You can use this property to exceed the default persistent volume (PV) limit for RHOSP of 26 PVs per node. To exceed the limit, set the <b>hw_scsi_model</b> property value to <b>virtio-scsi</b> and the <b>hw_disk_bus</b> value to <b>scsi</b>.</p> <p>You can also use this property to enable the QEMU guest agent by including the <b>hw_qemu_guest_agent</b> property with a value of <b>yes</b>.</p>	A list of key-value string pairs. For example, <b>["hw_scsi_model": "virtio-scsi", "hw_disk_bus": "scsi"]</b> .
<b>platform.openstack.defaultMachinePlatform</b>	The default machine pool platform configuration.	<pre>{   "type": "ml.large",   "rootVolume": {     "size": 30,     "type": "performance"   } }</pre>
<b>platform.openstack.ingressFloatingIP</b>	An existing floating IP address to associate with the Ingress port. To use this property, you must also define the <b>platform.openstack.externalNetwork</b> property.	An IP address, for example <b>128.0.0.1</b> .
<b>platform.openstack.apiFloatingIP</b>	An existing floating IP address to associate with the API load balancer. To use this property, you must also define the <b>platform.openstack.externalNetwork</b> property.	An IP address, for example <b>128.0.0.1</b> .
<b>platform.openstack.externalDNS</b>	IP addresses for external DNS servers that cluster instances use for DNS resolution.	A list of IP addresses as strings. For example, <b>["8.8.8.8", "192.168.1.12"]</b> .

Parameter	Description	Values
<b>platform.openstack.machinesSubnet</b>	<p>The UUID of a RHOSP subnet that the cluster's nodes use. Nodes and virtual IP (VIP) ports are created on this subnet.</p> <p>The first item in <b>networking.machineNetwork</b> must match the value of <b>machinesSubnet</b>.</p> <p>If you deploy to a custom subnet, you cannot specify an external DNS server to the OpenShift Container Platform installer. Instead, <a href="#">add DNS to the subnet in RHOSP</a>.</p>	A UUID as a string. For example, <b>fa806b2f-ac49-4bce-b9db-124bc64209bf</b> .

### 15.3.11.6. Custom subnets in RHOSP deployments

Optionally, you can deploy a cluster on a Red Hat OpenStack Platform (RHOSP) subnet of your choice. The subnet's GUID is passed as the value of **platform.openstack.machinesSubnet** in the **install-config.yaml** file.

This subnet is used as the cluster's primary subnet. By default, nodes and ports are created on it. You can create nodes and ports on a different RHOSP subnet by setting the value of the **platform.openstack.machinesSubnet** property to the subnet's UUID.

Before you run the OpenShift Container Platform installer with a custom subnet, verify that your configuration meets the following requirements:

- The subnet that is used by **platform.openstack.machinesSubnet** has DHCP enabled.
- The CIDR of **platform.openstack.machinesSubnet** matches the CIDR of **networking.machineNetwork**.
- The installation program user has permission to create ports on this network, including ports with fixed IP addresses.

Clusters that use custom subnets have the following limitations:

- If you plan to install a cluster that uses floating IP addresses, the **platform.openstack.machinesSubnet** subnet must be attached to a router that is connected to the **externalNetwork** network.
- If the **platform.openstack.machinesSubnet** value is set in the **install-config.yaml** file, the installation program does not create a private network or subnet for your RHOSP machines.
- You cannot use the **platform.openstack.externalDNS** property at the same time as a custom subnet. To add DNS to a cluster that uses a custom subnet, configure DNS on the RHOSP network.

**NOTE**

By default, the API VIP takes x.x.x.5 and the Ingress VIP takes x.x.x.7 from your network's CIDR block. To override these default values, set values for **platform.openstack.apiVIP** and **platform.openstack.ingressVIP** that are outside of the DHCP allocation pool.

**15.3.11.7. Sample customized install-config.yaml file for RHOSP with Kuryr**

To deploy with Kuryr SDN instead of the default OpenShift SDN, you must modify the **install-config.yaml** file to include **Kuryr** as the desired **networking.networkType** and proceed with the default OpenShift Container Platform SDN installation steps. This sample **install-config.yaml** demonstrates all of the possible Red Hat OpenStack Platform (RHOSP) customization options.

**IMPORTANT**

This sample file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program.

```

apiVersion: v1
baseDomain: example.com
controlPlane:
  name: master
  platform: {}
  replicas: 3
compute:
- name: worker
  platform:
    openstack:
      type: ml.large
  replicas: 3
metadata:
  name: example
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  serviceNetwork:
  - 172.30.0.0/16 1
  networkType: Kuryr
platform:
  openstack:
    cloud: mycloud
    externalNetwork: external
    computeFlavor: m1.xlarge
    apiFloatingIP: 128.0.0.1
    trunkSupport: true 2
    octaviaSupport: true 3
pullSecret: '{"auths": ...}'
sshKey: ssh-ed25519 AAAA...

```



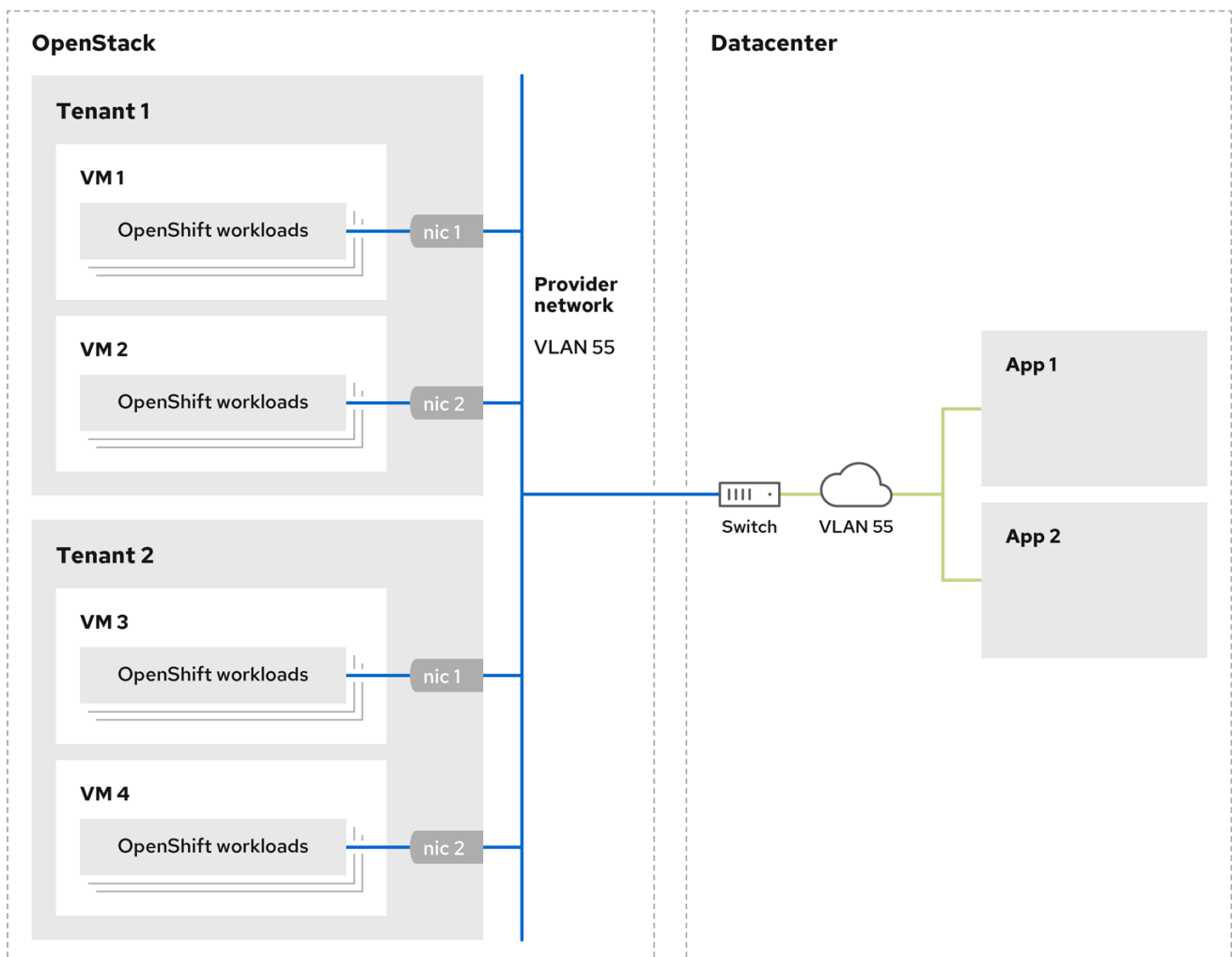
- 1 The Amphora Octavia driver creates two ports per load balancer. As a result, the service subnet that the installer creates is twice the size of the CIDR that is specified as the value of the
- 2
- 3 Both **trunkSupport** and **octaviaSupport** are automatically discovered by the installer, so there is no need to set them. But if your environment does not meet both requirements, Kuryr SDN will not properly work. Trunks are needed to connect the pods to the RHOSP network and Octavia is required to create the OpenShift Container Platform services.

### 15.3.11.8. Cluster deployment on RHOSP provider networks

You can deploy your OpenShift Container Platform clusters on Red Hat OpenStack Platform (RHOSP) with a primary network interface on a provider network. Provider networks are commonly used to give projects direct access to a public network that can be used to reach the internet. You can also share provider networks among projects as part of the network creation process.

RHOSP provider networks map directly to an existing physical network in the data center. A RHOSP administrator must create them.

In the following example, OpenShift Container Platform workloads are connected to a data center by using a provider network:



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OpenShift Container Platform clusters that are installed on provider networks do not require tenant networks or floating IP addresses. The installer does not create these resources during installation.

Example provider network types include flat (untagged) and VLAN (802.1Q tagged).



#### NOTE

A cluster can support as many provider network connections as the network type allows. For example, VLAN networks typically support up to 4096 connections.

You can learn more about provider and tenant networks in [the RHOSP documentation](#).

#### 15.3.11.8.1. RHOSP provider network requirements for cluster installation

Before you install an OpenShift Container Platform cluster, your Red Hat OpenStack Platform (RHOSP) deployment and provider network must meet a number of conditions:

- The [RHOSP networking service \(Neutron\) is enabled](#) and accessible through the RHOSP networking API.
- The RHOSP networking service has the [port security and allowed address pairs extensions enabled](#).
- The provider network can be shared with other tenants.

#### TIP

Use the **openstack network create** command with the **--share** flag to create a network that can be shared.

- The RHOSP project that you use to install the cluster must own the provider network, as well as an appropriate subnet.

#### TIP

To create a network for a project that is named "openshift," enter the following command

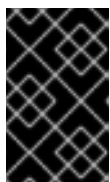
```
$ openstack network create --project openshift
```

To create a subnet for a project that is named "openshift," enter the following command

```
$ openstack subnet create --project openshift
```

To learn more about creating networks on RHOSP, read [the provider networks documentation](#).

If the cluster is owned by the **admin** user, you must run the installer as that user to create ports on the network.



#### IMPORTANT

Provider networks must be owned by the RHOSP project that is used to create the cluster. If they are not, the RHOSP Compute service (Nova) cannot request a port from that network.

- Verify that the provider network can reach the RHOSP metadata service IP address, which is **169.254.169.254** by default.  
Depending on your RHOSP SDN and networking service configuration, you might need to provide the route when you create the subnet. For example:

```
$ openstack subnet create --dhcp --host-route
destination=169.254.169.254/32,gateway=192.0.2.2 ...
```

- Optional: To secure the network, create [role-based access control \(RBAC\)](#) rules that limit network access to a single project.

### 15.3.11.8.2. Deploying a cluster that has a primary interface on a provider network

You can deploy an OpenShift Container Platform cluster that has its primary network interface on an Red Hat OpenStack Platform (RHOSP) provider network. .Prerequisites

- Your Red Hat OpenStack Platform (RHOSP) deployment is configured as described by "RHOSP provider network requirements for cluster installation".

#### Procedure

1. In a text editor, open the **install-config.yaml** file.
2. Set the value of the **platform.openstack.apiVIP** property to the IP address for the API VIP.
3. Set the value of the **platform.openstack.ingressVIP** property to the IP address for the Ingress VIP.
4. Set the value of the **platform.openstack.machinesSubnet** property to the UUID of the provider network subnet.
5. Set the value of the **networking.machineNetwork.cidr** property to the CIDR block of the provider network subnet.



#### IMPORTANT

The **platform.openstack.apiVIP** and **platform.openstack.ingressVIP** properties must both be unassigned IP addresses from the **networking.machineNetwork.cidr** block.

#### Section of an installation configuration file for a cluster that relies on a RHOSP provider network

```
...
platform:
  openstack:
    apiVIP: 192.0.2.13
    ingressVIP: 192.0.2.23
    machinesSubnet: fa806b2f-ac49-4bce-b9db-124bc64209bf
    # ...
  networking:
    machineNetwork:
      - cidr: 192.0.2.0/24
```

**WARNING**

You cannot set the **platform.openstack.externalNetwork** or **platform.openstack.externalDNS** parameters while using a provider network for the primary network interface.

When you deploy the cluster, the installer uses the **install-config.yaml** file to deploy the cluster on the provider network.

**TIP**

You can add additional networks, including provider networks, to the **platform.openstack.additionalNetworkIDs** list.

After you deploy your cluster, you can attach pods to additional networks. For more information, see [Understanding multiple networks](#).

### 15.3.11.9. Kuryr ports pools

A Kuryr ports pool maintains a number of ports on standby for pod creation.

Keeping ports on standby minimizes pod creation time. Without ports pools, Kuryr must explicitly request port creation or deletion whenever a pod is created or deleted.

The Neutron ports that Kuryr uses are created in subnets that are tied to namespaces. These pod ports are also added as subports to the primary port of OpenShift Container Platform cluster nodes.

Because Kuryr keeps each namespace in a separate subnet, a separate ports pool is maintained for each namespace-worker pair.

Prior to installing a cluster, you can set the following parameters in the **cluster-network-03-config.yml** manifest file to configure ports pool behavior:

- The **enablePortPoolsPrepopulation** parameter controls pool prepopulation, which forces Kuryr to add ports to the pool when it is created, such as when a new host is added, or a new namespace is created. The default value is **false**.
- The **poolMinPorts** parameter is the minimum number of free ports that are kept in the pool. The default value is **1**.
- The **poolMaxPorts** parameter is the maximum number of free ports that are kept in the pool. A value of **0** disables that upper bound. This is the default setting. If your OpenStack port quota is low, or you have a limited number of IP addresses on the pod network, consider setting this option to ensure that unneeded ports are deleted.
- The **poolBatchPorts** parameter defines the maximum number of Neutron ports that can be created at once. The default value is **3**.

### 15.3.11.10. Adjusting Kuryr ports pools during installation

During installation, you can configure how Kuryr manages Red Hat OpenStack Platform (RHOSP) Neutron ports to control the speed and efficiency of pod creation.

## Prerequisites

- Create and modify the **install-config.yaml** file.

## Procedure

1. From a command line, create the manifest files:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

- 1 For **<installation\_directory>**, specify the name of the directory that contains the **install-config.yaml** file for your cluster.

2. Create a file that is named **cluster-network-03-config.yml** in the **<installation\_directory>/manifests/** directory:

```
$ touch <installation_directory>/manifests/cluster-network-03-config.yml 1
```

- 1 For **<installation\_directory>**, specify the directory name that contains the **manifests/** directory for your cluster.

After creating the file, several network configuration files are in the **manifests/** directory, as shown:

```
$ ls <installation_directory>/manifests/cluster-network-*
```

## Example output

```
cluster-network-01-crd.yml
cluster-network-02-config.yml
cluster-network-03-config.yml
```

3. Open the **cluster-network-03-config.yml** file in an editor, and enter a custom resource (CR) that describes the Cluster Network Operator configuration that you want:

```
$ oc edit networks.operator.openshift.io cluster
```

4. Edit the settings to meet your requirements. The following file is provided as an example:

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  clusterNetwork:
    - cidr: 10.128.0.0/14
      hostPrefix: 23
  serviceNetwork:
    - 172.30.0.0/16
```

```

defaultNetwork:
  type: Kuryr
  kuryrConfig:
    enablePortPoolsPrepopulation: false 1
    poolMinPorts: 1 2
    poolBatchPorts: 3 3
    poolMaxPorts: 5 4
    openstackServiceNetwork: 172.30.0.0/15 5

```

- 1 Set the value of **enablePortPoolsPrepopulation** to **true** to make Kuryr create new Neutron ports after a namespace is created or a new node is added to the cluster. This setting raises the Neutron ports quota but can reduce the time that is required to spawn pods. The default value is **false**.
- 2 Kuryr creates new ports for a pool if the number of free ports in that pool is lower than the value of **poolMinPorts**. The default value is **1**.
- 3 **poolBatchPorts** controls the number of new ports that are created if the number of free ports is lower than the value of **poolMinPorts**. The default value is **3**.
- 4 If the number of free ports in a pool is higher than the value of **poolMaxPorts**, Kuryr deletes them until the number matches that value. Setting this value to **0** disables this upper bound, preventing pools from shrinking. The default value is **0**.
- 5 The **openStackServiceNetwork** parameter defines the CIDR range of the network from which IP addresses are allocated to RHOSP Octavia's LoadBalancers.

If this parameter is used with the Amphora driver, Octavia takes two IP addresses from this network for each load balancer: one for OpenShift and the other for VRRP connections. Because these IP addresses are managed by OpenShift Container Platform and Neutron respectively, they must come from different pools. Therefore, the value of **openStackServiceNetwork** must be at least twice the size of the value of **serviceNetwork**, and the value of **serviceNetwork** must overlap entirely with the range that is defined by **openStackServiceNetwork**.

The CNO verifies that VRRP IP addresses that are taken from the range that is defined by this parameter do not overlap with the range that is defined by the **serviceNetwork** parameter.

If this parameter is not set, the CNO uses an expanded value of **serviceNetwork** that is determined by decrementing the prefix size by 1.

5. Save the **cluster-network-03-config.yml** file, and exit the text editor.
6. Optional: Back up the **manifests/cluster-network-03-config.yml** file. The installation program deletes the **manifests/** directory while creating the cluster.

### 15.3.12. Setting compute machine affinity

Optionally, you can set the affinity policy for compute machines during installation. The installer does not select an affinity policy for compute machines by default.

You can also create machine sets that use particular RHOSP server groups after installation.

**NOTE**

Control plane machines are created with a **soft-anti-affinity** policy.

**TIP**

You can learn more about [RHOSP instance scheduling and placement](#) in the RHOSP documentation.

**Prerequisites**

- Create the **install-config.yaml** file and complete any modifications to it.

**Procedure**

1. Using the RHOSP command-line interface, create a server group for your compute machines. For example:

```
$ openstack \
  --os-compute-api-version=2.15 \
  server group create \
  --policy anti-affinity \
  my-openshift-worker-group
```

For more information, see the [server group create command documentation](#).

2. Change to the directory that contains the installation program and create the manifests:

```
$ ./openshift-install create manifests --dir <installation_directory>
```

where:

**installation\_directory**

Specifies the name of the directory that contains the **install-config.yaml** file for your cluster.

3. Open **manifests/99\_openshift-cluster-api\_worker-machineset-0.yaml**, the **MachineSet** definition file.
4. Add the property **serverGroupID** to the definition beneath the **spec.template.spec.providerSpec.value** property. For example:

```
apiVersion: machine.openshift.io/v1beta1
kind: MachineSet
metadata:
  labels:
    machine.openshift.io/cluster-api-cluster: <infrastructure_ID>
    machine.openshift.io/cluster-api-machine-role: <node_role>
    machine.openshift.io/cluster-api-machine-type: <node_role>
  name: <infrastructure_ID>-<node_role>
  namespace: openshift-machine-api
spec:
  replicas: <number_of_replicas>
  selector:
    matchLabels:
      machine.openshift.io/cluster-api-cluster: <infrastructure_ID>
```

```

machine.openshift.io/cluster-api-machineset: <infrastructure_ID>-<node_role>
template:
  metadata:
    labels:
      machine.openshift.io/cluster-api-cluster: <infrastructure_ID>
      machine.openshift.io/cluster-api-machine-role: <node_role>
      machine.openshift.io/cluster-api-machine-type: <node_role>
      machine.openshift.io/cluster-api-machineset: <infrastructure_ID>-<node_role>
  spec:
    providerSpec:
      value:
        apiVersion: openstackproviderconfig.openshift.io/v1alpha1
        cloudName: openstack
        cloudsSecret:
          name: openstack-cloud-credentials
          namespace: openshift-machine-api
        flavor: <nova_flavor>
        image: <glance_image_name_or_location>
        serverGroupID: aaaaaaaaa-bbbb-cccc-dddd-eeeeeeeeeeeeee 1
        kind: OpenstackProviderSpec
        networks:
          - filter: {}
            subnets:
              - filter:
                  name: <subnet_name>
                  tags: openshiftClusterID=<infrastructure_ID>
        securityGroups:
          - filter: {}
            name: <infrastructure_ID>-<node_role>
        serverMetadata:
          Name: <infrastructure_ID>-<node_role>
          openshiftClusterID: <infrastructure_ID>
        tags:
          - openshiftClusterID=<infrastructure_ID>
        trunk: true
        userDataSecret:
          name: <node_role>-user-data
        availabilityZone: <optional_openstack_availability_zone>

```

**1** Add the UUID of your server group here.

- Optional: Back up the **manifests/99\_openshift-cluster-api\_worker-machineset-0.yaml** file. The installation program deletes the **manifests/** directory when creating the cluster.

When you install the cluster, the installer uses the **MachineSet** definition that you modified to create compute machines within your RHOSP server group.

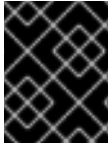
### 15.3.13. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the **~/.ssh/authorized\_keys** list for the **core** user on each node, which enables password-less authentication.



After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.



### IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

### Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.



### NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

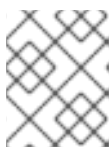
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.



### NOTE

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

-

**Example output**

```
Agent pid 31874
```

**NOTE**

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1** Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

**Example output**

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

**Next steps**

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

**15.3.14. Enabling access to the environment**

At deployment, all OpenShift Container Platform machines are created in a Red Hat OpenStack Platform (RHOSP)-tenant network. Therefore, they are not accessible directly in most RHOSP deployments.

You can configure OpenShift Container Platform API and application access by using floating IP addresses (FIPs) during installation. You can also complete an installation without configuring FIPs, but the installer will not configure a way to reach the API or applications externally.

**15.3.14.1. Enabling access with floating IP addresses**

Create floating IP (FIP) addresses for external access to the OpenShift Container Platform API and cluster applications.

**Procedure**

1. Using the Red Hat OpenStack Platform (RHOSP) CLI, create the API FIP:

```
$ openstack floating ip create --description "API <cluster_name>.<base_domain>"
<external_network>
```

2. Using the Red Hat OpenStack Platform (RHOSP) CLI, create the apps, or Ingress, FIP:

```
$ openstack floating ip create --description "Ingress <cluster_name>.<base_domain>"
<external_network>
```

3. Add records that follow these patterns to your DNS server for the API and Ingress FIPs:

```
api.<cluster_name>.<base_domain>. IN A <API_FIP>
*.apps.<cluster_name>.<base_domain>. IN A <apps_FIP>
```

## NOTE

If you do not control the DNS server, you can access the cluster by adding the cluster domain names such as the following to your `/etc/hosts` file:

- `<api_floating_ip> api.<cluster_name>.<base_domain>`
- `<application_floating_ip> grafana-openshift-monitoring.apps.<cluster_name>.<base_domain>`
- `<application_floating_ip> prometheus-k8s-openshift-monitoring.apps.<cluster_name>.<base_domain>`
- `<application_floating_ip> oauth-openshift.apps.<cluster_name>.<base_domain>`
- `<application_floating_ip> console-openshift-console.apps.<cluster_name>.<base_domain>`
- `application_floating_ip integrated-oauth-server-openshift-authentication.apps.<cluster_name>.<base_domain>`

The cluster domain names in the `/etc/hosts` file grant access to the web console and the monitoring interface of your cluster locally. You can also use the `kubectl` or `oc`. You can access the user applications by using the additional entries pointing to the `<application_floating_ip>`. This action makes the API and applications accessible to only you, which is not suitable for production deployment, but does allow installation for development and testing.

4. Add the FIPs to the `install-config.yaml` file as the values of the following parameters:

- `platform.openstack.ingressFloatingIP`
- `platform.openstack.apiFloatingIP`

If you use these values, you must also enter an external network as the value of the `platform.openstack.externalNetwork` parameter in the `install-config.yaml` file.

## TIP

You can make OpenShift Container Platform resources available outside of the cluster by assigning a floating IP address and updating your firewall configuration.

### 15.3.14.2. Completing installation without floating IP addresses

You can install OpenShift Container Platform on Red Hat OpenStack Platform (RHOSP) without providing floating IP addresses.

In the `install-config.yaml` file, do not define the following parameters:

- **platform.openstack.ingressFloatingIP**
- **platform.openstack.apiFloatingIP**

If you cannot provide an external network, you can also leave **platform.openstack.externalNetwork** blank. If you do not provide a value for **platform.openstack.externalNetwork**, a router is not created for you, and, without additional action, the installer will fail to retrieve an image from Glance. You must configure external connectivity on your own.

If you run the installer from a system that cannot reach the cluster API due to a lack of floating IP addresses or name resolution, installation fails. To prevent installation failure in these cases, you can use a proxy network or run the installer from a system that is on the same network as your machines.



## NOTE

You can enable name resolution by creating DNS records for the API and Ingress ports. For example:

```
api.<cluster_name>.<base_domain>. IN A <api_port_IP>
*.apps.<cluster_name>.<base_domain>. IN A <ingress_port_IP>
```

If you do not control the DNS server, you can add the record to your **/etc/hosts** file. This action makes the API accessible to only you, which is not suitable for production deployment but does allow installation for development and testing.

## 15.3.15. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



## IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

### Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

### Procedure

1. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
--log-level=info 2
```

- 1 For **<installation\_directory>**, specify the location of your customized **./install-config.yaml** file.
- 2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

**NOTE**

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

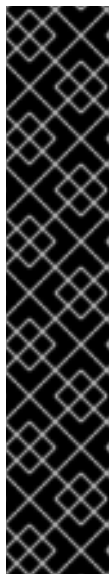
When the cluster deployment completes, directions for accessing your cluster, including a link to its web console and credentials for the **kubeadmin** user, display in your terminal.

**Example output**

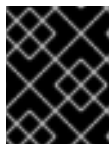
```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Ee6gm-ymBZj-
Wt5AL"
INFO Time elapsed: 36m22s
```

**NOTE**

The cluster access and credential information also outputs to **<installation\_directory>/openshift\_install.log** when an installation succeeds.

**IMPORTANT**

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

**IMPORTANT**

You must not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

**15.3.16. Verifying cluster status**

You can verify your OpenShift Container Platform cluster's status during or after installation.

**Procedure**

1. In the cluster environment, export the administrator's kubeconfig file:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server.

2. View the control plane and compute machines created after a deployment:

```
$ oc get nodes
```

3. View your cluster's version:

```
$ oc get clusterversion
```

4. View your Operators' status:

```
$ oc get clusteroperator
```

5. View all running pods in the cluster:

```
$ oc get pods -A
```

### 15.3.17. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

#### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

#### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

## Example output

```
system:admin
```

### Additional resources

- See [Accessing the web console](#) for more details about accessing and understanding the OpenShift Container Platform web console.

### 15.3.18. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

### 15.3.19. Next steps

- [Customize your cluster](#).
- If necessary, you can [opt out of remote health reporting](#).
- If you need to enable external access to node ports, [configure ingress cluster traffic by using a node port](#).
- If you did not configure RHOSP to accept application traffic over floating IP addresses, [configure RHOSP access with floating IP addresses](#).

## 15.4. INSTALLING A CLUSTER ON OPENSTACK THAT SUPPORTS SR-IOV-CONNECTED COMPUTE MACHINES

In OpenShift Container Platform version 4.9, you can install a cluster on Red Hat OpenStack Platform (RHOSP) that can use compute machines with single-root I/O virtualization (SR-IOV) technology.

### 15.4.1. Prerequisites

- Review details about the [OpenShift Container Platform installation and update](#) processes.
  - Verify that OpenShift Container Platform 4.9 is compatible with your RHOSP version by using the "Supported platforms for OpenShift clusters" section. You can also compare platform support across different versions by viewing the [OpenShift Container Platform on RHOSP support matrix](#).
- Verify that your network configuration does not rely on a provider network. Provider networks are not supported.

- Have a storage service installed in RHOSP, like block storage (Cinder) or object storage (Swift). Object storage is the recommended storage technology for OpenShift Container Platform registry cluster deployment. For more information, see [Optimizing storage](#).
- Have metadata service enabled in RHOSP

### 15.4.2. Resource guidelines for installing OpenShift Container Platform on RHOSP

To support an OpenShift Container Platform installation, your Red Hat OpenStack Platform (RHOSP) quota must meet the following requirements:

**Table 15.13. Recommended resources for a default OpenShift Container Platform cluster on RHOSP**

Resource	Value
Floating IP addresses	3
Ports	15
Routers	1
Subnets	1
RAM	88 GB
vCPUs	22
Volume storage	275 GB
Instances	7
Security groups	3
Security group rules	60

A cluster might function with fewer than recommended resources, but its performance is not guaranteed.



#### IMPORTANT

If RHOSP object storage (Swift) is available and operated by a user account with the **swiftoperator** role, it is used as the default backend for the OpenShift Container Platform image registry. In this case, the volume storage requirement is 175 GB. Swift space requirements vary depending on the size of the image registry.



#### NOTE

By default, your security group and security group rule quotas might be low. If you encounter problems, run **openstack quota set --secgroups 3 --secgroup-rules 60 <project>** as an administrator to increase them.



An OpenShift Container Platform deployment comprises control plane machines, compute machines, and a bootstrap machine.

### 15.4.2.1. Control plane machines

By default, the OpenShift Container Platform installation process creates three control plane machines.

Each machine requires:

- An instance from the RHOSP quota
- A port from the RHOSP quota
- A flavor with at least 16 GB memory and 4 vCPUs
- At least 100 GB storage space from the RHOSP quota

### 15.4.2.2. Compute machines

By default, the OpenShift Container Platform installation process creates three compute machines.

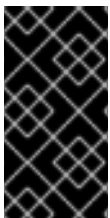
Each machine requires:

- An instance from the RHOSP quota
- A port from the RHOSP quota
- A flavor with at least 8 GB memory and 2 vCPUs
- At least 100 GB storage space from the RHOSP quota

#### TIP

Compute machines host the applications that you run on OpenShift Container Platform; aim to run as many as you can.

Additionally, for clusters that use single-root input/output virtualization (SR-IOV), RHOSP compute nodes require a flavor that supports [huge pages](#).



#### IMPORTANT

SR-IOV deployments often employ performance optimizations, such as dedicated or isolated CPUs. For maximum performance, configure your underlying RHOSP deployment to use these optimizations, and then run OpenShift Container Platform compute machines on the optimized infrastructure.

#### Additional resources

- For more information about configuring performant RHOSP compute nodes, see [Configuring Compute nodes for performance](#).

### 15.4.2.3. Bootstrap machine

During installation, a bootstrap machine is temporarily provisioned to stand up the control plane. After the production control plane is ready, the bootstrap machine is deprovisioned.

The bootstrap machine requires:

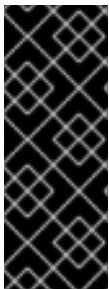
- An instance from the RHOSP quota
- A port from the RHOSP quota
- A flavor with at least 16 GB memory and 4 vCPUs
- At least 100 GB storage space from the RHOSP quota

### 15.4.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

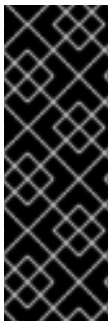


#### IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

### 15.4.4. Enabling Swift on RHOSP

Swift is operated by a user account with the **swiftoperator** role. Add the role to an account before you run the installation program.



#### IMPORTANT

If [the Red Hat OpenStack Platform \(RHOSP\) object storage service](#), commonly known as Swift, is available, OpenShift Container Platform uses it as the image registry storage. If it is unavailable, the installation program relies on the RHOSP block storage service, commonly known as Cinder.

If Swift is present and you want to use it, you must enable access to it. If it is not present, or if you do not want to use it, skip this section.

#### Prerequisites

- You have a RHOSP administrator account on the target environment.
- The Swift service is installed.
- On [Ceph RGW](#), the **account in url** option is enabled.

## Procedure

To enable Swift on RHOSP:

1. As an administrator in the RHOSP CLI, add the **swiftoperator** role to the account that will access Swift:

```
$ openstack role add --user <user> --project <project> swiftoperator
```

Your RHOSP deployment can now use Swift for the image registry.

### 15.4.5. Verifying external network access

The OpenShift Container Platform installation process requires external network access. You must provide an external network value to it, or deployment fails. Before you begin the process, verify that a network with the external router type exists in Red Hat OpenStack Platform (RHOSP).

#### Prerequisites

- [Configure OpenStack's networking service to have DHCP agents forward instances' DNS queries](#)

#### Procedure

1. Using the RHOSP CLI, verify the name and ID of the 'External' network:

```
$ openstack network list --long -c ID -c Name -c "Router Type"
```

#### Example output

```
+-----+-----+-----+
| ID                | Name          | Router Type |
+-----+-----+-----+
| 148a8023-62a7-4672-b018-003462f8d7dc | public_network | External    |
+-----+-----+-----+
```

A network with an external router type appears in the network list. If at least one does not, see [Creating a default floating IP network](#) and [Creating a default provider network](#).



#### NOTE

If the Neutron trunk service plugin is enabled, a trunk port is created by default. For more information, see [Neutron trunk port](#).

### 15.4.6. Defining parameters for the installation program

The OpenShift Container Platform installation program relies on a file that is called **clouds.yaml**. The file describes Red Hat OpenStack Platform (RHOSP) configuration parameters, including the project name, log in information, and authorization service URLs.

#### Procedure

1. Create the **clouds.yaml** file:

- If your RHOSP distribution includes the Horizon web UI, generate a **clouds.yaml** file in it.



### IMPORTANT

Remember to add a password to the **auth** field. You can also keep secrets in [a separate file](#) from **clouds.yaml**.

- If your RHOSP distribution does not include the Horizon web UI, or you do not want to use Horizon, create the file yourself. For detailed information about **clouds.yaml**, see [Config files](#) in the RHOSP documentation.

```
clouds:
  shiftstack:
    auth:
      auth_url: http://10.10.14.42:5000/v3
      project_name: shiftstack
      username: shiftstack_user
      password: XXX
      user_domain_name: Default
      project_domain_name: Default
    dev-env:
      region_name: RegionOne
      auth:
        username: 'devuser'
        password: XXX
        project_name: 'devonly'
        auth_url: 'https://10.10.14.22:5001/v2.0'
```

2. If your RHOSP installation uses self-signed certificate authority (CA) certificates for endpoint authentication:
  - a. Copy the certificate authority file to your machine.
  - b. Add the **cacerts** key to the **clouds.yaml** file. The value must be an absolute, non-root-accessible path to the CA certificate:

```
clouds:
  shiftstack:
    ...
    cacert: "/etc/pki/ca-trust/source/anchors/ca.crt.pem"
```

### TIP

After you run the installer with a custom CA certificate, you can update the certificate by editing the value of the **ca-cert.pem** key in the **cloud-provider-config** keymap. On a command line, run:

```
$ oc edit configmap -n openshift-config cloud-provider-config
```

3. Place the **clouds.yaml** file in one of the following locations:
  - a. The value of the **OS\_CLIENT\_CONFIG\_FILE** environment variable
  - b. The current directory

- c. A Unix-specific user configuration directory, for example `~/.config/openstack/clouds.yaml`
- d. A Unix-specific site configuration directory, for example `/etc/openstack/clouds.yaml`  
The installation program searches for **clouds.yaml** in that order.

### 15.4.7. Obtaining the installation program

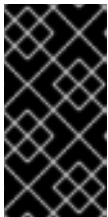
Before you install OpenShift Container Platform, download the installation file on a local computer.

#### Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space

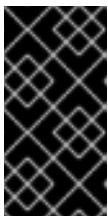
#### Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



#### IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



#### IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#) . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

### 15.4.8. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on

#### Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

## Procedure

1. Create the **install-config.yaml** file.
  - a. Change to the directory that contains the installation program and run the following command:

```
$. /openshift-install create install-config --dir <installation_directory> 1
```

- 1** For **<installation\_directory>**, specify the directory name to store the files that the installation program creates.



### IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

- b. At the prompts, provide the configuration details for your cloud:
  - i. Optional: Select an SSH key to use to access your cluster machines.



### NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

- ii. Enter a descriptive name for your cluster.
  - iii. Paste the [pull secret from the Red Hat OpenShift Cluster Manager](#) .
2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.
  3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



### IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

## 15.4.8.1. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

## Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



### NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

## Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
  additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
  ...
```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations.
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents

specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

**NOTE**

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

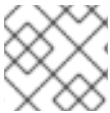
The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

**NOTE**

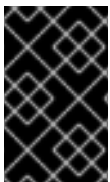
Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

### 15.4.9. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.

**NOTE**

After installation, you cannot modify these parameters in the **install-config.yaml** file.

**IMPORTANT**

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

#### 15.4.9.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 15.14. Required parameters

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String



Parameter	Description	Values
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;.&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}.{{.baseDomain}}</b> .	String of lowercase letters, hyphens (-), and periods (.), such as <b>dev</b> .
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws, baremetal, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b> . For additional information about <b>platform.&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object


Parameter	Description	Values
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } }</pre>

### 15.4.9.2. Network configuration parameters


You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

Table 15.15. Network parameters

Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	Object <div style="display: flex; align-items: center; margin-top: 10px;">  <div> <p><b>NOTE</b></p> <p>You cannot modify parameters specified by the <b>networking</b> object after installation.</p> </div> </div>
<b>networking.networkType</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .

Parameter	Description	Values
<b>networking.clusterNetwork</b>	<p>The IP address blocks for pods.</p> <p>The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b>.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   clusterNetwork:     - cidr: 10.128.0.0/14       hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	<p>Required if you use <b>networking.clusterNetwork</b>. An IP address block.</p> <p>An IPv4 network.</p>	<p>An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b>.</p>
<b>networking.clusterNetwork.hostPrefix</b>	<p>The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b>. A <b>hostPrefix</b> value of <b>23</b> provides 510 (<math>2^{(32 - 23)} - 2</math>) pod IP addresses.</p>	<p>A subnet prefix.</p> <p>The default value is <b>23</b>.</p>
<b>networking.serviceNetwork</b>	<p>The IP address block for services. The default value is <b>172.30.0.0/16</b>.</p> <p>The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.</p>	<p>An array with an IP address block in CIDR format. For example:</p> <pre>networking:   serviceNetwork:     - 172.30.0.0/16</pre>
<b>networking.machineNetwork</b>	<p>The IP address blocks for machines.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   machineNetwork:     - cidr: 10.0.0.0/16</pre>


Parameter	Description	Values
<b>networking.machineNetwork.cidr</b>	Required if you use <b>networking.machineNetwork</b> . An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b> .	<p>An IP network block in CIDR notation.</p> <p>For example, <b>10.0.0.0/16</b>.</p>  <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p>


### 15.4.9.3. Optional configuration parameters



Optional installation configuration parameters are described in the following table:

Table 15.16. Optional parameters

Parameter	Description	Values
<b>additionalTrustBundle</b>	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
<b>compute</b>	The configuration for the machines that comprise the compute nodes.	Array of <b>MachinePool</b> objects.
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String


Parameter	Description	Values
<b>compute.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b>
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String

Parameter	Description	Values
<b>controlPlane.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platform</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>controlPlane.replicas</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.

Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.</p> <div data-bbox="486 510 595 862" style="border: 1px solid black; padding: 5px; margin-bottom: 10px;">  </div> <p><b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators</i> reference content.</p> <div data-bbox="486 907 595 1258" style="border: 1px solid black; padding: 5px;">  </div> <p><b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p>	<b>Mint, Passthrough, Manual</b> or an empty string ("").

Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start;"> <div style="width: 60px; height: 60px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 60px; height: 60px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<b>Internal</b> or <b>External</b> . The default value is <b>External</b> .  Setting this field to <b>Internal</b> is not supported on non-cloud platforms.



Parameter	Description	Values
<b>sshKey</b>	<p>The SSH key or keys to authenticate access your cluster machines.</p>  <p><b>NOTE</b></p> <p>For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.</p>	<p>One or more keys. For example:</p> <pre>sshKey:   &lt;key1&gt;   &lt;key2&gt;   &lt;key3&gt;</pre>

#### 15.4.9.4. Custom subnets in RHOSP deployments

Optionally, you can deploy a cluster on a Red Hat OpenStack Platform (RHOSP) subnet of your choice. The subnet's GUID is passed as the value of **platform.openstack.machinesSubnet** in the **install-config.yaml** file.

This subnet is used as the cluster's primary subnet. By default, nodes and ports are created on it. You can create nodes and ports on a different RHOSP subnet by setting the value of the **platform.openstack.machinesSubnet** property to the subnet's UUID.

Before you run the OpenShift Container Platform installer with a custom subnet, verify that your configuration meets the following requirements:

- The subnet that is used by **platform.openstack.machinesSubnet** has DHCP enabled.
- The CIDR of **platform.openstack.machinesSubnet** matches the CIDR of **networking.machineNetwork**.
- The installation program user has permission to create ports on this network, including ports with fixed IP addresses.

Clusters that use custom subnets have the following limitations:

- If you plan to install a cluster that uses floating IP addresses, the **platform.openstack.machinesSubnet** subnet must be attached to a router that is connected to the **externalNetwork** network.
- If the **platform.openstack.machinesSubnet** value is set in the **install-config.yaml** file, the installation program does not create a private network or subnet for your RHOSP machines.
- You cannot use the **platform.openstack.externalDNS** property at the same time as a custom subnet. To add DNS to a cluster that uses a custom subnet, configure DNS on the RHOSP network.

**NOTE**

By default, the API VIP takes x.x.x.5 and the Ingress VIP takes x.x.x.7 from your network's CIDR block. To override these default values, set values for **platform.openstack.apiVIP** and **platform.openstack.ingressVIP** that are outside of the DHCP allocation pool.

**15.4.9.5. Deploying a cluster with bare metal machines**

If you want your cluster to use bare metal machines, modify the **inventory.yaml** file. Your cluster can have both control plane and compute machines running on bare metal, or just compute machines.

Bare-metal compute machines are not supported on clusters that use Kuryr.

**NOTE**

Be sure that your **install-config.yaml** file reflects whether the RHOSP network that you use for bare metal workers supports floating IP addresses or not.

**Prerequisites**

- The RHOSP [Bare Metal service \(Ironic\)](#) is enabled and accessible via the RHOSP Compute API.
- Bare metal is available as [a RHOSP flavor](#).
- The RHOSP network supports both VM and bare metal server attachment.
- Your network configuration does not rely on a provider network. Provider networks are not supported.
- If you want to deploy the machines on a pre-existing network, a RHOSP subnet is provisioned.
- If you want to deploy the machines on an installer-provisioned network, the RHOSP Bare Metal service (Ironic) is able to listen for and interact with Preboot eXecution Environment (PXE) boot machines that run on tenant networks.
- You created an **inventory.yaml** file as part of the OpenShift Container Platform installation process.

**Procedure**

1. In the **inventory.yaml** file, edit the flavors for machines:
  - a. If you want to use bare-metal control plane machines, change the value of **os\_flavor\_master** to a bare metal flavor.
  - b. Change the value of **os\_flavor\_worker** to a bare metal flavor.

**An example bare metal inventory.yaml file**

```
all:
  hosts:
    localhost:
      ansible_connection: local
      ansible_python_interpreter: "{{ansible_playbook_python}}"

  # User-provided values
```

```

os_subnet_range: '10.0.0.0/16'
os_flavor_master: 'my-bare-metal-flavor' 1
os_flavor_worker: 'my-bare-metal-flavor' 2
os_image_rhcos: 'rhcos'
os_external_network: 'external'

```

...

- 1 If you want to have bare-metal control plane machines, change this value to a bare metal flavor.
- 2 Change this value to a bare metal flavor to use for compute machines.

Use the updated **inventory.yaml** file to complete the installation process. Machines that are created during deployment use the flavor that you added to the file.



## NOTE

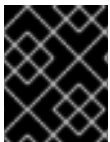
The installer may time out while waiting for bare metal machines to boot.

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
./openshift-install wait-for install-complete --log-level debug
```

### 15.4.9.6. Sample customized **install-config.yaml** file for RHOSP

This sample **install-config.yaml** demonstrates all of the possible Red Hat OpenStack Platform (RHOSP) customization options.



## IMPORTANT

This sample file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program.

```

apiVersion: v1
baseDomain: example.com
controlPlane:
  name: master
  platform: {}
  replicas: 3
compute:
  - name: worker
    platform:
      openstack:
        type: ml.large
    replicas: 3
metadata:
  name: example
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23

```

```

machineNetwork:
- cidr: 10.0.0.0/16
serviceNetwork:
- 172.30.0.0/16
networkType: OpenShiftSDN
platform:
openstack:
cloud: mycloud
externalNetwork: external
computeFlavor: m1.xlarge
apiFloatingIP: 128.0.0.1
fips: false
pullSecret: '{"auths": ...}'
sshKey: ssh-ed25519 AAAA...

```

### 15.4.10. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.



#### IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



#### NOTE

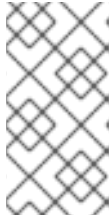
You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

#### Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1** Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.

**NOTE**

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.

**NOTE**

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

**Example output**

```
Agent pid 31874
```

**NOTE**

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1** Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

**Example output**

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

**Next steps**

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

## 15.4.11. Enabling access to the environment

At deployment, all OpenShift Container Platform machines are created in a Red Hat OpenStack Platform (RHOSP)-tenant network. Therefore, they are not accessible directly in most RHOSP deployments.

You can configure OpenShift Container Platform API and application access by using floating IP addresses (FIPs) during installation. You can also complete an installation without configuring FIPs, but the installer will not configure a way to reach the API or applications externally.

### 15.4.11.1. Enabling access with floating IP addresses

Create floating IP (FIP) addresses for external access to the OpenShift Container Platform API and cluster applications.

#### Procedure

1. Using the Red Hat OpenStack Platform (RHOSP) CLI, create the API FIP:

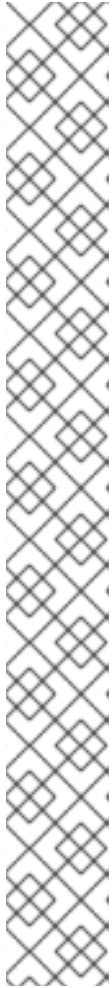
```
$ openstack floating ip create --description "API <cluster_name>.<base_domain>"  
<external_network>
```

2. Using the Red Hat OpenStack Platform (RHOSP) CLI, create the apps, or Ingress, FIP:

```
$ openstack floating ip create --description "Ingress <cluster_name>.<base_domain>"  
<external_network>
```

3. Add records that follow these patterns to your DNS server for the API and Ingress FIPs:

```
api.<cluster_name>.<base_domain>. IN A <API_FIP>  
*.apps.<cluster_name>.<base_domain>. IN A <apps_FIP>
```



## NOTE

If you do not control the DNS server, you can access the cluster by adding the cluster domain names such as the following to your `/etc/hosts` file:

- `<api_floating_ip> api.<cluster_name>.<base_domain>`
- `<application_floating_ip> grafana-openshift-monitoring.apps.<cluster_name>.<base_domain>`
- `<application_floating_ip> prometheus-k8s-openshift-monitoring.apps.<cluster_name>.<base_domain>`
- `<application_floating_ip> oauth-openshift.apps.<cluster_name>.<base_domain>`
- `<application_floating_ip> console-openshift-console.apps.<cluster_name>.<base_domain>`
- `application_floating_ip integrated-oauth-server-openshift-authentication.apps.<cluster_name>.<base_domain>`

The cluster domain names in the `/etc/hosts` file grant access to the web console and the monitoring interface of your cluster locally. You can also use the `kubectl` or `oc`. You can access the user applications by using the additional entries pointing to the `<application_floating_ip>`. This action makes the API and applications accessible to only you, which is not suitable for production deployment, but does allow installation for development and testing.

4. Add the FIPs to the `install-config.yaml` file as the values of the following parameters:

- `platform.openstack.ingressFloatingIP`
- `platform.openstack.apiFloatingIP`

If you use these values, you must also enter an external network as the value of the `platform.openstack.externalNetwork` parameter in the `install-config.yaml` file.

## TIP

You can make OpenShift Container Platform resources available outside of the cluster by assigning a floating IP address and updating your firewall configuration.

### 15.4.11.2. Completing installation without floating IP addresses

You can install OpenShift Container Platform on Red Hat OpenStack Platform (RHOSP) without providing floating IP addresses.

In the file, do not define the following

If you run the installer from a system that cannot reach the cluster API due to a lack of floating IP addresses or name resolution, installation fails. To prevent installation failure in these cases, you can use a proxy network or run the installer from a system that is on the same network as your machines.

**NOTE**

You can enable name resolution by creating DNS records for the API and Ingress ports. For example:

```
api.<cluster_name>.<base_domain>. IN A <api_port_IP>
*.apps.<cluster_name>.<base_domain>. IN A <ingress_port_IP>
```

If you do not control the DNS server, you can add the record to your `/etc/hosts` file. This action makes the API accessible to only you, which is not suitable for production deployment but does allow installation for development and testing.

### 15.4.12. Creating SR-IOV networks for compute machines

If your Red Hat OpenStack Platform (RHOSP) deployment supports [single root I/O virtualization \(SR-IOV\)](#), you can provision SR-IOV networks that compute machines run on.

**NOTE**

The following instructions entail creating an external flat network and an external, VLAN-based network that can be attached to a compute machine. Depending on your RHOSP deployment, other network types might be required.

#### Prerequisites

- Your cluster supports SR-IOV.

**NOTE**

If you are unsure about what your cluster supports, review the OpenShift Container Platform SR-IOV hardware networks documentation.

- You created radio and uplink provider networks as part of your RHOSP deployment. The names **radio** and **uplink** are used in all example commands to represent these networks.

#### Procedure

1. On a command line, create a radio RHOSP network:

```
$ openstack network create radio --provider-physical-network radio --provider-network-type flat --external
```

2. Create an uplink RHOSP network:

```
$ openstack network create uplink --provider-physical-network uplink --provider-network-type vlan --external
```

3. Create a subnet for the radio network:

```
$ openstack subnet create --network radio --subnet-range <radio_network_subnet_range> radio
```

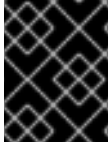
4. Create a subnet for the uplink network:



```
$ openstack subnet create --network uplink --subnet-range <uplink_network_subnet_range>
uplink
```

### 15.4.13. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



#### IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

#### Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

#### Procedure

1. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
--log-level=info 2
```

- 1 For **<installation\_directory>**, specify the location of your customized **./install-config.yaml** file.
- 2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.



#### NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

When the cluster deployment completes, directions for accessing your cluster, including a link to its web console and credentials for the **kubeadmin** user, display in your terminal.

#### Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Ee6gm-ymBZj-
Wt5AL"
INFO Time elapsed: 36m22s
```

**NOTE**

The cluster access and credential information also outputs to `<installation_directory>/openshift_install.log` when an installation succeeds.

**IMPORTANT**

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

**IMPORTANT**

You must not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

### 15.4.14. Verifying cluster status

You can verify your OpenShift Container Platform cluster's status during or after installation.

**Procedure**

1. In the cluster environment, export the administrator's kubeconfig file:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For `<installation_directory>`, specify the path to the directory that you stored the installation files in.

The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server.

2. View the control plane and compute machines created after a deployment:

```
$ oc get nodes
```

3. View your cluster's version:

```
$ oc get clusterversion
```

4. View your Operators' status:

```
$ oc get clusteroperator
```

- View all running pods in the cluster:

```
$ oc get pods -A
```

### 15.4.15. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

#### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

#### Procedure

- Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

- Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

#### Example output

```
system:admin
```

The cluster is operational. Before you can add SR-IOV compute machines though, you must perform additional tasks.

### 15.4.16. Preparing a cluster that runs on RHOSP for SR-IOV

Before you use [single root I/O virtualization \(SR-IOV\)](#) on a cluster that runs on Red Hat OpenStack Platform (RHOSP), make the RHOSP metadata service mountable as a drive and enable the No-IOMMU Operator for the virtual function I/O (VFIO) driver.

#### 15.4.16.1. Enabling the RHOSP metadata service as a mountable drive

You can apply a machine config to your machine pool that makes the Red Hat OpenStack Platform (RHOSP) metadata service available as a mountable drive.

The following machine config enables the display of RHOSP network UUIDs from within the SR-IOV Network Operator. This configuration simplifies the association of SR-IOV resources to cluster SR-IOV resources.

## Procedure

1. Create a machine config file from the following template:

### A mountable metadata service machine config file

```
kind: MachineConfig
apiVersion: machineconfiguration.openshift.io/v1
metadata:
  name: 20-mount-config 1
  labels:
    machineconfiguration.openshift.io/role: worker
spec:
  config:
    ignition:
      version: 3.2.0
    systemd:
      units:
        - name: create-mountpoint-var-config.service
          enabled: true
          contents: |
            [Unit]
            Description=Create mountpoint /var/config
            Before=kubelet.service

            [Service]
            ExecStart=/bin/mkdir -p /var/config

            [Install]
            WantedBy=var-config.mount

        - name: var-config.mount
          enabled: true
          contents: |
            [Unit]
            Before=local-fs.target
            [Mount]
            Where=/var/config
            What=/dev/disk/by-label/config-2
            [Install]
            WantedBy=local-fs.target
```

**1** You can substitute a name of your choice.

2. From a command line, apply the machine config:

```
$ oc apply -f <machine_config_file_name>.yaml
```

## 15.4.16.2. Enabling the No-IOMMU feature for the RHOSP VFIO driver

You can apply a machine config to your machine pool that enables the No-IOMMU feature for the Red Hat OpenStack Platform (RHOSP) virtual function I/O (VFIO) driver. The RHOSP vfio-pci driver requires this feature.

## Procedure

1. Create a machine config file from the following template:

### A No-IOMMU VFIO machine config file

```
kind: MachineConfig
apiVersion: machineconfiguration.openshift.io/v1
metadata:
  name: 99-vfio-noiommu 1
  labels:
    machineconfiguration.openshift.io/role: worker
spec:
  config:
    ignition:
      version: 3.2.0
    storage:
      files:
        - path: /etc/modprobe.d/vfio-noiommu.conf
          mode: 0644
          contents:
            source:
              data:;base64,b3B0aW9ucyB2ZmlvIGVuYWJsZV91bnNhZmVfbm9pb21tdV9tb2RIPTEK
```

- 1 You can substitute a name of your choice.

2. From a command line, apply the machine config:

```
$ oc apply -f <machine_config_file_name>.yaml
```

The cluster is installed and prepared for SR-IOV configuration. Complete the post-installation SR-IOV tasks that are listed in the "Next steps" section.

## 15.4.17. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

## 15.4.18. Next steps

- To complete SR-IOV configuration for your cluster:
  - [Install the Performance Addon Operator](#).
  - [Configure the Performance Addon Operator with huge pages support](#).
  - [Install the SR-IOV Operator](#).
  - [Configure your SR-IOV network device](#).
  - [Add an SR-IOV compute machine set](#).
- [Customize your cluster](#).
- If necessary, you can [opt out of remote health reporting](#).
- If you need to enable external access to node ports, [configure ingress cluster traffic by using a node port](#).
- If you did not configure RHOSP to accept application traffic over floating IP addresses, [configure RHOSP access with floating IP addresses](#).

## 15.5. INSTALLING A CLUSTER ON OPENSTACK ON YOUR OWN INFRASTRUCTURE

In OpenShift Container Platform version 4.9, you can install a cluster on Red Hat OpenStack Platform (RHOSP) that runs on user-provisioned infrastructure.

Using your own infrastructure allows you to integrate your cluster with existing infrastructure and modifications. The process requires more labor on your part than installer-provisioned installations, because you must create all RHOSP resources, like Nova servers, Neutron ports, and security groups. However, Red Hat provides Ansible playbooks to help you in the deployment process.

### 15.5.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You verified that OpenShift Container Platform 4.9 is compatible with your RHOSP version by using the [Supported platforms for OpenShift clusters](#) section. You can also compare platform support across different versions by viewing the [OpenShift Container Platform on RHOSP support matrix](#).
- You have an RHOSP account where you want to install OpenShift Container Platform.
- On the machine from which you run the installation program, you have:
  - A single directory in which you can keep the files you create during the installation process
  - Python 3

### 15.5.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



### IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

### 15.5.3. Resource guidelines for installing OpenShift Container Platform on RHOSP

To support an OpenShift Container Platform installation, your Red Hat OpenStack Platform (RHOSP) quota must meet the following requirements:

**Table 15.17. Recommended resources for a default OpenShift Container Platform cluster on RHOSP**

Resource	Value
Floating IP addresses	3
Ports	15
Routers	1
Subnets	1
RAM	88 GB
vCPUs	22
Volume storage	275 GB
Instances	7
Security groups	3
Security group rules	60

A cluster might function with fewer than recommended resources, but its performance is not guaranteed.



### IMPORTANT

If RHOSP object storage (Swift) is available and operated by a user account with the **swiftoperator** role, it is used as the default backend for the OpenShift Container Platform image registry. In this case, the volume storage requirement is 175 GB. Swift space requirements vary depending on the size of the image registry.



### NOTE

By default, your security group and security group rule quotas might be low. If you encounter problems, run **openstack quota set --secgroups 3 --secgroup-rules 60 <project>** as an administrator to increase them.

An OpenShift Container Platform deployment comprises control plane machines, compute machines, and a bootstrap machine.

#### 15.5.3.1. Control plane machines

By default, the OpenShift Container Platform installation process creates three control plane machines.

Each machine requires:

- An instance from the RHOSP quota
- A port from the RHOSP quota
- A flavor with at least 16 GB memory and 4 vCPUs
- At least 100 GB storage space from the RHOSP quota

#### 15.5.3.2. Compute machines

By default, the OpenShift Container Platform installation process creates three compute machines.

Each machine requires:

- An instance from the RHOSP quota
- A port from the RHOSP quota
- A flavor with at least 8 GB memory and 2 vCPUs
- At least 100 GB storage space from the RHOSP quota

### TIP

Compute machines host the applications that you run on OpenShift Container Platform; aim to run as many as you can.

#### 15.5.3.3. Bootstrap machine



During installation, a bootstrap machine is temporarily provisioned to stand up the control plane. After the production control plane is ready, the bootstrap machine is deprovisioned.

The bootstrap machine requires:

- An instance from the RHOSP quota
- A port from the RHOSP quota
- A flavor with at least 16 GB memory and 4 vCPUs
- At least 100 GB storage space from the RHOSP quota

#### 15.5.4. Downloading playbook dependencies

The Ansible playbooks that simplify the installation process on user-provisioned infrastructure require several Python modules. On the machine where you will run the installer, add the modules' repositories and then download them.



#### NOTE

These instructions assume that you are using Red Hat Enterprise Linux (RHEL) 8.

#### Prerequisites

- Python 3 is installed on your machine.

#### Procedure

1. On a command line, add the repositories:

- a. Register with Red Hat Subscription Manager:

```
$ sudo subscription-manager register # If not done already
```

- b. Pull the latest subscription data:

```
$ sudo subscription-manager attach --pool=$YOUR_POOLID # If not done already
```

- c. Disable the current repositories:

```
$ sudo subscription-manager repos --disable=* # If not done already
```

- d. Add the required repositories:

```
$ sudo subscription-manager repos \
  --enable=rhel-8-for-x86_64-baseos-rpms \
  --enable=openstack-16-tools-for-rhel-8-x86_64-rpms \
  --enable=ansible-2.9-for-rhel-8-x86_64-rpms \
  --enable=rhel-8-for-x86_64-appstream-rpms
```

2. Install the modules:

```
$ sudo yum install python3-openstackclient ansible python3-openstacksdk python3-netaddr
```

3. Ensure that the **python** command points to **python3**:

```
$ sudo alternatives --set python /usr/bin/python3
```

### 15.5.5. Downloading the installation playbooks

Download Ansible playbooks that you can use to install OpenShift Container Platform on your own Red Hat OpenStack Platform (RHOSP) infrastructure.

#### Prerequisites

- The curl command-line tool is available on your machine.

#### Procedure

- To download the playbooks to your working directory, run the following script from a command line:

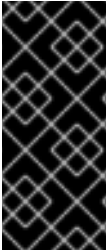
```
$ xargs -n 1 curl -O <<< '  
  https://raw.githubusercontent.com/openshift/installer/release-  
4.9/upi/openstack/bootstrap.yaml  
  https://raw.githubusercontent.com/openshift/installer/release-  
4.9/upi/openstack/common.yaml  
  https://raw.githubusercontent.com/openshift/installer/release-  
4.9/upi/openstack/compute-nodes.yaml  
  https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/openstack/control-  
plane.yaml  
  https://raw.githubusercontent.com/openshift/installer/release-  
4.9/upi/openstack/inventory.yaml  
  https://raw.githubusercontent.com/openshift/installer/release-  
4.9/upi/openstack/network.yaml  
  https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/openstack/security-  
groups.yaml  
  https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/openstack/down-  
bootstrap.yaml  
  https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/openstack/down-  
compute-nodes.yaml  
  https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/openstack/down-  
control-plane.yaml  
  https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/openstack/down-  
load-balancers.yaml  
  https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/openstack/down-  
network.yaml  
  https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/openstack/down-  
security-groups.yaml  
  https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/openstack/down-  
containers.yaml'
```

The playbooks are downloaded to your machine.

**IMPORTANT**

During the installation process, you can modify the playbooks to configure your deployment.

Retain all playbooks for the life of your cluster. You must have the playbooks to remove your OpenShift Container Platform cluster from RHOSP.

**IMPORTANT**

You must match any edits you make in the **bootstrap.yaml**, **compute-nodes.yaml**, **control-plane.yaml**, **network.yaml**, and **security-groups.yaml** files to the corresponding playbooks that are prefixed with **down-**. For example, edits to the **bootstrap.yaml** file must be reflected in the **down-bootstrap.yaml** file, too. If you do not edit both files, the supported cluster removal process will fail.

### 15.5.6. Obtaining the installation program

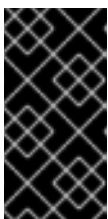
Before you install OpenShift Container Platform, download the installation file on a local computer.

#### Prerequisites

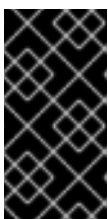
- You have a computer that runs Linux or macOS, with 500 MB of local disk space

#### Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.

**IMPORTANT**

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.

**IMPORTANT**

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

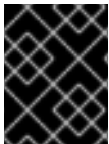
5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#) . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

### 15.5.7. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.



#### IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



#### NOTE

You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

#### Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.



#### NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.



#### NOTE

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the `ssh-agent` process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

#### Example output

```
Agent pid 31874
```



#### NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the `ssh-agent`:

```
$ ssh-add <path>/<file_name> 1
```

- 1** Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

#### Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

#### Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

### 15.5.8. Creating the Red Hat Enterprise Linux CoreOS (RHCOS) image

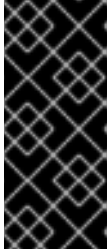
The OpenShift Container Platform installation program requires that a Red Hat Enterprise Linux CoreOS (RHCOS) image be present in the Red Hat OpenStack Platform (RHOSP) cluster. Retrieve the latest RHCOS image, then upload it using the RHOSP CLI.

#### Prerequisites

- The RHOSP CLI is installed.

## Procedure

1. Log in to the Red Hat Customer Portal's [Product Downloads page](#).
2. Under **Version**, select the most recent release of OpenShift Container Platform 4.9 for Red Hat Enterprise Linux (RHEL) 8.



### IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image versions that match your OpenShift Container Platform version if they are available.

3. Download the *Red Hat Enterprise Linux CoreOS (RHCOS) - OpenStack Image (QCOW)*.
4. Decompress the image.



### NOTE

You must decompress the RHOSP image before the cluster can use it. The name of the downloaded file might not contain a compression extension, like **.gz** or **.tgz**. To find out if or how the file is compressed, in a command line, enter:

```
$ file <name_of_downloaded_file>
```

5. From the image that you downloaded, create an image that is named **rhcos** in your cluster by using the RHOSP CLI:

```
$ openstack image create --container-format=bare --disk-format=qcow2 --file rhcos-
${RHCOS_VERSION}-openstack.qcow2 rhcos
```



### IMPORTANT

Depending on your RHOSP environment, you might be able to upload the image in either **.raw** or **.qcow2** formats. If you use Ceph, you must use the **.raw** format.



### WARNING

If the installation program finds multiple images with the same name, it chooses one of them at random. To avoid this behavior, create unique names for resources in RHOSP.

After you upload the image to RHOSP, it is usable in the installation process.

### 15.5.9. Verifying external network access

The OpenShift Container Platform installation process requires external network access. You must provide an external network value to it, or deployment fails. Before you begin the process, verify that a network with the external router type exists in Red Hat OpenStack Platform (RHOSP).

#### Prerequisites

- [Configure OpenStack's networking service to have DHCP agents forward instances' DNS queries](#)

#### Procedure

1. Using the RHOSP CLI, verify the name and ID of the 'External' network:

```
$ openstack network list --long -c ID -c Name -c "Router Type"
```

#### Example output

```
+-----+-----+-----+
| ID                | Name      | Router Type |
+-----+-----+-----+
| 148a8023-62a7-4672-b018-003462f8d7dc | public_network | External    |
+-----+-----+-----+
```

A network with an external router type appears in the network list. If at least one does not, see [Creating a default floating IP network](#) and [Creating a default provider network](#).



#### NOTE

If the Neutron trunk service plugin is enabled, a trunk port is created by default. For more information, see [Neutron trunk port](#).

### 15.5.10. Enabling access to the environment

At deployment, all OpenShift Container Platform machines are created in a Red Hat OpenStack Platform (RHOSP)-tenant network. Therefore, they are not accessible directly in most RHOSP deployments.

You can configure OpenShift Container Platform API and application access by using floating IP addresses (FIPs) during installation. You can also complete an installation without configuring FIPs, but the installer will not configure a way to reach the API or applications externally.

#### 15.5.10.1. Enabling access with floating IP addresses

Create floating IP (FIP) addresses for external access to the OpenShift Container Platform API, cluster applications, and the bootstrap process.

#### Procedure

1. Using the Red Hat OpenStack Platform (RHOSP) CLI, create the API FIP:

```
$ openstack floating ip create --description "API <cluster_name>.<base_domain>"
<external_network>
```

- Using the Red Hat OpenStack Platform (RHOSP) CLI, create the apps, or Ingress, FIP:

```
$ openstack floating ip create --description "Ingress <cluster_name>.<base_domain>"
<external_network>
```

- By using the Red Hat OpenStack Platform (RHOSP) CLI, create the bootstrap FIP:

```
$ openstack floating ip create --description "bootstrap machine" <external_network>
```

- Add records that follow these patterns to your DNS server for the API and Ingress FIPs:

```
api.<cluster_name>.<base_domain>. IN A <API_FIP>
*.apps.<cluster_name>.<base_domain>. IN A <apps_FIP>
```

## NOTE

If you do not control the DNS server, you can access the cluster by adding the cluster domain names such as the following to your `/etc/hosts` file:

- `<api_floating_ip> api.<cluster_name>.<base_domain>`
- `<application_floating_ip> grafana-openshift-monitoring.apps.<cluster_name>.<base_domain>`
- `<application_floating_ip> prometheus-k8s-openshift-monitoring.apps.<cluster_name>.<base_domain>`
- `<application_floating_ip> oauth-openshift.apps.<cluster_name>.<base_domain>`
- `<application_floating_ip> console-openshift-console.apps.<cluster_name>.<base_domain>`
- `application_floating_ip integrated-oauth-server-openshift-authentication.apps.<cluster_name>.<base_domain>`

The cluster domain names in the `/etc/hosts` file grant access to the web console and the monitoring interface of your cluster locally. You can also use the `kubectl` or `oc`. You can access the user applications by using the additional entries pointing to the `<application_floating_ip>`. This action makes the API and applications accessible to only you, which is not suitable for production deployment, but does allow installation for development and testing.

- Add the FIPs to the `inventory.yaml` file as the values of the following variables:

- `os_api_fip`
- `os_bootstrap_fip`
- `os_ingress_fip`



If you use these values, you must also enter an external network as the value of the **os\_external\_network** variable in the **inventory.yaml** file.

## TIP

You can make OpenShift Container Platform resources available outside of the cluster by assigning a floating IP address and updating your firewall configuration.

### 15.5.10.2. Completing installation without floating IP addresses

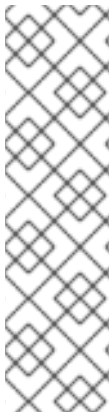
You can install OpenShift Container Platform on Red Hat OpenStack Platform (RHOSP) without providing floating IP addresses.

In the **inventory.yaml** file, do not define the following variables:

- **os\_api\_fip**
- **os\_bootstrap\_fip**
- **os\_ingress\_fip**

If you cannot provide an external network, you can also leave **os\_external\_network** blank. If you do not provide a value for **os\_external\_network**, a router is not created for you, and, without additional action, the installer will fail to retrieve an image from Glance. Later in the installation process, when you create network resources, you must configure external connectivity on your own.

If you run the installer with the **wait-for** command from a system that cannot reach the cluster API due to a lack of floating IP addresses or name resolution, installation fails. To prevent installation failure in these cases, you can use a proxy network or run the installer from a system that is on the same network as your machines.



## NOTE

You can enable name resolution by creating DNS records for the API and Ingress ports. For example:

```
api.<cluster_name>.<base_domain>. IN A <api_port_IP>
*.apps.<cluster_name>.<base_domain>. IN A <ingress_port_IP>
```

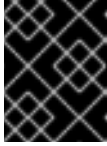
If you do not control the DNS server, you can add the record to your **/etc/hosts** file. This action makes the API accessible to only you, which is not suitable for production deployment but does allow installation for development and testing.

### 15.5.11. Defining parameters for the installation program

The OpenShift Container Platform installation program relies on a file that is called **clouds.yaml**. The file describes Red Hat OpenStack Platform (RHOSP) configuration parameters, including the project name, log in information, and authorization service URLs.

## Procedure

1. Create the **clouds.yaml** file:
  - If your RHOSP distribution includes the Horizon web UI, generate a **clouds.yaml** file in it.



## IMPORTANT

Remember to add a password to the **auth** field. You can also keep secrets in a [separate file](#) from **clouds.yaml**.

- If your RHOSP distribution does not include the Horizon web UI, or you do not want to use Horizon, create the file yourself. For detailed information about **clouds.yaml**, see [Config files](#) in the RHOSP documentation.

```
clouds:
  shiftstack:
    auth:
      auth_url: http://10.10.14.42:5000/v3
      project_name: shiftstack
      username: shiftstack_user
      password: XXX
      user_domain_name: Default
      project_domain_name: Default
  dev-env:
    region_name: RegionOne
    auth:
      username: 'devuser'
      password: XXX
      project_name: 'devonly'
      auth_url: 'https://10.10.14.22:5001/v2.0'
```

2. If your RHOSP installation uses self-signed certificate authority (CA) certificates for endpoint authentication:
  - a. Copy the certificate authority file to your machine.
  - b. Add the **cacerts** key to the **clouds.yaml** file. The value must be an absolute, non-root-accessible path to the CA certificate:

```
clouds:
  shiftstack:
    ...
    cacert: "/etc/pki/ca-trust/source/anchors/ca.crt.pem"
```

## TIP

After you run the installer with a custom CA certificate, you can update the certificate by editing the value of the **ca-cert.pem** key in the **cloud-provider-config** keymap. On a command line, run:

```
$ oc edit configmap -n openshift-config cloud-provider-config
```

3. Place the **clouds.yaml** file in one of the following locations:
  - a. The value of the **OS\_CLIENT\_CONFIG\_FILE** environment variable
  - b. The current directory
  - c. A Unix-specific user configuration directory, for example **~/.config/openstack/clouds.yaml**

- d. A Unix-specific site configuration directory, for example `/etc/openstack/clouds.yaml`  
The installation program searches for **clouds.yaml** in that order.

## 15.5.12. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Red Hat OpenStack Platform (RHOSP).

### Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

### Procedure

1. Create the **install-config.yaml** file.
  - a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

- 1 For **<installation\_directory>**, specify the directory name to store the files that the installation program creates.



### IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

- b. At the prompts, provide the configuration details for your cloud:
  - i. Optional: Select an SSH key to use to access your cluster machines.

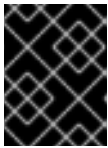


### NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

- ii. Select **openstack** as the platform to target.
- iii. Specify the Red Hat OpenStack Platform (RHOSP) external network name to use for installing the cluster.
- iv. Specify the floating IP address to use for external access to the OpenShift API.

- v. Specify a RHOSP flavor with at least 16 GB RAM to use for control plane nodes and 8 GB RAM for compute nodes.
  - vi. Select the base domain to deploy the cluster to. All DNS records will be sub-domains of this base and will also include the cluster name.
  - vii. Enter a name for your cluster. The name must be 14 or fewer characters long.
  - viii. Paste the [pull secret from the Red Hat OpenShift Cluster Manager](#) .
2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.
  3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



### IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

You now have the file **install-config.yaml** in the directory that you specified.

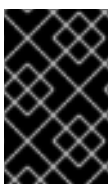
## 15.5.13. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.



### NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.



### IMPORTANT

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

### 15.5.13.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 15.18. Required parameters

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String


Parameter	Description	Values
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;.&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}</b> . <b>{{.baseDomain}}</b> .	String of lowercase letters, hyphens (-), and periods (.), such as <b>dev</b> . The string must be 14 characters or fewer long.
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws, baremetal, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre> {   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } } </pre>


### 15.5.13.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

Table 15.19. Network parameters

Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	Object   <b>NOTE</b> You cannot modify parameters specified by the <b>networking</b> object after installation.
<b>networking.network Type</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .
<b>networking.clusterNetwork</b>	The IP address blocks for pods.  The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b> .  If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example:  <pre>networking:   clusterNetwork:     - cidr: 10.128.0.0/14       hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	Required if you use <b>networking.clusterNetwork</b> . An IP address block.  An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b> .
<b>networking.clusterNetwork.hostPrefix</b>	The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b> . A <b>hostPrefix</b> value of <b>23</b> provides 510 ( $2^{(32 - 23)} - 2$ ) pod IP addresses.	A subnet prefix.  The default value is <b>23</b> .


Parameter	Description	Values
<b>networking.serviceNetwork</b>	<p>The IP address block for services. The default value is <b>172.30.0.0/16</b>.</p> <p>The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.</p>	<p>An array with an IP address block in CIDR format. For example:</p> <pre>networking:   serviceNetwork:     - 172.30.0.0/16</pre>
<b>networking.machineNetwork</b>	<p>The IP address blocks for machines.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   machineNetwork:     - cidr: 10.0.0.0/16</pre>
<b>networking.machineNetwork.cidr</b>	<p>Required if you use <b>networking.machineNetwork</b>. An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b>.</p>	<p>An IP network block in CIDR notation.</p> <p>For example, <b>10.0.0.0/16</b>.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p> </div> </div>

### 15.5.13.3. Optional configuration parameters


Optional installation configuration parameters are described in the following table:



Table 15.20. Optional parameters

Parameter	Description	Values
<b>additionalTrustBundle</b>	<p>A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.</p>	String
<b>compute</b>	<p>The configuration for the machines that comprise the compute nodes.</p>	Array of <b>MachinePool</b> objects.


Parameter	Description	Values
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String
<b>compute.hyperthreading</b>	Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b> , on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.   <b>IMPORTANT</b>  If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b>
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String



Parameter	Description	Values
<b>controlPlane.hypert hreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platfor m</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>controlPlane.replica s</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.

Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.</p> <p> <b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators reference content</i>.</p> <p> <b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p>	<b>Mint, Passthrough, Manual</b> or an empty string ("").

Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 60px; height: 60px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 60px; height: 60px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<p><b>Internal</b> or <b>External</b>. The default value is <b>External</b>.</p> <p>Setting this field to <b>Internal</b> is not supported on non-cloud platforms.</p>

Parameter	Description	Values
<b>sshKey</b>	<p>The SSH key or keys to authenticate access your cluster machines.</p>  <p><b>NOTE</b></p> <p>For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.</p>	<p>One or more keys. For example:</p> <pre>sshKey:   &lt;key1&gt;   &lt;key2&gt;   &lt;key3&gt;</pre>

#### 15.5.13.4. Additional Red Hat OpenStack Platform (RHOSP) configuration parameters

Additional RHOSP configuration parameters are described in the following table:

Table 15.21. Additional RHOSP parameters

Parameter	Description	Values
<b>compute.platform.openstack.rootVolume.size</b>	For compute machines, the size in gigabytes of the root volume. If you do not set this value, machines use ephemeral storage.	Integer, for example <b>30</b> .
<b>compute.platform.openstack.rootVolume.type</b>	For compute machines, the root volume's type.	String, for example <b>performance</b> .
<b>controlPlane.platform.openstack.rootVolume.size</b>	For control plane machines, the size in gigabytes of the root volume. If you do not set this value, machines use ephemeral storage.	Integer, for example <b>30</b> .
<b>controlPlane.platform.openstack.rootVolume.type</b>	For control plane machines, the root volume's type.	String, for example <b>performance</b> .

Parameter	Description	Values
<b>platform.openstack.cloud</b>	The name of the RHOSP cloud to use from the list of clouds in the <b>clouds.yaml</b> file.	String, for example <b>MyCloud</b> .
<b>platform.openstack.externalNetwork</b>	The RHOSP external network name to be used for installation.	String, for example <b>external</b> .
<b>platform.openstack.computeFlavor</b>	<p>The RHOSP flavor to use for control plane and compute machines.</p> <p>This property is deprecated. To use a flavor as the default for all machine pools, add it as the value of the <b>type</b> key in the <b>platform.openstack.defaultMachinePlatform</b> property. You can also set a flavor value for each machine pool individually.</p>	String, for example <b>m1.xlarge</b> .

### 15.5.13.5. Optional RHOSP configuration parameters

Optional RHOSP configuration parameters are described in the following table:

Table 15.22. Optional RHOSP parameters

Parameter	Description	Values
<b>compute.platform.openstack.additionalNetworkIDs</b>	Additional networks that are associated with compute machines. Allowed address pairs are not created for additional networks.	A list of one or more UUIDs as strings. For example, <b>fa806b2f-ac49-4bce-b9db-124bc64209bf</b> .
<b>compute.platform.openstack.additionalSecurityGroupIDs</b>	Additional security groups that are associated with compute machines.	A list of one or more UUIDs as strings. For example, <b>7ee219f3-d2e9-48a1-96c2-e7429f1b0da7</b> .

Parameter	Description	Values
<b>compute.platform.openstack.zones</b>	<p>RHOSP Compute (Nova) availability zones (AZs) to install machines on. If this parameter is not set, the installer relies on the default settings for Nova that the RHOSP administrator configured.</p> <p>On clusters that use Kuryr, RHOSP Octavia does not support availability zones. Load balancers and, if you are using the Amphora provider driver, OpenShift Container Platform services that rely on Amphora VMs, are not created according to the value of this property.</p>	A list of strings. For example, <b>["zone-1", "zone-2"]</b> .
<b>compute.platform.openstack.rootVolume.zones</b>	For compute machines, the availability zone to install root volumes on. If you do not set a value for this parameter, the installer selects the default availability zone.	A list of strings, for example <b>["zone-1", "zone-2"]</b> .
<b>controlPlane.platform.openstack.additionalNetworkIDs</b>	Additional networks that are associated with control plane machines. Allowed address pairs are not created for additional networks.	A list of one or more UUIDs as strings. For example, <b>fa806b2f-ac49-4bce-b9db-124bc64209bf</b> .
<b>controlPlane.platform.openstack.additionalSecurityGroupIDs</b>	Additional security groups that are associated with control plane machines.	A list of one or more UUIDs as strings. For example, <b>7ee219f3-d2e9-48a1-96c2-e7429f1b0da7</b> .

Parameter	Description	Values
<b>controlPlane.platform.openstack.zones</b>	<p>RHOSP Compute (Nova) availability zones (AZs) to install machines on. If this parameter is not set, the installer relies on the default settings for Nova that the RHOSP administrator configured.</p> <p>On clusters that use Kuryr, RHOSP Octavia does not support availability zones. Load balancers and, if you are using the Amphora provider driver, OpenShift Container Platform services that rely on Amphora VMs, are not created according to the value of this property.</p>	A list of strings. For example, <b>["zone-1", "zone-2"]</b> .
<b>controlPlane.platform.openstack.rootVolume.zones</b>	For control plane machines, the availability zone to install root volumes on. If you do not set this value, the installer selects the default availability zone.	A list of strings, for example <b>["zone-1", "zone-2"]</b> .
<b>platform.openstack.clusterOSImage</b>	<p>The location from which the installer downloads the RHCOS image.</p> <p>You must set this parameter to perform an installation in a restricted network.</p>	<p>An HTTP or HTTPS URL, optionally with an SHA-256 checksum.</p> <p>For example,  <b>http://mirror.example.com/images/rhcos-43.81.201912131630.0-openstack.x86_64.qcow2.gz?sha256=ffebbd68e8a1f2a245ca19522c16c86f67f9ac8e4e0c1f0a812b068b16f7265d</b>. The value can also be the name of an existing Glance image, for example <b>my-rhcos</b>.</p>

Parameter	Description	Values
<b>platform.openstack.clusterOSImageProperties</b>	<p>Properties to add to the installer-uploaded ClusterOSImage in Glance. This property is ignored if <b>platform.openstack.clusterOSImage</b> is set to an existing Glance image.</p> <p>You can use this property to exceed the default persistent volume (PV) limit for RHOSP of 26 PVs per node. To exceed the limit, set the <b>hw_scsi_model</b> property value to <b>virtio-scsi</b> and the <b>hw_disk_bus</b> value to <b>scsi</b>.</p> <p>You can also use this property to enable the QEMU guest agent by including the <b>hw_qemu_guest_agent</b> property with a value of <b>yes</b>.</p>	A list of key-value string pairs. For example, <b>[{"hw_scsi_model": "virtio-scsi", "hw_disk_bus": "scsi"}]</b> .
<b>platform.openstack.defaultMachinePlatform</b>	The default machine pool platform configuration.	<pre>{   "type": "ml.large",   "rootVolume": {     "size": 30,     "type": "performance"   } }</pre>
<b>platform.openstack.ingressFloatingIP</b>	An existing floating IP address to associate with the Ingress port. To use this property, you must also define the <b>platform.openstack.externalNetwork</b> property.	An IP address, for example <b>128.0.0.1</b> .
<b>platform.openstack.apiFloatingIP</b>	An existing floating IP address to associate with the API load balancer. To use this property, you must also define the <b>platform.openstack.externalNetwork</b> property.	An IP address, for example <b>128.0.0.1</b> .
<b>platform.openstack.externalDNS</b>	IP addresses for external DNS servers that cluster instances use for DNS resolution.	A list of IP addresses as strings. For example, <b>["8.8.8.8", "192.168.1.12"]</b> .



Parameter	Description	Values
<b>platform.openstack.machinesSubnet</b>	<p>The UUID of a RHOSP subnet that the cluster's nodes use. Nodes and virtual IP (VIP) ports are created on this subnet.</p> <p>The first item in <b>networking.machineNetwork</b> must match the value of <b>machinesSubnet</b>.</p> <p>If you deploy to a custom subnet, you cannot specify an external DNS server to the OpenShift Container Platform installer. Instead, <a href="#">add DNS to the subnet in RHOSP</a>.</p>	A UUID as a string. For example, <b>fa806b2f-ac49-4bce-b9db-124bc64209bf</b> .

#### 15.5.13.6. Custom subnets in RHOSP deployments

Optionally, you can deploy a cluster on a Red Hat OpenStack Platform (RHOSP) subnet of your choice. The subnet's GUID is passed as the value of **platform.openstack.machinesSubnet** in the **install-config.yaml** file.

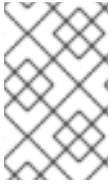
This subnet is used as the cluster's primary subnet. By default, nodes and ports are created on it. You can create nodes and ports on a different RHOSP subnet by setting the value of the **platform.openstack.machinesSubnet** property to the subnet's UUID.

Before you run the OpenShift Container Platform installer with a custom subnet, verify that your configuration meets the following requirements:

- The subnet that is used by **platform.openstack.machinesSubnet** has DHCP enabled.
- The CIDR of **platform.openstack.machinesSubnet** matches the CIDR of **networking.machineNetwork**.
- The installation program user has permission to create ports on this network, including ports with fixed IP addresses.

Clusters that use custom subnets have the following limitations:

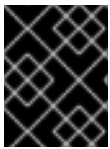
- If you plan to install a cluster that uses floating IP addresses, the **platform.openstack.machinesSubnet** subnet must be attached to a router that is connected to the **externalNetwork** network.
- If the **platform.openstack.machinesSubnet** value is set in the **install-config.yaml** file, the installation program does not create a private network or subnet for your RHOSP machines.
- You cannot use the **platform.openstack.externalDNS** property at the same time as a custom subnet. To add DNS to a cluster that uses a custom subnet, configure DNS on the RHOSP network.

**NOTE**

By default, the API VIP takes x.x.x.5 and the Ingress VIP takes x.x.x.7 from your network's CIDR block. To override these default values, set values for **platform.openstack.apiVIP** and **platform.openstack.ingressVIP** that are outside of the DHCP allocation pool.

**15.5.13.7. Sample customized install-config.yaml file for RHOSP**

This sample **install-config.yaml** demonstrates all of the possible Red Hat OpenStack Platform (RHOSP) customization options.

**IMPORTANT**

This sample file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program.

```
apiVersion: v1
baseDomain: example.com
controlPlane:
  name: master
  platform: {}
  replicas: 3
compute:
- name: worker
  platform:
    openstack:
      type: m1.large
  replicas: 3
metadata:
  name: example
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  serviceNetwork:
  - 172.30.0.0/16
  networkType: OpenShiftSDN
platform:
  openstack:
    cloud: mycloud
    externalNetwork: external
    computeFlavor: m1.xlarge
    apiFloatingIP: 128.0.0.1
fips: false
pullSecret: '{"auths": ...}'
sshKey: ssh-ed25519 AAAA...
```

**15.5.13.8. Setting a custom subnet for machines**

The IP range that the installation program uses by default might not match the Neutron subnet that you create when you install OpenShift Container Platform. If necessary, update the CIDR value for new machines by editing the installation configuration file.

## Prerequisites

- You have the **install-config.yaml** file that was generated by the OpenShift Container Platform installation program.

## Procedure

1. On a command line, browse to the directory that contains **install-config.yaml**.
2. From that directory, either run a script to edit the **install-config.yaml** file or update the file manually:
  - To set the value by using a script, run:

```
$ python -c '
import yaml;
path = "install-config.yaml";
data = yaml.safe_load(open(path));
data["networking"]["machineNetwork"] = [{"cidr": "192.168.0.0/18"}]; 1
open(path, "w").write(yaml.dump(data, default_flow_style=False))'
```

- 1** Insert a value that matches your intended Neutron subnet, e.g. **192.0.2.0/24**.

- To set the value manually, open the file and set the value of **networking.machineCIDR** to something that matches your intended Neutron subnet.

### 15.5.13.9. Emptying compute machine pools

To proceed with an installation that uses your own infrastructure, set the number of compute machines in the installation configuration file to zero. Later, you create these machines manually.

## Prerequisites

- You have the **install-config.yaml** file that was generated by the OpenShift Container Platform installation program.

## Procedure

1. On a command line, browse to the directory that contains **install-config.yaml**.
2. From that directory, either run a script to edit the **install-config.yaml** file or update the file manually:
  - To set the value by using a script, run:

```
$ python -c '
import yaml;
path = "install-config.yaml";
data = yaml.safe_load(open(path));
data["compute"][0]["replicas"] = 0;
open(path, "w").write(yaml.dump(data, default_flow_style=False))'
```

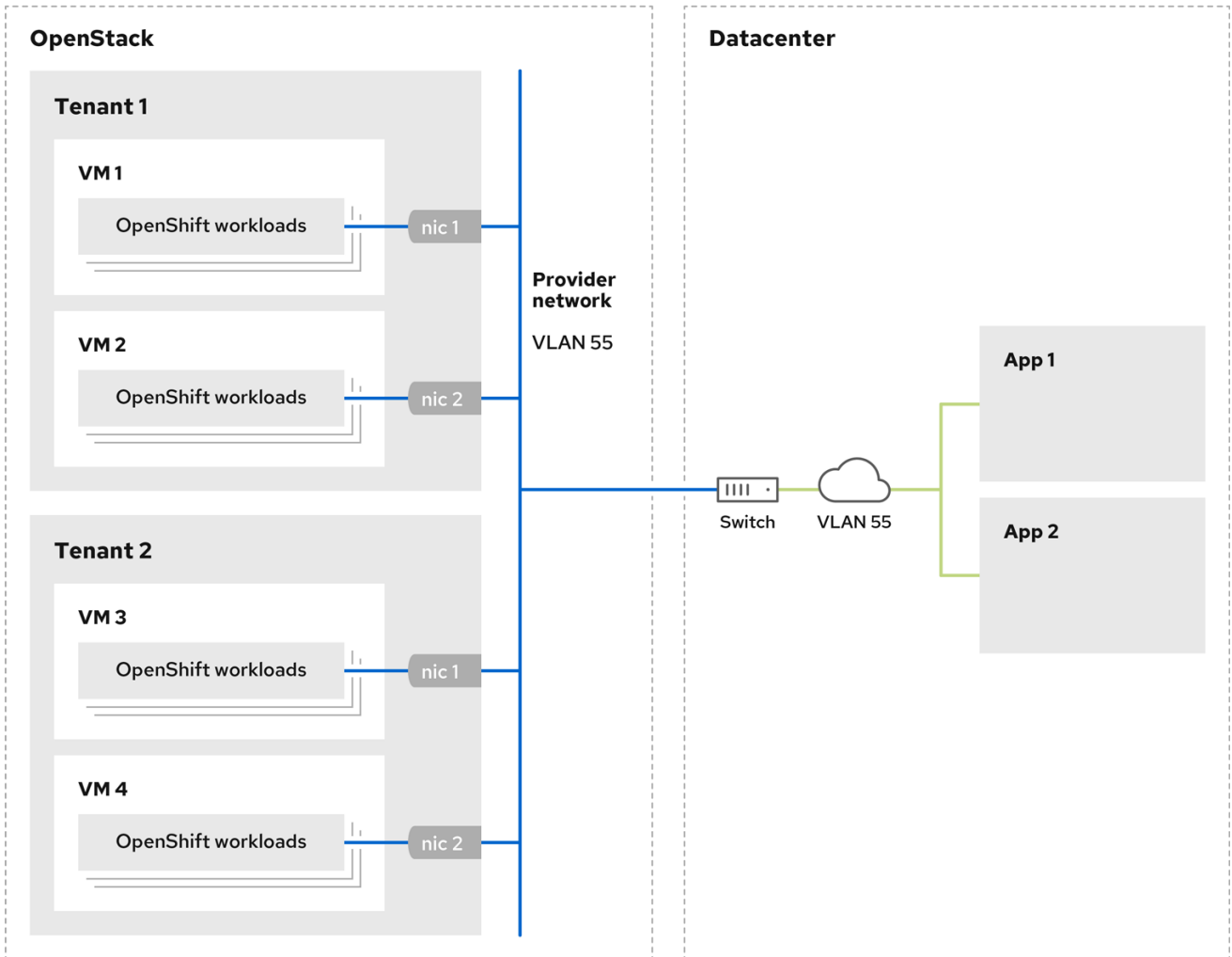
- To set the value manually, open the file and set the value of **compute.<first entry>.replicas** to **0**.

### 15.5.13.10. Cluster deployment on RHOSP provider networks

You can deploy your OpenShift Container Platform clusters on Red Hat OpenStack Platform (RHOSP) with a primary network interface on a provider network. Provider networks are commonly used to give projects direct access to a public network that can be used to reach the internet. You can also share provider networks among projects as part of the network creation process.

RHOSP provider networks map directly to an existing physical network in the data center. A RHOSP administrator must create them.

In the following example, OpenShift Container Platform workloads are connected to a data center by using a provider network:



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OpenShift Container Platform clusters that are installed on provider networks do not require tenant networks or floating IP addresses. The installer does not create these resources during installation.

Example provider network types include flat (untagged) and VLAN (802.1Q tagged).



#### NOTE

A cluster can support as many provider network connections as the network type allows. For example, VLAN networks typically support up to 4096 connections.

You can learn more about provider and tenant networks in [the RHOSP documentation](#).

#### 15.5.13.10.1. RHOSP provider network requirements for cluster installation

Before you install an OpenShift Container Platform cluster, your Red Hat OpenStack Platform (RHOSP) deployment and provider network must meet a number of conditions:

- The [RHOSP networking service \(Neutron\) is enabled](#) and accessible through the RHOSP networking API.
- The RHOSP networking service has the [port security and allowed address pairs extensions enabled](#).
- The provider network can be shared with other tenants.

#### TIP

Use the **openstack network create** command with the **--share** flag to create a network that can be shared.

- The RHOSP project that you use to install the cluster must own the provider network, as well as an appropriate subnet.

#### TIP

To create a network for a project that is named "openshift," enter the following command

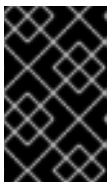
```
$ openstack network create --project openshift
```

To create a subnet for a project that is named "openshift," enter the following command

```
$ openstack subnet create --project openshift
```

To learn more about creating networks on RHOSP, read [the provider networks documentation](#).

If the cluster is owned by the **admin** user, you must run the installer as that user to create ports on the network.



#### IMPORTANT

Provider networks must be owned by the RHOSP project that is used to create the cluster. If they are not, the RHOSP Compute service (Nova) cannot request a port from that network.

- Verify that the provider network can reach the RHOSP metadata service IP address, which is **169.254.169.254** by default.

Depending on your RHOSP SDN and networking service configuration, you might need to provide the route when you create the subnet. For example:

```
$ openstack subnet create --dhcp --host-route
destination=169.254.169.254/32,gateway=192.0.2.2 ...
```

- Optional: To secure the network, create [role-based access control \(RBAC\)](#) rules that limit network access to a single project.

### 15.5.13.10.2. Deploying a cluster that has a primary interface on a provider network

You can deploy an OpenShift Container Platform cluster that has its primary network interface on an Red Hat OpenStack Platform (RHOSP) provider network. .Prerequisites

- Your Red Hat OpenStack Platform (RHOSP) deployment is configured as described by "RHOSP provider network requirements for cluster installation".

#### Procedure

1. In a text editor, open the **install-config.yaml** file.
2. Set the value of the **platform.openstack.apiVIP** property to the IP address for the API VIP.
3. Set the value of the **platform.openstack.ingressVIP** property to the IP address for the Ingress VIP.
4. Set the value of the **platform.openstack.machinesSubnet** property to the UUID of the provider network subnet.
5. Set the value of the **networking.machineNetwork.cidr** property to the CIDR block of the provider network subnet.



#### IMPORTANT

The **platform.openstack.apiVIP** and **platform.openstack.ingressVIP** properties must both be unassigned IP addresses from the **networking.machineNetwork.cidr** block.

#### Section of an installation configuration file for a cluster that relies on a RHOSP provider network

```
...
platform:
  openstack:
    apiVIP: 192.0.2.13
    ingressVIP: 192.0.2.23
    machinesSubnet: fa806b2f-ac49-4bce-b9db-124bc64209bf
    # ...
networking:
  machineNetwork:
    - cidr: 192.0.2.0/24
```



#### WARNING

You cannot set the **platform.openstack.externalNetwork** or **platform.openstack.externalDNS** parameters while using a provider network for the primary network interface.

When you deploy the cluster, the installer uses the **install-config.yaml** file to deploy the cluster on the provider network.

## TIP

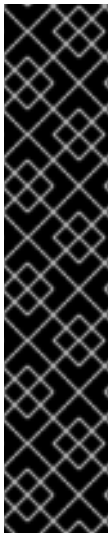
You can add additional networks, including provider networks, to the **platform.openstack.additionalNetworkIDs** list.

After you deploy your cluster, you can attach pods to additional networks. For more information, see [Understanding multiple networks](#).

### 15.5.14. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.



## IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

## Prerequisites

- You obtained the OpenShift Container Platform installation program.
- You created the **install-config.yaml** installation configuration file.

## Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

- 1** For **<installation\_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

2. Remove the Kubernetes manifest files that define the control plane machines and compute machine sets:

```
$ rm -f openshift/99_openshift-cluster-api_master-machines-*.yaml openshift/99_openshift-
cluster-api_worker-machineset-*.yaml
```

Because you create and manage these resources yourself, you do not have to initialize them.

- You can preserve the machine set files to create compute machines by using the machine API, but you must update references to them to match your environment.
3. Check that the **mastersSchedulable** parameter in the `<installation_directory>/manifests/cluster-scheduler-02-config.yml` Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:
    - a. Open the `<installation_directory>/manifests/cluster-scheduler-02-config.yml` file.
    - b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.
    - c. Save and exit the file.
  4. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

- 1** For `<installation_directory>`, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the `./<installation_directory>/auth` directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

5. Export the metadata file's **infraID** key as an environment variable:

```
$ export INFRA_ID=$(jq -r .infraID metadata.json)
```

## TIP

Extract the **infraID** key from **metadata.json** and use it as a prefix for all of the RHOSP resources that you create. By doing so, you avoid name conflicts when making multiple deployments in the same project.

### 15.5.15. Preparing the bootstrap Ignition files

The OpenShift Container Platform installation process relies on bootstrap machines that are created from a bootstrap Ignition configuration file.



Edit the file and upload it. Then, create a secondary bootstrap Ignition configuration file that Red Hat OpenStack Platform (RHOSP) uses to download the primary file.

## Prerequisites

- You have the bootstrap Ignition file that the installer program generates, **bootstrap.ign**.
- The infrastructure ID from the installer's metadata file is set as an environment variable (**\$INFRA\_ID**).
  - If the variable is not set, see **Creating the Kubernetes manifest and Ignition config files**
- You have an HTTP(S)-accessible way to store the bootstrap Ignition file.
  - The documented procedure uses the RHOSP image service (Glance), but you can also use the RHOSP storage service (Swift), Amazon S3, an internal HTTP server, or an ad hoc Nova server.

## Procedure

1. Run the following Python script. The script modifies the bootstrap Ignition file to set the hostname and, if available, CA certificate file when it runs:

```
import base64
import json
import os

with open('bootstrap.ign', 'r') as f:
    ignition = json.load(f)

files = ignition['storage'].get('files', [])

infra_id = os.environ.get('INFRA_ID', 'openshift').encode()
hostname_b64 = base64.standard_b64encode(infra_id + b'-bootstrap\n').decode().strip()
files.append(
{
    'path': '/etc/hostname',
    'mode': 420,
    'contents': {
        'source': 'data:text/plain;charset=utf-8;base64,' + hostname_b64
    }
})

ca_cert_path = os.environ.get('OS_CACERT', "")
if ca_cert_path:
    with open(ca_cert_path, 'r') as f:
        ca_cert = f.read().encode()
        ca_cert_b64 = base64.standard_b64encode(ca_cert).decode().strip()

files.append(
{
    'path': '/opt/openshift/tls/cloud-ca-cert.pem',
    'mode': 420,
    'contents': {
        'source': 'data:text/plain;charset=utf-8;base64,' + ca_cert_b64
    }
})
```

```

    })
    ignition['storage']['files'] = files;

    with open('bootstrap.ign', 'w') as f:
        json.dump(ignition, f)

```

- Using the RHOSP CLI, create an image that uses the bootstrap Ignition file:

```

$ openstack image create --disk-format=raw --container-format=bare --file bootstrap.ign
<image_name>

```

- Get the image's details:

```

$ openstack image show <image_name>

```

Make a note of the **file** value; it follows the pattern **v2/images/<image\_ID>/file**.



#### NOTE

Verify that the image you created is active.

- Retrieve the image service's public address:

```

$ openstack catalog show image

```

- Combine the public address with the image **file** value and save the result as the storage location. The location follows the pattern **<image\_service\_public\_URL>/v2/images/<image\_ID>/file**.

- Generate an auth token and save the token ID:

```

$ openstack token issue -c id -f value

```

- Insert the following content into a file called **\$INFRA\_ID-bootstrap-ignition.json** and edit the placeholders to match your own values:

```

{
  "ignition": {
    "config": {
      "merge": [{
        "source": "<storage_url>", 1
        "httpHeaders": [{
          "name": "X-Auth-Token", 2
          "value": "<token_ID>" 3
        }]
      }]
    },
    "security": {
      "tls": {
        "certificateAuthorities": [{
          "source": "data:text/plain;charset=utf-8;base64,<base64_encoded_certificate>" 4
        }]
      }
    }
  }
}

```

```

    }
  },
  "version": "3.2.0"
}
}

```

- 1 Replace the value of **ignition.config.merge.source** with the bootstrap Ignition file storage URL.
- 2 Set **name** in **httpHeaders** to **"X-Auth-Token"**.
- 3 Set **value** in **httpHeaders** to your token's ID.
- 4 If the bootstrap Ignition file server uses a self-signed certificate, include the base64-encoded certificate.

8. Save the secondary Ignition config file.

The bootstrap Ignition data will be passed to RHOSP during installation.



### WARNING

The bootstrap Ignition file contains sensitive information, like **clouds.yaml** credentials. Ensure that you store it in a secure place, and delete it after you complete the installation process.

## 15.5.16. Creating control plane Ignition config files on RHOSP

Installing OpenShift Container Platform on Red Hat OpenStack Platform (RHOSP) on your own infrastructure requires control plane Ignition config files. You must create multiple config files.



### NOTE

As with the bootstrap Ignition configuration, you must explicitly define a hostname for each control plane machine.

### Prerequisites

- The infrastructure ID from the installation program's metadata file is set as an environment variable (**\$INFRA\_ID**).
  - If the variable is not set, see "Creating the Kubernetes manifest and Ignition config files".

### Procedure

- On a command line, run the following Python script:

```

$ for index in $(seq 0 2); do
  MASTER_HOSTNAME="$INFRA_ID-master-$index\n"
  python -c "import base64, json, sys;

```

```

ignition = json.load(sys.stdin);
storage = ignition.get('storage', {});
files = storage.get('files', []);
files.append({'path': '/etc/hostname', 'mode': 420, 'contents': {'source':
'data:text/plain;charset=utf-8;base64,' +
base64.standard_b64encode(b'$MASTER_HOSTNAME').decode().strip(), 'verification': {}},
'filesystem': 'root'});
storage['files'] = files;
ignition['storage'] = storage
json.dump(ignition, sys.stdout) <master.ign >"$INFRA_ID-master-$index-ignition.json"
done

```

You now have three control plane Ignition files: **<INFRA\_ID>-master-0-ignition.json**, **<INFRA\_ID>-master-1-ignition.json**, and **<INFRA\_ID>-master-2-ignition.json**.

### 15.5.17. Creating network resources on RHOSP

Create the network resources that an OpenShift Container Platform on Red Hat OpenStack Platform (RHOSP) installation on your own infrastructure requires. To save time, run supplied Ansible playbooks that generate security groups, networks, subnets, routers, and ports.

#### Prerequisites

- Python 3 is installed on your machine.
- You downloaded the modules in "Downloading playbook dependencies".
- You downloaded the playbooks in "Downloading the installation playbooks".

#### Procedure

1. Optional: Add an external network value to the **inventory.yaml** playbook:

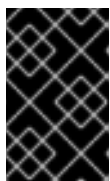
#### Example external network value in the **inventory.yaml** Ansible playbook

```

...
# The public network providing connectivity to the cluster. If not
# provided, the cluster external connectivity must be provided in another
# way.

# Required for os_api_fip, os_ingress_fip, os_bootstrap_fip.
os_external_network: 'external'
...

```



#### IMPORTANT

If you did not provide a value for **os\_external\_network** in the **inventory.yaml** file, you must ensure that VMs can access Glance and an external connection yourself.

2. Optional: Add external network and floating IP (FIP) address values to the **inventory.yaml** playbook:

#### Example FIP values in the **inventory.yaml** Ansible playbook

```

...
# OpenShift API floating IP address. If this value is non-empty, the
# corresponding floating IP will be attached to the Control Plane to
# serve the OpenShift API.
os_api_fip: '203.0.113.23'

# OpenShift Ingress floating IP address. If this value is non-empty, the
# corresponding floating IP will be attached to the worker nodes to serve
# the applications.
os_ingress_fip: '203.0.113.19'

# If this value is non-empty, the corresponding floating IP will be
# attached to the bootstrap machine. This is needed for collecting logs
# in case of install failure.
os_bootstrap_fip: '203.0.113.20'

```



### IMPORTANT

If you do not define values for **os\_api\_fip** and **os\_ingress\_fip**, you must perform post-installation network configuration.

If you do not define a value for **os\_bootstrap\_fip**, the installer cannot download debugging information from failed installations.

See "Enabling access to the environment" for more information.

3. On a command line, create security groups by running the **security-groups.yaml** playbook:

```
$ ansible-playbook -i inventory.yaml security-groups.yaml
```

4. On a command line, create a network, subnet, and router by running the **network.yaml** playbook:

```
$ ansible-playbook -i inventory.yaml network.yaml
```

5. Optional: If you want to control the default resolvers that Nova servers use, run the RHOSP CLI command:

```
$ openstack subnet set --dns-nameserver <server_1> --dns-nameserver <server_2>
"$INFRA_ID-nodes"
```

Optionally, you can use the **inventory.yaml** file that you created to customize your installation. For example, you can deploy a cluster that uses bare metal machines.

#### 15.5.17.1. Deploying a cluster with bare metal machines

If you want your cluster to use bare metal machines, modify the **inventory.yaml** file. Your cluster can have both control plane and compute machines running on bare metal, or just compute machines.

Bare-metal compute machines are not supported on clusters that use Kuryr.



## NOTE

Be sure that your **install-config.yaml** file reflects whether the RHOSP network that you use for bare metal workers supports floating IP addresses or not.

## Prerequisites

- The RHOSP [Bare Metal service \(Ironic\)](#) is enabled and accessible via the RHOSP Compute API.
- Bare metal is available as [a RHOSP flavor](#).
- The RHOSP network supports both VM and bare metal server attachment.
- Your network configuration does not rely on a provider network. Provider networks are not supported.
- If you want to deploy the machines on a pre-existing network, a RHOSP subnet is provisioned.
- If you want to deploy the machines on an installer-provisioned network, the RHOSP Bare Metal service (Ironic) is able to listen for and interact with Preboot eXecution Environment (PXE) boot machines that run on tenant networks.
- You created an **inventory.yaml** file as part of the OpenShift Container Platform installation process.

## Procedure

1. In the **inventory.yaml** file, edit the flavors for machines:
  - a. If you want to use bare-metal control plane machines, change the value of **os\_flavor\_master** to a bare metal flavor.
  - b. Change the value of **os\_flavor\_worker** to a bare metal flavor.

### An example bare metal inventory.yaml file

```
all:
  hosts:
    localhost:
      ansible_connection: local
      ansible_python_interpreter: "{{ansible_playbook_python}}"

      # User-provided values
      os_subnet_range: '10.0.0.0/16'
      os_flavor_master: 'my-bare-metal-flavor' 1
      os_flavor_worker: 'my-bare-metal-flavor' 2
      os_image_rhcos: 'rhcos'
      os_external_network: 'external'

  ...
```

- 1 If you want to have bare-metal control plane machines, change this value to a bare metal flavor.
- 2 Change this value to a bare metal flavor to use for compute machines.

Use the updated **inventory.yaml** file to complete the installation process. Machines that are created during deployment use the flavor that you added to the file.



## NOTE

The installer may time out while waiting for bare metal machines to boot.

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
./openshift-install wait-for install-complete --log-level debug
```

### 15.5.18. Creating the bootstrap machine on RHOSP

Create a bootstrap machine and give it the network access it needs to run on Red Hat OpenStack Platform (RHOSP). Red Hat provides an Ansible playbook that you run to simplify this process.

#### Prerequisites

- You downloaded the modules in "Downloading playbook dependencies".
- You downloaded the playbooks in "Downloading the installation playbooks".
- The **inventory.yaml**, **common.yaml**, and **bootstrap.yaml** Ansible playbooks are in a common directory.
- The **metadata.json** file that the installation program created is in the same directory as the Ansible playbooks.

#### Procedure

1. On a command line, change the working directory to the location of the playbooks.
2. On a command line, run the **bootstrap.yaml** playbook:

```
$ ansible-playbook -i inventory.yaml bootstrap.yaml
```

3. After the bootstrap server is active, view the logs to verify that the Ignition files were received:

```
$ openstack console log show "$INFRA_ID-bootstrap"
```

### 15.5.19. Creating the control plane machines on RHOSP

Create three control plane machines by using the Ignition config files that you generated. Red Hat provides an Ansible playbook that you run to simplify this process.

#### Prerequisites

- You downloaded the modules in "Downloading playbook dependencies".
- You downloaded the playbooks in "Downloading the installation playbooks".

- The infrastructure ID from the installation program's metadata file is set as an environment variable (**\$INFRA\_ID**).
- The **inventory.yaml**, **common.yaml**, and **control-plane.yaml** Ansible playbooks are in a common directory.
- You have the three Ignition files that were created in "Creating control plane Ignition config files".

## Procedure

1. On a command line, change the working directory to the location of the playbooks.
2. If the control plane Ignition config files aren't already in your working directory, copy them into it.
3. On a command line, run the **control-plane.yaml** playbook:

```
$ ansible-playbook -i inventory.yaml control-plane.yaml
```

4. Run the following command to monitor the bootstrapping process:

```
$ openshift-install wait-for bootstrap-complete
```

You will see messages that confirm that the control plane machines are running and have joined the cluster:

```
INFO API v1.22.1 up
INFO Waiting up to 30m0s for bootstrapping to complete...
...
INFO It is now safe to remove the bootstrap resources
```

## 15.5.20. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.



2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

#### Example output

```
system:admin
```

### 15.5.21. Deleting bootstrap resources from RHOSP

Delete the bootstrap resources that you no longer need.

#### Prerequisites

- You downloaded the modules in "Downloading playbook dependencies".
- You downloaded the playbooks in "Downloading the installation playbooks".
- The **inventory.yaml**, **common.yaml**, and **down-bootstrap.yaml** Ansible playbooks are in a common directory.
- The control plane machines are running.
  - If you do not know the status of the machines, see "Verifying cluster status".

#### Procedure

1. On a command line, change the working directory to the location of the playbooks.
2. On a command line, run the **down-bootstrap.yaml** playbook:

```
$ ansible-playbook -i inventory.yaml down-bootstrap.yaml
```

The bootstrap port, server, and floating IP address are deleted.



#### WARNING

If you did not disable the bootstrap Ignition file URL earlier, do so now.

### 15.5.22. Creating compute machines on RHOSP

After standing up the control plane, create compute machines. Red Hat provides an Ansible playbook that you run to simplify this process.

#### Prerequisites

- You downloaded the modules in "Downloading playbook dependencies".
- You downloaded the playbooks in "Downloading the installation playbooks".

- The **inventory.yaml**, **common.yaml**, and **compute-nodes.yaml** Ansible playbooks are in a common directory.
- The **metadata.json** file that the installation program created is in the same directory as the Ansible playbooks.
- The control plane is active.

### Procedure

1. On a command line, change the working directory to the location of the playbooks.
2. On a command line, run the playbook:

```
$ ansible-playbook -i inventory.yaml compute-nodes.yaml
```

### Next steps

- Approve the certificate signing requests for the machines.

## 15.5.23. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

### Prerequisites

- You added machines to your cluster.

### Procedure

1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

### Example output

```
NAME      STATUS    ROLES    AGE    VERSION
master-0  Ready    master   63m    v1.22.1
master-1  Ready    master   63m    v1.22.1
master-2  Ready    master   64m    v1.22.1
```

The output lists all of the machines that you created.



### NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

2. Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

### Example output

```
NAME      AGE   REQUESTOR                                     CONDITION
csr-8b2br 15m   system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper Pending
csr-8vnps 15m   system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper Pending
...
```

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

- If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:



#### NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.



#### NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

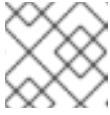
- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{\n"}\n{{end}}\n{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```

**NOTE**

Some Operators might not become available until some CSRs are approved.

- Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

**Example output**

```
NAME      AGE   REQUESTOR                                     CONDITION
csr-bfd72 5m26s system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv 5m26s system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

- If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

**1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{"\n"}\n{{end}}{{end}}' | xargs oc adm certificate approve
```

- After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

**Example output**

```
NAME      STATUS  ROLES  AGE  VERSION
master-0  Ready   master 73m  v1.22.1
master-1  Ready   master 73m  v1.22.1
master-2  Ready   master 74m  v1.22.1
worker-0  Ready   worker 11m  v1.22.1
worker-1  Ready   worker 11m  v1.22.1
```

**NOTE**

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

### Additional information

- For more information on CSRs, see [Certificate Signing Requests](#).

### 15.5.24. Verifying a successful installation

Verify that the OpenShift Container Platform installation is complete.

#### Prerequisites

- You have the installation program (**openshift-install**)

#### Procedure

- On a command line, enter:

```
$ openshift-install --log-level debug wait-for install-complete
```

The program outputs the console URL, as well as the administrator's login information.

### 15.5.25. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

#### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

### 15.5.26. Next steps

- [Customize your cluster](#).
- If necessary, you can [opt out of remote health reporting](#).
- If you need to enable external access to node ports, [configure ingress cluster traffic by using a node port](#).
- If you did not configure RHOSP to accept application traffic over floating IP addresses, [configure RHOSP access with floating IP addresses](#).

## 15.6. INSTALLING A CLUSTER ON OPENSTACK WITH KURYR ON YOUR OWN INFRASTRUCTURE

In OpenShift Container Platform version 4.9, you can install a cluster on Red Hat OpenStack Platform (RHOSP) that runs on user-provisioned infrastructure.

Using your own infrastructure allows you to integrate your cluster with existing infrastructure and modifications. The process requires more labor on your part than installer-provisioned installations,

because you must create all RHOSP resources, like Nova servers, Neutron ports, and security groups. However, Red Hat provides Ansible playbooks to help you in the deployment process.

### 15.6.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You verified that OpenShift Container Platform 4.9 is compatible with your RHOSP version by using the [Supported platforms for OpenShift clusters](#) section. You can also compare platform support across different versions by viewing the [OpenShift Container Platform on RHOSP support matrix](#).
- You have an RHOSP account where you want to install OpenShift Container Platform.
- On the machine from which you run the installation program, you have:
  - A single directory in which you can keep the files you create during the installation process
  - Python 3

### 15.6.2. About Kuryr SDN

[Kuryr](#) is a container network interface (CNI) plugin solution that uses the [Neutron](#) and [Octavia](#) Red Hat OpenStack Platform (RHOSP) services to provide networking for pods and Services.

Kuryr and OpenShift Container Platform integration is primarily designed for OpenShift Container Platform clusters running on RHOSP VMs. Kuryr improves the network performance by plugging OpenShift Container Platform pods into RHOSP SDN. In addition, it provides interconnectivity between pods and RHOSP virtual instances.

Kuryr components are installed as pods in OpenShift Container Platform using the **openshift-kuryr** namespace:

- **kuryr-controller** - a single service instance installed on a **master** node. This is modeled in OpenShift Container Platform as a **Deployment** object.
- **kuryr-cni** - a container installing and configuring Kuryr as a CNI driver on each OpenShift Container Platform node. This is modeled in OpenShift Container Platform as a **DaemonSet** object.

The Kuryr controller watches the OpenShift Container Platform API server for pod, service, and namespace create, update, and delete events. It maps the OpenShift Container Platform API calls to corresponding objects in Neutron and Octavia. This means that every network solution that implements the Neutron trunk port functionality can be used to back OpenShift Container Platform via Kuryr. This includes open source solutions such as Open vSwitch (OVS) and Open Virtual Network (OVN) as well as Neutron-compatible commercial SDNs.

Kuryr is recommended for OpenShift Container Platform deployments on encapsulated RHOSP tenant networks to avoid double encapsulation, such as running an encapsulated OpenShift Container Platform SDN over an RHOSP network.

If you use provider networks or tenant VLANs, you do not need to use Kuryr to avoid double encapsulation. The performance benefit is negligible. Depending on your configuration, though, using Kuryr to avoid having two overlays might still be beneficial.

Kuryr is not recommended in deployments where all of the following criteria are true:

- The RHOSP version is less than 16.
- The deployment uses UDP services, or a large number of TCP services on few hypervisors.

or

- The **ovn-octavia** Octavia driver is disabled.
- The deployment uses a large number of TCP services on few hypervisors.

### 15.6.3. Resource guidelines for installing OpenShift Container Platform on RHOSP with Kuryr

When using Kuryr SDN, the pods, services, namespaces, and network policies are using resources from the RHOSP quota; this increases the minimum requirements. Kuryr also has some additional requirements on top of what a default install requires.

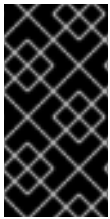
Use the following quota to satisfy a default cluster's minimum requirements:

**Table 15.23. Recommended resources for a default OpenShift Container Platform cluster on RHOSP with Kuryr**

Resource	Value
Floating IP addresses	3 - plus the expected number of Services of LoadBalancer type
Ports	1500 - 1 needed per Pod
Routers	1
Subnets	250 - 1 needed per Namespace/Project
Networks	250 - 1 needed per Namespace/Project
RAM	112 GB
vCPUs	28
Volume storage	275 GB
Instances	7
Security groups	250 - 1 needed per Service and per NetworkPolicy
Security group rules	1000

Resource	Value
Load balancers	100 - 1 needed per Service
Load balancer listeners	500 - 1 needed per Service-exposed port
Load balancer pools	500 - 1 needed per Service-exposed port

A cluster might function with fewer than recommended resources, but its performance is not guaranteed.



### IMPORTANT

If RHOSP object storage (Swift) is available and operated by a user account with the **swiftoperator** role, it is used as the default backend for the OpenShift Container Platform image registry. In this case, the volume storage requirement is 175 GB. Swift space requirements vary depending on the size of the image registry.



### IMPORTANT

If you are using Red Hat OpenStack Platform (RHOSP) version 16 with the Amphora driver rather than the OVN Octavia driver, security groups are associated with service accounts instead of user projects.

Take the following notes into consideration when setting resources:

- The number of ports that are required is larger than the number of pods. Kuryr uses ports pools to have pre-created ports ready to be used by pods and speed up the pods' booting time.
- Each network policy is mapped into an RHOSP security group, and depending on the **NetworkPolicy** spec, one or more rules are added to the security group.
- Each service is mapped to an RHOSP load balancer. Consider this requirement when estimating the number of security groups required for the quota.  
If you are using RHOSP version 15 or earlier, or the **ovn-octavia driver**, each load balancer has a security group with the user project.
- The quota does not account for load balancer resources (such as VM resources), but you must consider these resources when you decide the RHOSP deployment's size. The default installation will have more than 50 load balancers; the clusters must be able to accommodate them.  
If you are using RHOSP version 16 with the OVN Octavia driver enabled, only one load balancer VM is generated; services are load balanced through OVN flows.

An OpenShift Container Platform deployment comprises control plane machines, compute machines, and a bootstrap machine.

To enable Kuryr SDN, your environment must meet the following requirements:

- Run RHOSP 13+.
- Have Overcloud with Octavia.



- Use Neutron Trunk ports extension.
- Use **openvswitch** firewall driver if ML2/OVS Neutron driver is used instead of **ovs-hybrid**.

### 15.6.3.1. Increasing quota

When using Kuryr SDN, you must increase quotas to satisfy the Red Hat OpenStack Platform (RHOSP) resources used by pods, services, namespaces, and network policies.

#### Procedure

- Increase the quotas for a project by running the following command:

```
$ sudo openstack quota set --secgroups 250 --secgroup-rules 1000 --ports 1500 --subnets 250 --networks 250 <project>
```

### 15.6.3.2. Configuring Neutron

Kuryr CNI leverages the Neutron Trunks extension to plug containers into the Red Hat OpenStack Platform (RHOSP) SDN, so you must use the **trunks** extension for Kuryr to properly work.

In addition, if you leverage the default ML2/OVS Neutron driver, the firewall must be set to **openvswitch** instead of **ovs\_hybrid** so that security groups are enforced on trunk subports and Kuryr can properly handle network policies.

### 15.6.3.3. Configuring Octavia

Kuryr SDN uses Red Hat OpenStack Platform (RHOSP)'s Octavia LBaaS to implement OpenShift Container Platform services. Thus, you must install and configure Octavia components in RHOSP to use Kuryr SDN.

To enable Octavia, you must include the Octavia service during the installation of the RHOSP Overcloud, or upgrade the Octavia service if the Overcloud already exists. The following steps for enabling Octavia apply to both a clean install of the Overcloud or an Overcloud update.



#### NOTE

The following steps only capture the key pieces required during the [deployment of RHOSP](#) when dealing with Octavia. It is also important to note that [registry methods](#) vary.

This example uses the local registry method.

#### Procedure

1. If you are using the local registry, create a template to upload the images to the registry. For example:

```
(undercloud) $ openstack overcloud container image prepare \
-e /usr/share/openstack-tripleo-heat-templates/environments/services-docker/octavia.yaml \
--namespace=registry.access.redhat.com/rhosp13 \
--push-destination=<local-ip-from-undercloud.conf>:8787 \
--prefix=openstack-
```

```
--tag-from-label {version}-{product-version} \
--output-env-file=/home/stack/templates/overcloud_images.yaml \
--output-images-file /home/stack/local_registry_images.yaml
```

- Verify that the **local\_registry\_images.yaml** file contains the Octavia images. For example:

```
...
- imagename: registry.access.redhat.com/rhosp13/openstack-octavia-api:13.0-43
  push_destination: <local-ip-from-undercloud.conf>:8787
- imagename: registry.access.redhat.com/rhosp13/openstack-octavia-health-manager:13.0-45
  push_destination: <local-ip-from-undercloud.conf>:8787
- imagename: registry.access.redhat.com/rhosp13/openstack-octavia-housekeeping:13.0-45
  push_destination: <local-ip-from-undercloud.conf>:8787
- imagename: registry.access.redhat.com/rhosp13/openstack-octavia-worker:13.0-44
  push_destination: <local-ip-from-undercloud.conf>:8787
```



#### NOTE

The Octavia container versions vary depending upon the specific RHOSP release installed.

- Pull the container images from **registry.redhat.io** to the Undercloud node:

```
(undercloud) $ sudo openstack overcloud container image upload \
--config-file /home/stack/local_registry_images.yaml \
--verbose
```

This may take some time depending on the speed of your network and Undercloud disk.

- Since an Octavia load balancer is used to access the OpenShift Container Platform API, you must increase their listeners' default timeouts for the connections. The default timeout is 50 seconds. Increase the timeout to 20 minutes by passing the following file to the Overcloud deploy command:

```
(undercloud) $ cat octavia_timeouts.yaml
parameter_defaults:
  OctaviaTimeoutClientData: 1200000
  OctaviaTimeoutMemberData: 1200000
```



#### NOTE

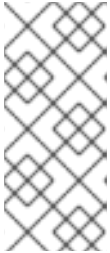
This is not needed for RHOSP 13.0.13+.

- Install or update your Overcloud environment with Octavia:

```
$ openstack overcloud deploy --templates \
-e /usr/share/openstack-tripleo-heat-templates/environments/services-docker/octavia.yaml \
-e octavia_timeouts.yaml
```

**NOTE**

This command only includes the files associated with Octavia; it varies based on your specific installation of RHOSP. See the RHOSP documentation for further information. For more information on customizing your Octavia installation, see [installation of Octavia using Director](#).

**NOTE**

When leveraging Kuryr SDN, the Overcloud installation requires the Neutron **trunk** extension. This is available by default on director deployments. Use the **openvswitch** firewall instead of the default **ovs-hybrid** when the Neutron backend is ML2/OVS. There is no need for modifications if the backend is ML2/OVN.

6. In RHOSP versions earlier than 13.0.13, add the project ID to the **octavia.conf** configuration file after you create the project.
  - To enforce network policies across services, like when traffic goes through the Octavia load balancer, you must ensure Octavia creates the Amphora VM security groups on the user project. This change ensures that required load balancer security groups belong to that project, and that they can be updated to enforce services isolation.

**NOTE**

This task is unnecessary in RHOSP version 13.0.13 or later.

Octavia implements a new ACL API that restricts access to the load balancers VIP.

- a. Get the project ID

```
$ openstack project show <project>
```

**Example output**

```
+-----+-----+
| Field  | Value                |
+-----+-----+
| description |                    |
| domain_id | default              |
| enabled    | True                 |
| id        | PROJECT_ID          |
| is_domain  | False                |
| name      | *<project>*         |
| parent_id | default              |
| tags      | []                   |
+-----+-----+
```

- b. Add the project ID to **octavia.conf** for the controllers.
  - i. Source the **stackrc** file:

```
$ source stackrc # Undercloud credentials
```

- ii. List the Openstack controllers:

```
$ openstack server list
```

### Example output

```
+-----+-----+-----+-----+-----+
| ID              | Name      | Status | Networks |
| Image          | Flavor    |        |          |
+-----+-----+-----+-----+-----+
| 6bef8e73-2ba5-4860-a0b1-3937f8ca7e01 | controller-0 | ACTIVE | ctlplane=192.168.24.8 | overcloud-full | controller |
| dda3173a-ab26-47f8-a2dc-8473b4a67ab9 | compute-0   | ACTIVE |           | overcloud-full | compute    |
+-----+-----+-----+-----+-----+
```

- iii. SSH into the controller(s).

```
$ ssh heat-admin@192.168.24.8
```

- iv. Edit the **octavia.conf** file to add the project into the list of projects where Amphora security groups are on the user's account.

```
# List of project IDs that are allowed to have Load balancer security groups
# belonging to them.
amp_secgroup_allowed_projects = PROJECT_ID
```

- c. Restart the Octavia worker so the new configuration loads.

```
controller-0$ sudo docker restart octavia_worker
```



### NOTE

Depending on your RHOSP environment, Octavia might not support UDP listeners. If you use Kuryr SDN on RHOSP version 13.0.13 or earlier, UDP services are not supported. RHOSP version 16 or later support UDP.

#### 15.6.3.3.1. The Octavia OVN Driver

Octavia supports multiple provider drivers through the Octavia API.

To see all available Octavia provider drivers, on a command line, enter:

■

```
$ openstack loadbalancer provider list
```

### Example output

```
+-----+-----+
| name | description |
+-----+-----+
| amphora | The Octavia Amphora driver. |
| octavia | Deprecated alias of the Octavia Amphora driver. |
| ovn | Octavia OVN driver. |
+-----+-----+
```

Beginning with RHOSP version 16, the Octavia OVN provider driver (**ovn**) is supported on OpenShift Container Platform on RHOSP deployments.

**ovn** is an integration driver for the load balancing that Octavia and OVN provide. It supports basic load balancing capabilities, and is based on OpenFlow rules. The driver is automatically enabled in Octavia by Director on deployments that use OVN Neutron ML2.

The Amphora provider driver is the default driver. If **ovn** is enabled, however, Kuryr uses it.

If Kuryr uses **ovn** instead of Amphora, it offers the following benefits:

- Decreased resource requirements. Kuryr does not require a load balancer VM for each service.
- Reduced network latency.
- Increased service creation speed by using OpenFlow rules instead of a VM for each service.
- Distributed load balancing actions across all nodes instead of centralized on Amphora VMs.

#### 15.6.3.4. Known limitations of installing with Kuryr

Using OpenShift Container Platform with Kuryr SDN has several known limitations.

##### RHOSP general limitations

Using OpenShift Container Platform with Kuryr SDN has several limitations that apply to all versions and environments:

- **Service** objects with the **NodePort** type are not supported.
- Clusters that use the OVN Octavia provider driver support **Service** objects for which the **.spec.selector** property is unspecified only if the **.subsets.addresses** property of the **Endpoints** object includes the subnet of the nodes or pods.
- If the subnet on which machines are created is not connected to a router, or if the subnet is connected, but the router has no external gateway set, Kuryr cannot create floating IPs for **Service** objects with type **LoadBalancer**.
- Configuring the **sessionAffinity=ClientIP** property on **Service** objects does not have an effect. Kuryr does not support this setting.

##### RHOSP version limitations

Using OpenShift Container Platform with Kuryr SDN has several limitations that depend on the RHOSP version.

- RHOSP versions before 16 use the default Octavia load balancer driver (Amphora). This driver requires that one Amphora load balancer VM is deployed per OpenShift Container Platform service. Creating too many services can cause you to run out of resources. Deployments of later versions of RHOSP that have the OVN Octavia driver disabled also use the Amphora driver. They are subject to the same resource concerns as earlier versions of RHOSP.
- Octavia RHOSP versions before 13.0.13 do not support UDP listeners. Therefore, OpenShift Container Platform UDP services are not supported.
- Octavia RHOSP versions before 13.0.13 cannot listen to multiple protocols on the same port. Services that expose the same port to different protocols, like TCP and UDP, are not supported.
- Kuryr SDN does not support automatic unidling by a service.

### RHOSP environment limitations

There are limitations when using Kuryr SDN that depend on your deployment environment.

Because of Octavia's lack of support for the UDP protocol and multiple listeners, if the RHOSP version is earlier than 13.0.13, Kuryr forces pods to use TCP for DNS resolution.

In Go versions 1.12 and earlier, applications that are compiled with CGO support disabled use UDP only. In this case, the native Go resolver does not recognize the **use-vc** option in **resolv.conf**, which controls whether TCP is forced for DNS resolution. As a result, UDP is still used for DNS resolution, which fails.

To ensure that TCP forcing is allowed, compile applications either with the environment variable **CGO\_ENABLED** set to **1**, i.e. **CGO\_ENABLED=1**, or ensure that the variable is absent.

In Go versions 1.13 and later, TCP is used automatically if DNS resolution using UDP fails.



### NOTE

musl-based containers, including Alpine-based containers, do not support the **use-vc** option.

### RHOSP upgrade limitations

As a result of the RHOSP upgrade process, the Octavia API might be changed, and upgrades to the Amphora images that are used for load balancers might be required.

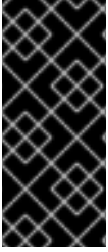
You can address API changes on an individual basis.

If the Amphora image is upgraded, the RHOSP operator can handle existing load balancer VMs in two ways:

- Upgrade each VM by triggering a [load balancer failover](#).
- Leave responsibility for upgrading the VMs to users.

If the operator takes the first option, there might be short downtimes during failovers.

If the operator takes the second option, the existing load balancers will not support upgraded Octavia API features, like UDP listeners. In this case, users must recreate their Services to use these features.



## IMPORTANT

If OpenShift Container Platform detects a new Octavia version that supports UDP load balancing, it recreates the DNS service automatically. The service recreation ensures that the service default supports UDP load balancing.

The recreation causes the DNS service approximately one minute of downtime.

### 15.6.3.5. Control plane machines

By default, the OpenShift Container Platform installation process creates three control plane machines.

Each machine requires:

- An instance from the RHOSP quota
- A port from the RHOSP quota
- A flavor with at least 16 GB memory and 4 vCPUs
- At least 100 GB storage space from the RHOSP quota

### 15.6.3.6. Compute machines

By default, the OpenShift Container Platform installation process creates three compute machines.

Each machine requires:

- An instance from the RHOSP quota
- A port from the RHOSP quota
- A flavor with at least 8 GB memory and 2 vCPUs
- At least 100 GB storage space from the RHOSP quota

## TIP

Compute machines host the applications that you run on OpenShift Container Platform; aim to run as many as you can.

### 15.6.3.7. Bootstrap machine

During installation, a bootstrap machine is temporarily provisioned to stand up the control plane. After the production control plane is ready, the bootstrap machine is deprovisioned.

The bootstrap machine requires:

- An instance from the RHOSP quota
- A port from the RHOSP quota
- A flavor with at least 16 GB memory and 4 vCPUs
- At least 100 GB storage space from the RHOSP quota

## 15.6.4. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



### IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

## 15.6.5. Downloading playbook dependencies

The Ansible playbooks that simplify the installation process on user-provisioned infrastructure require several Python modules. On the machine where you will run the installer, add the modules' repositories and then download them.



### NOTE

These instructions assume that you are using Red Hat Enterprise Linux (RHEL) 8.

### Prerequisites

- Python 3 is installed on your machine.

### Procedure

1. On a command line, add the repositories:

a. Register with Red Hat Subscription Manager:

```
$ sudo subscription-manager register # If not done already
```

b. Pull the latest subscription data:

```
$ sudo subscription-manager attach --pool=$YOUR_POOLID # If not done already
```

c. Disable the current repositories:

```
$ sudo subscription-manager repos --disable=* # If not done already
```

d. Add the required repositories:



```
$ sudo subscription-manager repos \
  --enable=rhel-8-for-x86_64-baseos-rpms \
  --enable=openstack-16-tools-for-rhel-8-x86_64-rpms \
  --enable=ansible-2.9-for-rhel-8-x86_64-rpms \
  --enable=rhel-8-for-x86_64-appstream-rpms
```

2. Install the modules:

```
$ sudo yum install python3-openstackclient ansible python3-openstacksdk python3-netaddr
```

3. Ensure that the **python** command points to **python3**:

```
$ sudo alternatives --set python /usr/bin/python3
```

### 15.6.6. Downloading the installation playbooks

Download Ansible playbooks that you can use to install OpenShift Container Platform on your own Red Hat OpenStack Platform (RHOSP) infrastructure.

#### Prerequisites

- The curl command-line tool is available on your machine.

#### Procedure

- To download the playbooks to your working directory, run the following script from a command line:

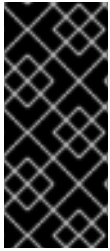
```
$ xargs -n 1 curl -O <<< '
  https://raw.githubusercontent.com/openshift/installer/release-
4.9/upi/openstack/bootstrap.yaml
  https://raw.githubusercontent.com/openshift/installer/release-
4.9/upi/openstack/common.yaml
  https://raw.githubusercontent.com/openshift/installer/release-
4.9/upi/openstack/compute-nodes.yaml
  https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/openstack/control-
plane.yaml
  https://raw.githubusercontent.com/openshift/installer/release-
4.9/upi/openstack/inventory.yaml
  https://raw.githubusercontent.com/openshift/installer/release-
4.9/upi/openstack/network.yaml
  https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/openstack/security-
groups.yaml
  https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/openstack/down-
bootstrap.yaml
  https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/openstack/down-
compute-nodes.yaml
  https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/openstack/down-
control-plane.yaml
  https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/openstack/down-
load-balancers.yaml
  https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/openstack/down-
network.yaml
  https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/openstack/down-
```



```
security-groups.yaml
```

```
https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/openshift/down-  
containers.yaml'
```

The playbooks are downloaded to your machine.



### IMPORTANT

During the installation process, you can modify the playbooks to configure your deployment.

Retain all playbooks for the life of your cluster. You must have the playbooks to remove your OpenShift Container Platform cluster from RHOSP.



### IMPORTANT

You must match any edits you make in the **bootstrap.yaml**, **compute-nodes.yaml**, **control-plane.yaml**, **network.yaml**, and **security-groups.yaml** files to the corresponding playbooks that are prefixed with **down-**. For example, edits to the **bootstrap.yaml** file must be reflected in the **down-bootstrap.yaml** file, too. If you do not edit both files, the supported cluster removal process will fail.

## 15.6.7. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

### Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space

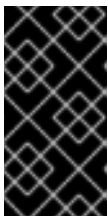
### Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



### IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



### IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

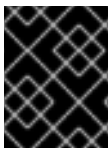
5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#). This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

### 15.6.8. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the `core` user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user `core`. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.



#### IMPORTANT

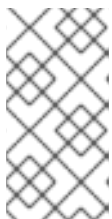
Do not skip this procedure in production environments, where disaster recovery and debugging is required.

#### Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.



#### NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the `x86_64` architecture, do not create a key that uses the `ed25519` algorithm. Instead, create a key that uses the `rsa` or `ecdsa` algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.



#### NOTE

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the `ssh-agent` process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

#### Example output

```
Agent pid 31874
```



#### NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the `ssh-agent`:

```
$ ssh-add <path>/<file_name> 1
```

- 1** Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

#### Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

#### Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

### 15.6.9. Creating the Red Hat Enterprise Linux CoreOS (RHCOS) image

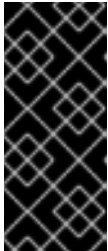
The OpenShift Container Platform installation program requires that a Red Hat Enterprise Linux CoreOS (RHCOS) image be present in the Red Hat OpenStack Platform (RHOSP) cluster. Retrieve the latest RHCOS image, then upload it using the RHOSP CLI.

#### Prerequisites

- The RHOSP CLI is installed.

## Procedure

1. Log in to the Red Hat Customer Portal's [Product Downloads page](#).
2. Under **Version**, select the most recent release of OpenShift Container Platform 4.9 for Red Hat Enterprise Linux (RHEL) 8.



### IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image versions that match your OpenShift Container Platform version if they are available.

3. Download the *Red Hat Enterprise Linux CoreOS (RHCOS) - OpenStack Image (QCOW)*.
4. Decompress the image.



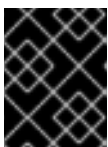
### NOTE

You must decompress the RHOSP image before the cluster can use it. The name of the downloaded file might not contain a compression extension, like **.gz** or **.tgz**. To find out if or how the file is compressed, in a command line, enter:

```
$ file <name_of_downloaded_file>
```

5. From the image that you downloaded, create an image that is named **rhcos** in your cluster by using the RHOSP CLI:

```
$ openstack image create --container-format=bare --disk-format=qcow2 --file rhcos-
${RHCOS_VERSION}-openstack.qcow2 rhcos
```



### IMPORTANT

Depending on your RHOSP environment, you might be able to upload the image in either **.raw** or **.qcow2** formats. If you use Ceph, you must use the **.raw** format.



### WARNING

If the installation program finds multiple images with the same name, it chooses one of them at random. To avoid this behavior, create unique names for resources in RHOSP.

After you upload the image to RHOSP, it is usable in the installation process.

## 15.6.10. Verifying external network access

The OpenShift Container Platform installation process requires external network access. You must provide an external network value to it, or deployment fails. Before you begin the process, verify that a network with the external router type exists in Red Hat OpenStack Platform (RHOSP).

### Prerequisites

- [Configure OpenStack's networking service to have DHCP agents forward instances' DNS queries](#)

### Procedure

1. Using the RHOSP CLI, verify the name and ID of the 'External' network:

```
$ openstack network list --long -c ID -c Name -c "Router Type"
```

### Example output

```
+-----+-----+-----+
| ID              | Name      | Router Type |
+-----+-----+-----+
| 148a8023-62a7-4672-b018-003462f8d7dc | public_network | External    |
+-----+-----+-----+
```

A network with an external router type appears in the network list. If at least one does not, see [Creating a default floating IP network](#) and [Creating a default provider network](#).



### NOTE

If the Neutron trunk service plugin is enabled, a trunk port is created by default. For more information, see [Neutron trunk port](#).

## 15.6.11. Enabling access to the environment

At deployment, all OpenShift Container Platform machines are created in a Red Hat OpenStack Platform (RHOSP)-tenant network. Therefore, they are not accessible directly in most RHOSP deployments.

You can configure OpenShift Container Platform API and application access by using floating IP addresses (FIPs) during installation. You can also complete an installation without configuring FIPs, but the installer will not configure a way to reach the API or applications externally.

### 15.6.11.1. Enabling access with floating IP addresses

Create floating IP (FIP) addresses for external access to the OpenShift Container Platform API, cluster applications, and the bootstrap process.

### Procedure

1. Using the Red Hat OpenStack Platform (RHOSP) CLI, create the API FIP:

```
$ openstack floating ip create --description "API <cluster_name>.<base_domain>"
<external_network>
```

- Using the Red Hat OpenStack Platform (RHOSP) CLI, create the apps, or Ingress, FIP:

```
$ openstack floating ip create --description "Ingress <cluster_name>.<base_domain>"
<external_network>
```

- By using the Red Hat OpenStack Platform (RHOSP) CLI, create the bootstrap FIP:

```
$ openstack floating ip create --description "bootstrap machine" <external_network>
```

- Add records that follow these patterns to your DNS server for the API and Ingress FIPs:

```
api.<cluster_name>.<base_domain>. IN A <API_FIP>
*.apps.<cluster_name>.<base_domain>. IN A <apps_FIP>
```

## NOTE

If you do not control the DNS server, you can access the cluster by adding the cluster domain names such as the following to your `/etc/hosts` file:

- `<api_floating_ip> api.<cluster_name>.<base_domain>`
- `<application_floating_ip> grafana-openshift-monitoring.apps.<cluster_name>.<base_domain>`
- `<application_floating_ip> prometheus-k8s-openshift-monitoring.apps.<cluster_name>.<base_domain>`
- `<application_floating_ip> oauth-openshift.apps.<cluster_name>.<base_domain>`
- `<application_floating_ip> console-openshift-console.apps.<cluster_name>.<base_domain>`
- `application_floating_ip integrated-oauth-server-openshift-authentication.apps.<cluster_name>.<base_domain>`

The cluster domain names in the `/etc/hosts` file grant access to the web console and the monitoring interface of your cluster locally. You can also use the `kubectl` or `oc`. You can access the user applications by using the additional entries pointing to the `<application_floating_ip>`. This action makes the API and applications accessible to only you, which is not suitable for production deployment, but does allow installation for development and testing.

- Add the FIPs to the `inventory.yaml` file as the values of the following variables:

- `os_api_fip`
- `os_bootstrap_fip`
- `os_ingress_fip`

If you use these values, you must also enter an external network as the value of the **os\_external\_network** variable in the **inventory.yaml** file.

## TIP

You can make OpenShift Container Platform resources available outside of the cluster by assigning a floating IP address and updating your firewall configuration.

### 15.6.11.2. Completing installation without floating IP addresses

You can install OpenShift Container Platform on Red Hat OpenStack Platform (RHOSP) without providing floating IP addresses.

In the **inventory.yaml** file, do not define the following variables:

- **os\_api\_fip**
- **os\_bootstrap\_fip**
- **os\_ingress\_fip**

If you cannot provide an external network, you can also leave **os\_external\_network** blank. If you do not provide a value for **os\_external\_network**, a router is not created for you, and, without additional action, the installer will fail to retrieve an image from Glance. Later in the installation process, when you create network resources, you must configure external connectivity on your own.

If you run the installer with the **wait-for** command from a system that cannot reach the cluster API due to a lack of floating IP addresses or name resolution, installation fails. To prevent installation failure in these cases, you can use a proxy network or run the installer from a system that is on the same network as your machines.



## NOTE

You can enable name resolution by creating DNS records for the API and Ingress ports. For example:

```
api.<cluster_name>.<base_domain>. IN A <api_port_IP>
*.apps.<cluster_name>.<base_domain>. IN A <ingress_port_IP>
```

If you do not control the DNS server, you can add the record to your **/etc/hosts** file. This action makes the API accessible to only you, which is not suitable for production deployment but does allow installation for development and testing.

### 15.6.12. Defining parameters for the installation program

The OpenShift Container Platform installation program relies on a file that is called **clouds.yaml**. The file describes Red Hat OpenStack Platform (RHOSP) configuration parameters, including the project name, log in information, and authorization service URLs.

## Procedure

1. Create the **clouds.yaml** file:
  - If your RHOSP distribution includes the Horizon web UI, generate a **clouds.yaml** file in it.





## IMPORTANT

Remember to add a password to the **auth** field. You can also keep secrets in a [separate file](#) from **clouds.yaml**.

- If your RHOSP distribution does not include the Horizon web UI, or you do not want to use Horizon, create the file yourself. For detailed information about **clouds.yaml**, see [Config files](#) in the RHOSP documentation.

```
clouds:
  shiftstack:
    auth:
      auth_url: http://10.10.14.42:5000/v3
      project_name: shiftstack
      username: shiftstack_user
      password: XXX
      user_domain_name: Default
      project_domain_name: Default
  dev-env:
    region_name: RegionOne
    auth:
      username: 'devuser'
      password: XXX
      project_name: 'devonly'
      auth_url: 'https://10.10.14.22:5001/v2.0'
```

2. If your RHOSP installation uses self-signed certificate authority (CA) certificates for endpoint authentication:
  - a. Copy the certificate authority file to your machine.
  - b. Add the **cacerts** key to the **clouds.yaml** file. The value must be an absolute, non-root-accessible path to the CA certificate:

```
clouds:
  shiftstack:
    ...
    cacert: "/etc/pki/ca-trust/source/anchors/ca.crt.pem"
```

## TIP

After you run the installer with a custom CA certificate, you can update the certificate by editing the value of the **ca-cert.pem** key in the **cloud-provider-config** keymap. On a command line, run:

```
$ oc edit configmap -n openshift-config cloud-provider-config
```

3. Place the **clouds.yaml** file in one of the following locations:
  - a. The value of the **OS\_CLIENT\_CONFIG\_FILE** environment variable
  - b. The current directory
  - c. A Unix-specific user configuration directory, for example **~/.config/openstack/clouds.yaml**

- d. A Unix-specific site configuration directory, for example `/etc/openstack/clouds.yaml`  
The installation program searches for **clouds.yaml** in that order.

### 15.6.13. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Red Hat OpenStack Platform (RHOSP).

#### Prerequisites

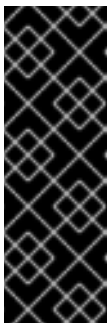
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

#### Procedure

1. Create the **install-config.yaml** file.
  - a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

- 1 For **<installation\_directory>**, specify the directory name to store the files that the installation program creates.



#### IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

- b. At the prompts, provide the configuration details for your cloud:
  - i. Optional: Select an SSH key to use to access your cluster machines.

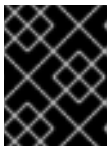


#### NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

- ii. Select **openstack** as the platform to target.
- iii. Specify the Red Hat OpenStack Platform (RHOSP) external network name to use for installing the cluster.
- iv. Specify the floating IP address to use for external access to the OpenShift API.

- v. Specify a RHOSP flavor with at least 16 GB RAM to use for control plane nodes and 8 GB RAM for compute nodes.
  - vi. Select the base domain to deploy the cluster to. All DNS records will be sub-domains of this base and will also include the cluster name.
  - vii. Enter a name for your cluster. The name must be 14 or fewer characters long.
  - viii. Paste the [pull secret from the Red Hat OpenShift Cluster Manager](#) .
2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.
  3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



### IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

You now have the file **install-config.yaml** in the directory that you specified.

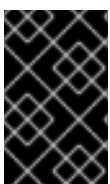
## 15.6.14. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.



### NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.



### IMPORTANT

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

### 15.6.14.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 15.24. Required parameters

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String

Parameter	Description	Values
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;.&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}</b> . <b>{{.baseDomain}}</b> .	String of lowercase letters, hyphens (-), and periods (.), such as <b>dev</b> . The string must be 14 characters or fewer long.
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws, baremetal, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } }</pre>


### 15.6.14.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

Table 15.25. Network parameters

Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	Object   <b>NOTE</b> You cannot modify parameters specified by the <b>networking</b> object after installation.
<b>networking.networkType</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .
<b>networking.clusterNetwork</b>	The IP address blocks for pods.  The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b> .  If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example:  <pre>networking:   clusterNetwork:   - cidr: 10.128.0.0/14     hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	Required if you use <b>networking.clusterNetwork</b> . An IP address block.  An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b> .
<b>networking.clusterNetwork.hostPrefix</b>	The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b> . A <b>hostPrefix</b> value of <b>23</b> provides 510 ( $2^{(32 - 23)} - 2$ ) pod IP addresses.	A subnet prefix.  The default value is <b>23</b> .


Parameter	Description	Values
<b>networking.serviceNetwork</b>	<p>The IP address block for services. The default value is <b>172.30.0.0/16</b>.</p> <p>The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.</p>	<p>An array with an IP address block in CIDR format. For example:</p> <pre>networking:   serviceNetwork:   - 172.30.0.0/16</pre>
<b>networking.machineNetwork</b>	<p>The IP address blocks for machines.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   machineNetwork:   - cidr: 10.0.0.0/16</pre>
<b>networking.machineNetwork.cidr</b>	<p>Required if you use <b>networking.machineNetwork</b>. An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b>.</p>	<p>An IP network block in CIDR notation.</p> <p>For example, <b>10.0.0.0/16</b>.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p> </div> </div>

### 15.6.14.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:



Table 15.26. Optional parameters

Parameter	Description	Values
<b>additionalTrustBundle</b>	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
<b>compute</b>	The configuration for the machines that comprise the compute nodes.	Array of <b>MachinePool</b> objects.


Parameter	Description	Values
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String
<b>compute.hyperthreading</b>	Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b> , on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.   <b>IMPORTANT</b>  If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b>
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String

Parameter	Description	Values
<b>controlPlane.hypert hreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hypert hreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platfor m</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>controlPlane.replica s</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.



Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.</p> <div data-bbox="485 510 595 864" style="border: 1px solid black; padding: 5px; margin-bottom: 10px;">  </div> <p><b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators reference content</i>.</p> <div data-bbox="485 909 595 1263" style="border: 1px solid black; padding: 5px;">  </div> <p><b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p>	<b>Mint, Passthrough, Manual</b> or an empty string ("").

Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start;"> <div style="width: 60px; height: 100px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 60px; height: 100px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<b>Internal</b> or <b>External</b> . The default value is <b>External</b> .  Setting this field to <b>Internal</b> is not supported on non-cloud platforms.

Parameter	Description	Values
<b>sshKey</b>	<p>The SSH key or keys to authenticate access your cluster machines.</p>  <p><b>NOTE</b></p> <p>For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.</p>	<p>One or more keys. For example:</p> <pre>sshKey:   &lt;key1&gt;   &lt;key2&gt;   &lt;key3&gt;</pre>

#### 15.6.14.4. Additional Red Hat OpenStack Platform (RHOSP) configuration parameters

Additional RHOSP configuration parameters are described in the following table:

Table 15.27. Additional RHOSP parameters

Parameter	Description	Values
<b>compute.platform.openstack.rootVolume.size</b>	For compute machines, the size in gigabytes of the root volume. If you do not set this value, machines use ephemeral storage.	Integer, for example <b>30</b> .
<b>compute.platform.openstack.rootVolume.type</b>	For compute machines, the root volume's type.	String, for example <b>performance</b> .
<b>controlPlane.platform.openstack.rootVolume.size</b>	For control plane machines, the size in gigabytes of the root volume. If you do not set this value, machines use ephemeral storage.	Integer, for example <b>30</b> .
<b>controlPlane.platform.openstack.rootVolume.type</b>	For control plane machines, the root volume's type.	String, for example <b>performance</b> .

Parameter	Description	Values
<b>platform.openstack.cloud</b>	The name of the RHOSP cloud to use from the list of clouds in the <b>clouds.yaml</b> file.	String, for example <b>MyCloud</b> .
<b>platform.openstack.externalNetwork</b>	The RHOSP external network name to be used for installation.	String, for example <b>external</b> .
<b>platform.openstack.computeFlavor</b>	<p>The RHOSP flavor to use for control plane and compute machines.</p> <p>This property is deprecated. To use a flavor as the default for all machine pools, add it as the value of the <b>type</b> key in the <b>platform.openstack.defaultMachinePlatform</b> property. You can also set a flavor value for each machine pool individually.</p>	String, for example <b>m1.xlarge</b> .

#### 15.6.14.5. Optional RHOSP configuration parameters

Optional RHOSP configuration parameters are described in the following table:

Table 15.28. Optional RHOSP parameters

Parameter	Description	Values
<b>compute.platform.openstack.additionalNetworks</b>	Additional networks that are associated with compute machines. Allowed address pairs are not created for additional networks.	A list of one or more UUIDs as strings. For example, <b>fa806b2f-ac49-4bce-b9db-124bc64209bf</b> .
<b>compute.platform.openstack.additionalSecurityGroupIDs</b>	Additional security groups that are associated with compute machines.	A list of one or more UUIDs as strings. For example, <b>7ee219f3-d2e9-48a1-96c2-e7429f1b0da7</b> .

Parameter	Description	Values
<b>compute.platform.openstack.zones</b>	<p>RHOSP Compute (Nova) availability zones (AZs) to install machines on. If this parameter is not set, the installer relies on the default settings for Nova that the RHOSP administrator configured.</p> <p>On clusters that use Kuryr, RHOSP Octavia does not support availability zones. Load balancers and, if you are using the Amphora provider driver, OpenShift Container Platform services that rely on Amphora VMs, are not created according to the value of this property.</p>	A list of strings. For example, <b>["zone-1", "zone-2"]</b> .
<b>compute.platform.openstack.rootVolume.zones</b>	For compute machines, the availability zone to install root volumes on. If you do not set a value for this parameter, the installer selects the default availability zone.	A list of strings, for example <b>["zone-1", "zone-2"]</b> .
<b>controlPlane.platform.openstack.additionalNetworkIDs</b>	Additional networks that are associated with control plane machines. Allowed address pairs are not created for additional networks.	A list of one or more UUIDs as strings. For example, <b>fa806b2f-ac49-4bce-b9db-124bc64209bf</b> .
<b>controlPlane.platform.openstack.additionalSecurityGroupIDs</b>	Additional security groups that are associated with control plane machines.	A list of one or more UUIDs as strings. For example, <b>7ee219f3-d2e9-48a1-96c2-e7429f1b0da7</b> .

Parameter	Description	Values
<b>controlPlane.platform.openstack.zones</b>	<p>RHOSP Compute (Nova) availability zones (AZs) to install machines on. If this parameter is not set, the installer relies on the default settings for Nova that the RHOSP administrator configured.</p> <p>On clusters that use Kuryr, RHOSP Octavia does not support availability zones. Load balancers and, if you are using the Amphora provider driver, OpenShift Container Platform services that rely on Amphora VMs, are not created according to the value of this property.</p>	A list of strings. For example, <b>["zone-1", "zone-2"]</b> .
<b>controlPlane.platform.openstack.rootVolume.zones</b>	For control plane machines, the availability zone to install root volumes on. If you do not set this value, the installer selects the default availability zone.	A list of strings, for example <b>["zone-1", "zone-2"]</b> .
<b>platform.openstack.clusterOSImage</b>	<p>The location from which the installer downloads the RHCOS image.</p> <p>You must set this parameter to perform an installation in a restricted network.</p>	<p>An HTTP or HTTPS URL, optionally with an SHA-256 checksum.</p> <p>For example,  <b>http://mirror.example.com/images/rhcos-43.81.201912131630.0-openstack.x86_64.qcow2.gz?sha256=ffebbd68e8a1f2a245ca19522c16c86f67f9ac8e4e0c1f0a812b068b16f7265d</b>. The value can also be the name of an existing Glance image, for example <b>my-rhcos</b>.</p>

Parameter	Description	Values
<b>platform.openstack.clusterOSImageProperties</b>	<p>Properties to add to the installer-uploaded ClusterOSImage in Glance. This property is ignored if <b>platform.openstack.clusterOSImage</b> is set to an existing Glance image.</p> <p>You can use this property to exceed the default persistent volume (PV) limit for RHOSP of 26 PVs per node. To exceed the limit, set the <b>hw_scsi_model</b> property value to <b>virtio-scsi</b> and the <b>hw_disk_bus</b> value to <b>scsi</b>.</p> <p>You can also use this property to enable the QEMU guest agent by including the <b>hw_qemu_guest_agent</b> property with a value of <b>yes</b>.</p>	A list of key-value string pairs. For example, <b>["hw_scsi_model": "virtio-scsi", "hw_disk_bus": "scsi"]</b> .
<b>platform.openstack.defaultMachinePlatform</b>	The default machine pool platform configuration.	<pre>{   "type": "ml.large",   "rootVolume": {     "size": 30,     "type": "performance"   } }</pre>
<b>platform.openstack.ingressFloatingIP</b>	An existing floating IP address to associate with the Ingress port. To use this property, you must also define the <b>platform.openstack.externalNetwork</b> property.	An IP address, for example <b>128.0.0.1</b> .
<b>platform.openstack.apiFloatingIP</b>	An existing floating IP address to associate with the API load balancer. To use this property, you must also define the <b>platform.openstack.externalNetwork</b> property.	An IP address, for example <b>128.0.0.1</b> .
<b>platform.openstack.externalDNS</b>	IP addresses for external DNS servers that cluster instances use for DNS resolution.	A list of IP addresses as strings. For example, <b>["8.8.8.8", "192.168.1.12"]</b> .

Parameter	Description	Values
<b>platform.openstack.machinesSubnet</b>	<p>The UUID of a RHOSP subnet that the cluster's nodes use. Nodes and virtual IP (VIP) ports are created on this subnet.</p> <p>The first item in <b>networking.machineNetwork</b> must match the value of <b>machinesSubnet</b>.</p> <p>If you deploy to a custom subnet, you cannot specify an external DNS server to the OpenShift Container Platform installer. Instead, <a href="#">add DNS to the subnet in RHOSP</a>.</p>	A UUID as a string. For example, <b>fa806b2f-ac49-4bce-b9db-124bc64209bf</b> .

#### 15.6.14.6. Custom subnets in RHOSP deployments

Optionally, you can deploy a cluster on a Red Hat OpenStack Platform (RHOSP) subnet of your choice. The subnet's GUID is passed as the value of **platform.openstack.machinesSubnet** in the **install-config.yaml** file.

This subnet is used as the cluster's primary subnet. By default, nodes and ports are created on it. You can create nodes and ports on a different RHOSP subnet by setting the value of the **platform.openstack.machinesSubnet** property to the subnet's UUID.

Before you run the OpenShift Container Platform installer with a custom subnet, verify that your configuration meets the following requirements:

- The subnet that is used by **platform.openstack.machinesSubnet** has DHCP enabled.
- The CIDR of **platform.openstack.machinesSubnet** matches the CIDR of **networking.machineNetwork**.
- The installation program user has permission to create ports on this network, including ports with fixed IP addresses.

Clusters that use custom subnets have the following limitations:

- If you plan to install a cluster that uses floating IP addresses, the **platform.openstack.machinesSubnet** subnet must be attached to a router that is connected to the **externalNetwork** network.
- If the **platform.openstack.machinesSubnet** value is set in the **install-config.yaml** file, the installation program does not create a private network or subnet for your RHOSP machines.
- You cannot use the **platform.openstack.externalDNS** property at the same time as a custom subnet. To add DNS to a cluster that uses a custom subnet, configure DNS on the RHOSP network.



**NOTE**

By default, the API VIP takes x.x.x.5 and the Ingress VIP takes x.x.x.7 from your network's CIDR block. To override these default values, set values for **platform.openstack.apiVIP** and **platform.openstack.ingressVIP** that are outside of the DHCP allocation pool.

### 15.6.14.7. Sample customized install-config.yaml file for RHOSP with Kuryr

To deploy with Kuryr SDN instead of the default OpenShift SDN, you must modify the **install-config.yaml** file to include **Kuryr** as the desired **networking.networkType** and proceed with the default OpenShift Container Platform SDN installation steps. This sample **install-config.yaml** demonstrates all of the possible Red Hat OpenStack Platform (RHOSP) customization options.

**IMPORTANT**

This sample file is provided for reference only. You must obtain your **install-config.yaml** file by using the installation program.

```

apiVersion: v1
baseDomain: example.com
controlPlane:
  name: master
  platform: {}
  replicas: 3
compute:
- name: worker
  platform:
    openstack:
      type: ml.large
  replicas: 3
metadata:
  name: example
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  serviceNetwork:
  - 172.30.0.0/16 1
  networkType: Kuryr
platform:
  openstack:
    cloud: mycloud
    externalNetwork: external
    computeFlavor: m1.xlarge
    apiFloatingIP: 128.0.0.1
    trunkSupport: true 2
    octaviaSupport: true 3
pullSecret: '{"auths": ...}'
sshKey: ssh-ed25519 AAAA...

```

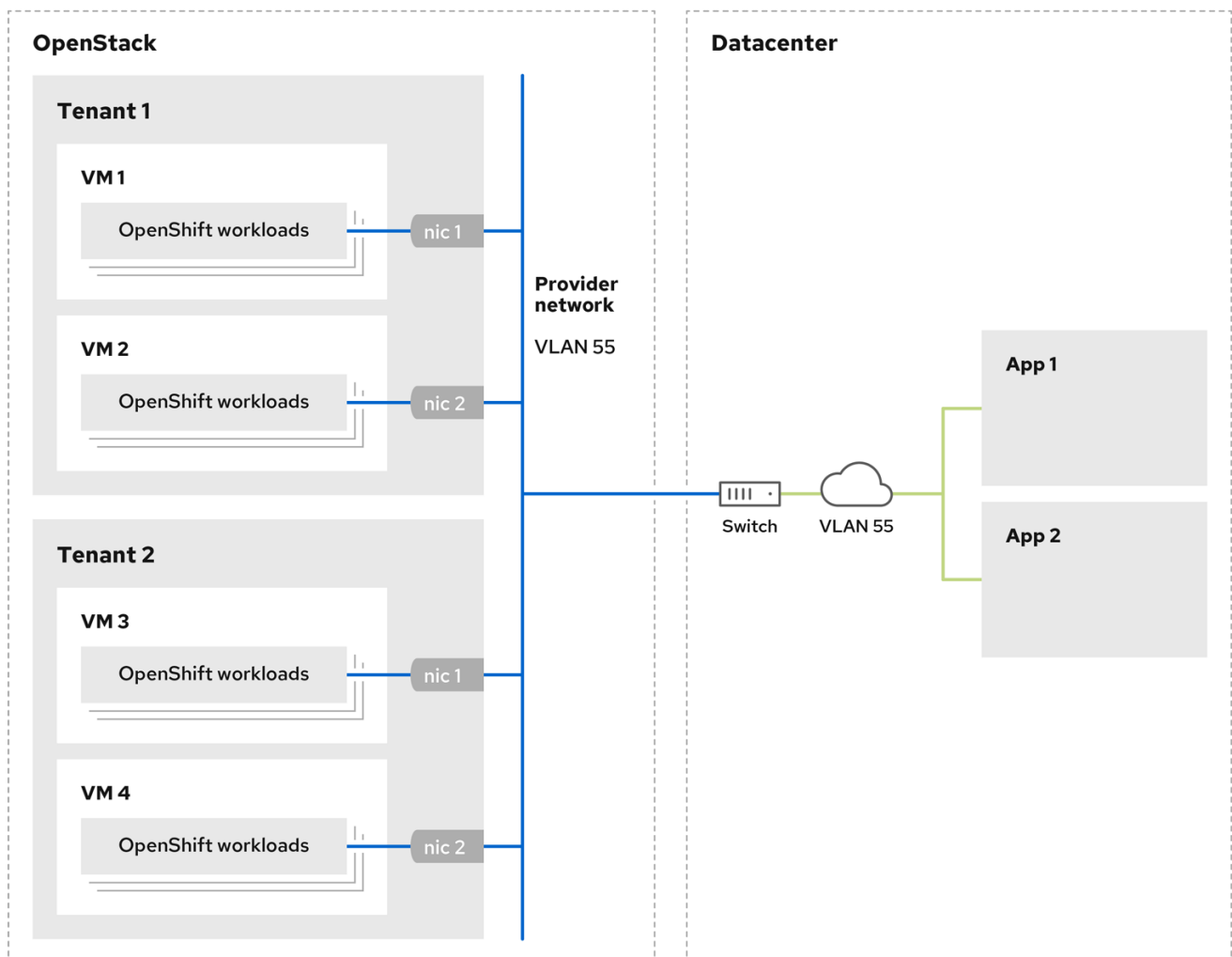
- 1 The Amphora Octavia driver creates two ports per load balancer. As a result, the service subnet that the installer creates is twice the size of the CIDR that is specified as the value of the **serviceNetwork** property. The larger range is required to prevent IP address conflicts.
- 2 3 Both **trunkSupport** and **octaviaSupport** are automatically discovered by the installer, so there is no need to set them. But if your environment does not meet both requirements, Kuryr SDN will not properly work. Trunks are needed to connect the pods to the RHOSP network and Octavia is required to create the OpenShift Container Platform services.

#### 15.6.14.8. Cluster deployment on RHOSP provider networks

You can deploy your OpenShift Container Platform clusters on Red Hat OpenStack Platform (RHOSP) with a primary network interface on a provider network. Provider networks are commonly used to give projects direct access to a public network that can be used to reach the internet. You can also share provider networks among projects as part of the network creation process.

RHOSP provider networks map directly to an existing physical network in the data center. A RHOSP administrator must create them.

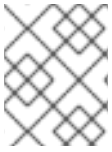
In the following example, OpenShift Container Platform workloads are connected to a data center by using a provider network:



170\_OpenShift\_0621

OpenShift Container Platform clusters that are installed on provider networks do not require tenant networks or floating IP addresses. The installer does not create these resources during installation.

Example provider network types include flat (untagged) and VLAN (802.1Q tagged).



#### NOTE

A cluster can support as many provider network connections as the network type allows. For example, VLAN networks typically support up to 4096 connections.

You can learn more about provider and tenant networks in [the RHOSP documentation](#).

#### 15.6.14.8.1. RHOSP provider network requirements for cluster installation

Before you install an OpenShift Container Platform cluster, your Red Hat OpenStack Platform (RHOSP) deployment and provider network must meet a number of conditions:

- The [RHOSP networking service \(Neutron\) is enabled](#) and accessible through the RHOSP networking API.
- The RHOSP networking service has the [port security and allowed address pairs extensions enabled](#).
- The provider network can be shared with other tenants.

#### TIP

Use the **openstack network create** command with the **--share** flag to create a network that can be shared.

- The RHOSP project that you use to install the cluster must own the provider network, as well as an appropriate subnet.

#### TIP

To create a network for a project that is named "openshift," enter the following command

```
$ openstack network create --project openshift
```

To create a subnet for a project that is named "openshift," enter the following command

```
$ openstack subnet create --project openshift
```

To learn more about creating networks on RHOSP, read [the provider networks documentation](#).

If the cluster is owned by the **admin** user, you must run the installer as that user to create ports on the network.

**IMPORTANT**

Provider networks must be owned by the RHOSP project that is used to create the cluster. If they are not, the RHOSP Compute service (Nova) cannot request a port from that network.

- Verify that the provider network can reach the RHOSP metadata service IP address, which is **169.254.169.254** by default.  
Depending on your RHOSP SDN and networking service configuration, you might need to provide the route when you create the subnet. For example:

```
$ openstack subnet create --dhcp --host-route
destination=169.254.169.254/32,gateway=192.0.2.2 ...
```

- Optional: To secure the network, create [role-based access control \(RBAC\)](#) rules that limit network access to a single project.

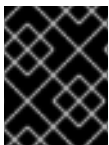
**15.6.14.8.2. Deploying a cluster that has a primary interface on a provider network**

You can deploy an OpenShift Container Platform cluster that has its primary network interface on an Red Hat OpenStack Platform (RHOSP) provider network. .Prerequisites

- Your Red Hat OpenStack Platform (RHOSP) deployment is configured as described by "RHOSP provider network requirements for cluster installation".

**Procedure**

1. In a text editor, open the **install-config.yaml** file.
2. Set the value of the **platform.openstack.apiVIP** property to the IP address for the API VIP.
3. Set the value of the **platform.openstack.ingressVIP** property to the IP address for the Ingress VIP.
4. Set the value of the **platform.openstack.machinesSubnet** property to the UUID of the provider network subnet.
5. Set the value of the **networking.machineNetwork.cidr** property to the CIDR block of the provider network subnet.

**IMPORTANT**

The **platform.openstack.apiVIP** and **platform.openstack.ingressVIP** properties must both be unassigned IP addresses from the **networking.machineNetwork.cidr** block.

**Section of an installation configuration file for a cluster that relies on a RHOSP provider network**

```
...
platform:
  openstack:
    apiVIP: 192.0.2.13
    ingressVIP: 192.0.2.23
    machinesSubnet: fa806b2f-ac49-4bce-b9db-124bc64209bf
```

```
# ...
networking:
  machineNetwork:
    - cidr: 192.0.2.0/24
```



### WARNING

You cannot set the **platform.openstack.externalNetwork** or **platform.openstack.externalDNS** parameters while using a provider network for the primary network interface.

When you deploy the cluster, the installer uses the **install-config.yaml** file to deploy the cluster on the provider network.

### TIP

You can add additional networks, including provider networks, to the **platform.openstack.additionalNetworkIDs** list.

After you deploy your cluster, you can attach pods to additional networks. For more information, see [Understanding multiple networks](#).

#### 15.6.14.9. Kuryr ports pools

A Kuryr ports pool maintains a number of ports on standby for pod creation.

Keeping ports on standby minimizes pod creation time. Without ports pools, Kuryr must explicitly request port creation or deletion whenever a pod is created or deleted.

The Neutron ports that Kuryr uses are created in subnets that are tied to namespaces. These pod ports are also added as subports to the primary port of OpenShift Container Platform cluster nodes.

Because Kuryr keeps each namespace in a separate subnet, a separate ports pool is maintained for each namespace-worker pair.

Prior to installing a cluster, you can set the following parameters in the **cluster-network-03-config.yml** manifest file to configure ports pool behavior:

- The **enablePortPoolsPrepopulation** parameter controls pool prepopulation, which forces Kuryr to add ports to the pool when it is created, such as when a new host is added, or a new namespace is created. The default value is **false**.
- The **poolMinPorts** parameter is the minimum number of free ports that are kept in the pool. The default value is **1**.
- The **poolMaxPorts** parameter is the maximum number of free ports that are kept in the pool. A value of **0** disables that upper bound. This is the default setting. If your OpenStack port quota is low, or you have a limited number of IP addresses on the pod network, consider setting this option to ensure that unneeded ports are deleted.

- The **poolBatchPorts** parameter defines the maximum number of Neutron ports that can be created at once. The default value is **3**.

#### 15.6.14.10. Adjusting Kuryr ports pools during installation

During installation, you can configure how Kuryr manages Red Hat OpenStack Platform (RHOSP) Neutron ports to control the speed and efficiency of pod creation.

##### Prerequisites

- Create and modify the **install-config.yaml** file.

##### Procedure

1. From a command line, create the manifest files:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

- 1** For **<installation\_directory>**, specify the name of the directory that contains the **install-config.yaml** file for your cluster.

2. Create a file that is named **cluster-network-03-config.yml** in the **<installation\_directory>/manifests/** directory:

```
$ touch <installation_directory>/manifests/cluster-network-03-config.yml 1
```

- 1** For **<installation\_directory>**, specify the directory name that contains the **manifests/** directory for your cluster.

After creating the file, several network configuration files are in the **manifests/** directory, as shown:

```
$ ls <installation_directory>/manifests/cluster-network-*
```

##### Example output

```
cluster-network-01-crd.yml  
cluster-network-02-config.yml  
cluster-network-03-config.yml
```

3. Open the **cluster-network-03-config.yml** file in an editor, and enter a custom resource (CR) that describes the Cluster Network Operator configuration that you want:

```
$ oc edit networks.operator.openshift.io cluster
```

4. Edit the settings to meet your requirements. The following file is provided as an example:

```
apiVersion: operator.openshift.io/v1  
kind: Network  
metadata:  
  name: cluster
```

```

spec:
  clusterNetwork:
    - cidr: 10.128.0.0/14
      hostPrefix: 23
  serviceNetwork:
    - 172.30.0.0/16
  defaultNetwork:
    type: Kuryr
    kuryrConfig:
      enablePortPoolsPrepopulation: false ❶
      poolMinPorts: 1 ❷
      poolBatchPorts: 3 ❸
      poolMaxPorts: 5 ❹
      openstackServiceNetwork: 172.30.0.0/15 ❺

```

- ❶ Set the value of **enablePortPoolsPrepopulation** to **true** to make Kuryr create new Neutron ports after a namespace is created or a new node is added to the cluster. This setting raises the Neutron ports quota but can reduce the time that is required to spawn pods. The default value is **false**.
- ❷ Kuryr creates new ports for a pool if the number of free ports in that pool is lower than the value of **poolMinPorts**. The default value is **1**.
- ❸ **poolBatchPorts** controls the number of new ports that are created if the number of free ports is lower than the value of **poolMinPorts**. The default value is **3**.
- ❹ If the number of free ports in a pool is higher than the value of **poolMaxPorts**, Kuryr deletes them until the number matches that value. Setting this value to **0** disables this upper bound, preventing pools from shrinking. The default value is **0**.
- ❺ The **openStackServiceNetwork** parameter defines the CIDR range of the network from which IP addresses are allocated to RHOSP Octavia's LoadBalancers.

If this parameter is used with the Amphora driver, Octavia takes two IP addresses from this network for each load balancer: one for OpenShift and the other for VRRP connections. Because these IP addresses are managed by OpenShift Container Platform and Neutron respectively, they must come from different pools. Therefore, the value of **openStackServiceNetwork** must be at least twice the size of the value of **serviceNetwork**, and the value of **serviceNetwork** must overlap entirely with the range that is defined by **openStackServiceNetwork**.

The CNO verifies that VRRP IP addresses that are taken from the range that is defined by this parameter do not overlap with the range that is defined by the **serviceNetwork** parameter.

If this parameter is not set, the CNO uses an expanded value of **serviceNetwork** that is determined by decrementing the prefix size by 1.

5. Save the **cluster-network-03-config.yml** file, and exit the text editor.
6. Optional: Back up the **manifests/cluster-network-03-config.yml** file. The installation program deletes the **manifests/** directory while creating the cluster.

#### 15.6.14.11. Setting a custom subnet for machines

The IP range that the installation program uses by default might not match the Neutron subnet that you create when you install OpenShift Container Platform. If necessary, update the CIDR value for new machines by editing the installation configuration file.

## Prerequisites

- You have the **install-config.yaml** file that was generated by the OpenShift Container Platform installation program.

## Procedure

1. On a command line, browse to the directory that contains **install-config.yaml**.
2. From that directory, either run a script to edit the **install-config.yaml** file or update the file manually:
  - To set the value by using a script, run:

```
$ python -c '  
import yaml;  
path = "install-config.yaml";  
data = yaml.safe_load(open(path));  
data["networking"]["machineNetwork"] = [{"cidr": "192.168.0.0/18"}]; 1  
open(path, "w").write(yaml.dump(data, default_flow_style=False))'
```

- 1** Insert a value that matches your intended Neutron subnet, e.g. **192.0.2.0/24**.

- To set the value manually, open the file and set the value of **networking.machineCIDR** to something that matches your intended Neutron subnet.

### 15.6.14.12. Emptying compute machine pools

To proceed with an installation that uses your own infrastructure, set the number of compute machines in the installation configuration file to zero. Later, you create these machines manually.

## Prerequisites

- You have the **install-config.yaml** file that was generated by the OpenShift Container Platform installation program.

## Procedure

1. On a command line, browse to the directory that contains **install-config.yaml**.
2. From that directory, either run a script to edit the **install-config.yaml** file or update the file manually:
  - To set the value by using a script, run:

```
$ python -c '  
import yaml;  
path = "install-config.yaml";
```



```
data = yaml.safe_load(open(path));
data["compute"][0]["replicas"] = 0;
open(path, "w").write(yaml.dump(data, default_flow_style=False))'
```

- To set the value manually, open the file and set the value of **compute.<first entry>.replicas** to **0**.

### 15.6.14.13. Modifying the network type

By default, the installation program selects the **OpenShiftSDN** network type. To use Kuryr instead, change the value in the installation configuration file that the program generated.

#### Prerequisites

- You have the file **install-config.yaml** that was generated by the OpenShift Container Platform installation program

#### Procedure

1. In a command prompt, browse to the directory that contains **install-config.yaml**.
2. From that directory, either run a script to edit the **install-config.yaml** file or update the file manually:
  - To set the value by using a script, run:

```
$ python -c '
import yaml;
path = "install-config.yaml";
data = yaml.safe_load(open(path));
data["networking"]["networkType"] = "Kuryr";
open(path, "w").write(yaml.dump(data, default_flow_style=False))'
```

- To set the value manually, open the file and set **networking.networkType** to **"Kuryr"**.

### 15.6.15. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.



## IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

## Prerequisites

- You obtained the OpenShift Container Platform installation program.
- You created the **install-config.yaml** installation configuration file.

## Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

- 1 For **<installation\_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

2. Remove the Kubernetes manifest files that define the control plane machines and compute machine sets:

```
$ rm -f openshift/99_openshift-cluster-api_master-machines-*.yaml openshift/99_openshift-cluster-api_worker-machineset-*.yaml
```

Because you create and manage these resources yourself, you do not have to initialize them.

- You can preserve the machine set files to create compute machines by using the machine API, but you must update references to them to match your environment.
3. Check that the **mastersSchedulable** parameter in the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:
    - a. Open the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** file.
    - b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.
    - c. Save and exit the file.

- To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

- For **<installation\_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation\_directory>/auth** directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

- Export the metadata file's **infraID** key as an environment variable:

```
$ export INFRA_ID=$(jq -r .infraID metadata.json)
```

## TIP

Extract the **infraID** key from **metadata.json** and use it as a prefix for all of the RHOSP resources that you create. By doing so, you avoid name conflicts when making multiple deployments in the same project.

### 15.6.16. Preparing the bootstrap Ignition files

The OpenShift Container Platform installation process relies on bootstrap machines that are created from a bootstrap Ignition configuration file.

Edit the file and upload it. Then, create a secondary bootstrap Ignition configuration file that Red Hat OpenStack Platform (RHOSP) uses to download the primary file.

#### Prerequisites

- You have the bootstrap Ignition file that the installer program generates, **bootstrap.ign**.
- The infrastructure ID from the installer's metadata file is set as an environment variable (**\$INFRA\_ID**).
  - If the variable is not set, see **Creating the Kubernetes manifest and Ignition config files**
- You have an HTTP(S)-accessible way to store the bootstrap Ignition file.
  - The documented procedure uses the RHOSP image service (Glance), but you can also use the RHOSP storage service (Swift), Amazon S3, an internal HTTP server, or an ad hoc Nova server.

## Procedure

1. Run the following Python script. The script modifies the bootstrap Ignition file to set the hostname and, if available, CA certificate file when it runs:

```
import base64
import json
import os

with open('bootstrap.ign', 'r') as f:
    ignition = json.load(f)

files = ignition['storage'].get('files', [])

infra_id = os.environ.get('INFRA_ID', 'openshift').encode()
hostname_b64 = base64.standard_b64encode(infra_id + b'-bootstrap\n').decode().strip()
files.append(
{
    'path': '/etc/hostname',
    'mode': 420,
    'contents': {
        'source': 'data:text/plain;charset=utf-8;base64,' + hostname_b64
    }
})

ca_cert_path = os.environ.get('OS_CACERT', "")
if ca_cert_path:
    with open(ca_cert_path, 'r') as f:
        ca_cert = f.read().encode()
        ca_cert_b64 = base64.standard_b64encode(ca_cert).decode().strip()

    files.append(
    {
        'path': '/opt/openshift/tls/cloud-ca-cert.pem',
        'mode': 420,
        'contents': {
            'source': 'data:text/plain;charset=utf-8;base64,' + ca_cert_b64
        }
    })

ignition['storage']['files'] = files;

with open('bootstrap.ign', 'w') as f:
    json.dump(ignition, f)
```

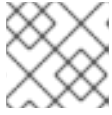
2. Using the RHOSP CLI, create an image that uses the bootstrap Ignition file:

```
$ openstack image create --disk-format=raw --container-format=bare --file bootstrap.ign
<image_name>
```

3. Get the image's details:

```
$ openstack image show <image_name>
```

Make a note of the **file** value; it follows the pattern **v2/images/<image\_ID>/file**.

**NOTE**

Verify that the image you created is active.

- Retrieve the image service's public address:

```
$ openstack catalog show image
```

- Combine the public address with the image **file** value and save the result as the storage location. The location follows the pattern **<image\_service\_public\_URL>/v2/images/<image\_ID>/file**.

- Generate an auth token and save the token ID:

```
$ openstack token issue -c id -f value
```

- Insert the following content into a file called **\$INFRA\_ID-bootstrap-ignition.json** and edit the placeholders to match your own values:

```
{
  "ignition": {
    "config": {
      "merge": [{
        "source": "<storage_url>", 1
        "httpHeaders": [{
          "name": "X-Auth-Token", 2
          "value": "<token_ID>" 3
        }]
      }]
    },
    "security": {
      "tls": {
        "certificateAuthorities": [{
          "source": "data:text/plain;charset=utf-8;base64,<base64_encoded_certificate>" 4
        }]
      }
    },
    "version": "3.2.0"
  }
}
```

- Replace the value of **ignition.config.merge.source** with the bootstrap Ignition file storage URL.
- Set **name** in **httpHeaders** to **"X-Auth-Token"**.
- Set **value** in **httpHeaders** to your token's ID.
- If the bootstrap Ignition file server uses a self-signed certificate, include the base64-encoded certificate.

- Save the secondary Ignition config file.

The bootstrap Ignition data will be passed to RHOSP during installation.

**WARNING**

The bootstrap Ignition file contains sensitive information, like **clouds.yaml** credentials. Ensure that you store it in a secure place, and delete it after you complete the installation process.

**15.6.17. Creating control plane Ignition config files on RHOSP**

Installing OpenShift Container Platform on Red Hat OpenStack Platform (RHOSP) on your own infrastructure requires control plane Ignition config files. You must create multiple config files.

**NOTE**

As with the bootstrap Ignition configuration, you must explicitly define a hostname for each control plane machine.

**Prerequisites**

- The infrastructure ID from the installation program's metadata file is set as an environment variable (**\$INFRA\_ID**).
  - If the variable is not set, see "Creating the Kubernetes manifest and Ignition config files".

**Procedure**

- On a command line, run the following Python script:

```
$ for index in $(seq 0 2); do
  MASTER_HOSTNAME="$INFRA_ID-master-$index\n"
  python -c "import base64, json, sys;
  ignition = json.load(sys.stdin);
  storage = ignition.get('storage', {});
  files = storage.get('files', []);
  files.append({'path': '/etc/hostname', 'mode': 420, 'contents': {'source':
  'data:text/plain;charset=utf-8;base64,' +
  base64.standard_b64encode(b'$MASTER_HOSTNAME').decode().strip(), 'verification': {}},
  'filesystem': 'root'});
  storage['files'] = files;
  ignition['storage'] = storage
  json.dump(ignition, sys.stdout) <master.ign >"$INFRA_ID-master-$index-ignition.json"
done
```

You now have three control plane Ignition files: **<INFRA\_ID>-master-0-ignition.json**, **<INFRA\_ID>-master-1-ignition.json**, and **<INFRA\_ID>-master-2-ignition.json**.

**15.6.18. Creating network resources on RHOSP**

Create the network resources that an OpenShift Container Platform on Red Hat OpenStack Platform (RHOSP) installation on your own infrastructure requires. To save time, run supplied Ansible playbooks that generate security groups, networks, subnets, routers, and ports.

## Prerequisites

- Python 3 is installed on your machine.
- You downloaded the modules in "Downloading playbook dependencies".
- You downloaded the playbooks in "Downloading the installation playbooks".

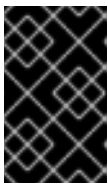
## Procedure

1. Optional: Add an external network value to the **inventory.yaml** playbook:

### Example external network value in the **inventory.yaml** Ansible playbook

```
...
# The public network providing connectivity to the cluster. If not
# provided, the cluster external connectivity must be provided in another
# way.

# Required for os_api_fip, os_ingress_fip, os_bootstrap_fip.
os_external_network: 'external'
...
```



### IMPORTANT

If you did not provide a value for **os\_external\_network** in the **inventory.yaml** file, you must ensure that VMs can access Glance and an external connection yourself.

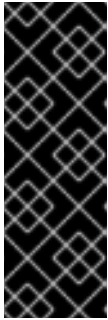
2. Optional: Add external network and floating IP (FIP) address values to the **inventory.yaml** playbook:

### Example FIP values in the **inventory.yaml** Ansible playbook

```
...
# OpenShift API floating IP address. If this value is non-empty, the
# corresponding floating IP will be attached to the Control Plane to
# serve the OpenShift API.
os_api_fip: '203.0.113.23'

# OpenShift Ingress floating IP address. If this value is non-empty, the
# corresponding floating IP will be attached to the worker nodes to serve
# the applications.
os_ingress_fip: '203.0.113.19'

# If this value is non-empty, the corresponding floating IP will be
# attached to the bootstrap machine. This is needed for collecting logs
# in case of install failure.
os_bootstrap_fip: '203.0.113.20'
```



## IMPORTANT

If you do not define values for **os\_api\_fip** and **os\_ingress\_fip**, you must perform post-installation network configuration.

If you do not define a value for **os\_bootstrap\_fip**, the installer cannot download debugging information from failed installations.

See "Enabling access to the environment" for more information.

3. On a command line, create security groups by running the **security-groups.yaml** playbook:

```
$ ansible-playbook -i inventory.yaml security-groups.yaml
```

4. On a command line, create a network, subnet, and router by running the **network.yaml** playbook:

```
$ ansible-playbook -i inventory.yaml network.yaml
```

5. Optional: If you want to control the default resolvers that Nova servers use, run the RHOSP CLI command:

```
$ openstack subnet set --dns-nameserver <server_1> --dns-nameserver <server_2> "$INFRA_ID-nodes"
```

### 15.6.19. Creating the bootstrap machine on RHOSP

Create a bootstrap machine and give it the network access it needs to run on Red Hat OpenStack Platform (RHOSP). Red Hat provides an Ansible playbook that you run to simplify this process.

#### Prerequisites

- You downloaded the modules in "Downloading playbook dependencies".
- You downloaded the playbooks in "Downloading the installation playbooks".
- The **inventory.yaml**, **common.yaml**, and **bootstrap.yaml** Ansible playbooks are in a common directory.
- The **metadata.json** file that the installation program created is in the same directory as the Ansible playbooks.

#### Procedure

1. On a command line, change the working directory to the location of the playbooks.
2. On a command line, run the **bootstrap.yaml** playbook:

```
$ ansible-playbook -i inventory.yaml bootstrap.yaml
```

3. After the bootstrap server is active, view the logs to verify that the Ignition files were received:

```
$ openstack console log show "$INFRA_ID-bootstrap"
```



## 15.6.20. Creating the control plane machines on RHOSP

Create three control plane machines by using the Ignition config files that you generated. Red Hat provides an Ansible playbook that you run to simplify this process.

### Prerequisites

- You downloaded the modules in "Downloading playbook dependencies".
- You downloaded the playbooks in "Downloading the installation playbooks".
- The infrastructure ID from the installation program's metadata file is set as an environment variable (**\$INFRA\_ID**).
- The **inventory.yaml**, **common.yaml**, and **control-plane.yaml** Ansible playbooks are in a common directory.
- You have the three Ignition files that were created in "Creating control plane Ignition config files".

### Procedure

1. On a command line, change the working directory to the location of the playbooks.
2. If the control plane Ignition config files aren't already in your working directory, copy them into it.
3. On a command line, run the **control-plane.yaml** playbook:

```
$ ansible-playbook -i inventory.yaml control-plane.yaml
```

4. Run the following command to monitor the bootstrapping process:

```
$ openshift-install wait-for bootstrap-complete
```

You will see messages that confirm that the control plane machines are running and have joined the cluster:

```
INFO API v1.22.1 up
INFO Waiting up to 30m0s for bootstrapping to complete...
...
INFO It is now safe to remove the bootstrap resources
```

## 15.6.21. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

### Prerequisites

- You deployed an OpenShift Container Platform cluster.

- You installed the **oc** CLI.

### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

### Example output

```
system:admin
```

## 15.6.22. Deleting bootstrap resources from RHOSP

Delete the bootstrap resources that you no longer need.

### Prerequisites

- You downloaded the modules in "Downloading playbook dependencies".
- You downloaded the playbooks in "Downloading the installation playbooks".
- The **inventory.yaml**, **common.yaml**, and **down-bootstrap.yaml** Ansible playbooks are in a common directory.
- The control plane machines are running.
  - If you do not know the status of the machines, see "Verifying cluster status".

### Procedure

1. On a command line, change the working directory to the location of the playbooks.
2. On a command line, run the **down-bootstrap.yaml** playbook:

```
$ ansible-playbook -i inventory.yaml down-bootstrap.yaml
```

The bootstrap port, server, and floating IP address are deleted.

**WARNING**

If you did not disable the bootstrap Ignition file URL earlier, do so now.

### 15.6.23. Creating compute machines on RHOSP

After standing up the control plane, create compute machines. Red Hat provides an Ansible playbook that you run to simplify this process.

#### Prerequisites

- You downloaded the modules in "Downloading playbook dependencies".
- You downloaded the playbooks in "Downloading the installation playbooks".
- The **inventory.yaml**, **common.yaml**, and **compute-nodes.yaml** Ansible playbooks are in a common directory.
- The **metadata.json** file that the installation program created is in the same directory as the Ansible playbooks.
- The control plane is active.

#### Procedure

1. On a command line, change the working directory to the location of the playbooks.
2. On a command line, run the playbook:

```
$ ansible-playbook -i inventory.yaml compute-nodes.yaml
```

#### Next steps

- Approve the certificate signing requests for the machines.

### 15.6.24. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

#### Prerequisites

- You added machines to your cluster.

#### Procedure

1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

## Example output

```

NAME      STATUS  ROLES  AGE  VERSION
master-0  Ready   master 63m  v1.22.1
master-1  Ready   master 63m  v1.22.1
master-2  Ready   master 64m  v1.22.1

```

The output lists all of the machines that you created.



### NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

- Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

## Example output

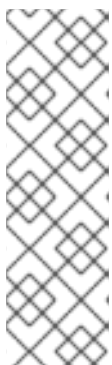
```

NAME      AGE  REQUESTOR                                     CONDITION
csr-8b2br 15m  system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper  Pending
csr-8vnps 15m  system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper  Pending
...

```

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

- If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:



### NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.

**NOTE**

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrap** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{"\n"}{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```

**NOTE**

Some Operators might not become available until some CSRs are approved.

4. Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

**Example output**

```
NAME      AGE   REQUESTOR                                     CONDITION
csr-bfd72 5m26s system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv 5m26s system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

5. If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

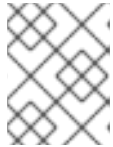
```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{\n"}\n{{end}}' | xargs oc adm certificate approve
```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

### Example output

```
NAME      STATUS  ROLES  AGE  VERSION
master-0  Ready   master 73m  v1.22.1
master-1  Ready   master 73m  v1.22.1
master-2  Ready   master 74m  v1.22.1
worker-0  Ready   worker 11m  v1.22.1
worker-1  Ready   worker 11m  v1.22.1
```



### NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

### Additional information

- For more information on CSRs, see [Certificate Signing Requests](#).

## 15.6.25. Verifying a successful installation

Verify that the OpenShift Container Platform installation is complete.

### Prerequisites

- You have the installation program (**openshift-install**)

### Procedure

- On a command line, enter:

```
$ openshift-install --log-level debug wait-for install-complete
```

The program outputs the console URL, as well as the administrator's login information.

## 15.6.26. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

### 15.6.27. Next steps

- [Customize your cluster.](#)
- If necessary, you can [opt out of remote health reporting](#) .
- If you need to enable external access to node ports, [configure ingress cluster traffic by using a node port.](#)
- If you did not configure RHOSP to accept application traffic over floating IP addresses, [configure RHOSP access with floating IP addresses](#) .

## 15.7. INSTALLING A CLUSTER ON OPENSTACK ON YOUR OWN SR-IOV INFRASTRUCTURE

In OpenShift Container Platform 4.9, you can install a cluster on Red Hat OpenStack Platform (RHOSP) that runs on user-provisioned infrastructure and uses single-root input/output virtualization (SR-IOV) networks to run compute machines.

Using your own infrastructure allows you to integrate your cluster with existing infrastructure and modifications. The process requires more labor on your part than installer-provisioned installations, because you must create all RHOSP resources, such as Nova servers, Neutron ports, and security groups. However, Red Hat provides Ansible playbooks to help you in the deployment process.

### 15.7.1. Prerequisites

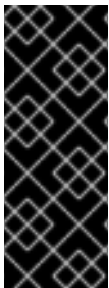
- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users.](#)
- You verified that OpenShift Container Platform 4.9 is compatible with your RHOSP version by using the [Supported platforms for OpenShift clusters](#) section. You can also compare platform support across different versions by viewing the [OpenShift Container Platform on RHOSP support matrix.](#)
- Your network configuration does not rely on a provider network. Provider networks are not supported.
- You have an RHOSP account where you want to install OpenShift Container Platform.
- On the machine where you run the installation program, you have:
  - A single directory in which you can keep the files you create during the installation process
  - Python 3

## 15.7.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



### IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

## 15.7.3. Resource guidelines for installing OpenShift Container Platform on RHOSP

To support an OpenShift Container Platform installation, your Red Hat OpenStack Platform (RHOSP) quota must meet the following requirements:

**Table 15.29. Recommended resources for a default OpenShift Container Platform cluster on RHOSP**

Resource	Value
Floating IP addresses	3
Ports	15
Routers	1
Subnets	1
RAM	88 GB
vCPUs	22
Volume storage	275 GB
Instances	7
Security groups	3



Resource	Value
Security group rules	60

A cluster might function with fewer than recommended resources, but its performance is not guaranteed.



### IMPORTANT

If RHOSP object storage (Swift) is available and operated by a user account with the **swiftoperator** role, it is used as the default backend for the OpenShift Container Platform image registry. In this case, the volume storage requirement is 175 GB. Swift space requirements vary depending on the size of the image registry.



### NOTE

By default, your security group and security group rule quotas might be low. If you encounter problems, run **openstack quota set --secgroups 3 --secgroup-rules 60 <project>** as an administrator to increase them.

An OpenShift Container Platform deployment comprises control plane machines, compute machines, and a bootstrap machine.

#### 15.7.3.1. Control plane machines

By default, the OpenShift Container Platform installation process creates three control plane machines.

Each machine requires:

- An instance from the RHOSP quota
- A port from the RHOSP quota
- A flavor with at least 16 GB memory and 4 vCPUs
- At least 100 GB storage space from the RHOSP quota

#### 15.7.3.2. Compute machines

By default, the OpenShift Container Platform installation process creates three compute machines.

Each machine requires:

- An instance from the RHOSP quota
- A port from the RHOSP quota
- A flavor with at least 8 GB memory and 2 vCPUs
- At least 100 GB storage space from the RHOSP quota

**TIP**

Compute machines host the applications that you run on OpenShift Container Platform; aim to run as many as you can.

Additionally, for clusters that use single-root input/output virtualization (SR-IOV), RHOSP compute nodes require a flavor that supports [huge pages](#).

**IMPORTANT**

SR-IOV deployments often employ performance optimizations, such as dedicated or isolated CPUs. For maximum performance, configure your underlying RHOSP deployment to use these optimizations, and then run OpenShift Container Platform compute machines on the optimized infrastructure.

**Additional resources**

- For more information about configuring performant RHOSP compute nodes, see [Configuring Compute nodes for performance](#).

**15.7.3.3. Bootstrap machine**

During installation, a bootstrap machine is temporarily provisioned to stand up the control plane. After the production control plane is ready, the bootstrap machine is deprovisioned.

The bootstrap machine requires:

- An instance from the RHOSP quota
- A port from the RHOSP quota
- A flavor with at least 16 GB memory and 4 vCPUs
- At least 100 GB storage space from the RHOSP quota

**15.7.4. Downloading playbook dependencies**

The Ansible playbooks that simplify the installation process on user-provisioned infrastructure require several Python modules. On the machine where you will run the installer, add the modules' repositories and then download them.

**NOTE**

These instructions assume that you are using Red Hat Enterprise Linux (RHEL) 8.

**Prerequisites**

- Python 3 is installed on your machine.

**Procedure**

1. On a command line, add the repositories:
  - a. Register with Red Hat Subscription Manager:

-

```
$ sudo subscription-manager register # If not done already
```

- b. Pull the latest subscription data:

```
$ sudo subscription-manager attach --pool=$YOUR_POOLID # If not done already
```

- c. Disable the current repositories:

```
$ sudo subscription-manager repos --disable=* # If not done already
```

- d. Add the required repositories:

```
$ sudo subscription-manager repos \
  --enable=rhel-8-for-x86_64-baseos-rpms \
  --enable=openstack-16-tools-for-rhel-8-x86_64-rpms \
  --enable=ansible-2.9-for-rhel-8-x86_64-rpms \
  --enable=rhel-8-for-x86_64-appstream-rpms
```

2. Install the modules:

```
$ sudo yum install python3-openstackclient ansible python3-openstacksdk python3-netaddr
```

3. Ensure that the **python** command points to **python3**:

```
$ sudo alternatives --set python /usr/bin/python3
```

### 15.7.5. Downloading the installation playbooks

Download Ansible playbooks that you can use to install OpenShift Container Platform on your own Red Hat OpenStack Platform (RHOSP) infrastructure.

#### Prerequisites

- The curl command-line tool is available on your machine.

#### Procedure

- To download the playbooks to your working directory, run the following script from a command line:

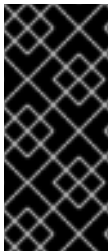
```
$ xargs -n 1 curl -O <<< '
  https://raw.githubusercontent.com/openshift/installer/release-
4.9/upi/openstack/bootstrap.yaml
  https://raw.githubusercontent.com/openshift/installer/release-
4.9/upi/openstack/common.yaml
  https://raw.githubusercontent.com/openshift/installer/release-
4.9/upi/openstack/compute-nodes.yaml
  https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/openstack/control-
plane.yaml
  https://raw.githubusercontent.com/openshift/installer/release-
4.9/upi/openstack/inventory.yaml
  https://raw.githubusercontent.com/openshift/installer/release-
4.9/upi/openstack/network.yaml
```

```

https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/openshift/security-
groups.yaml
https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/openshift/down-
bootstrap.yaml
https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/openshift/down-
compute-nodes.yaml
https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/openshift/down-
control-plane.yaml
https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/openshift/down-
load-balancers.yaml
https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/openshift/down-
network.yaml
https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/openshift/down-
security-groups.yaml
https://raw.githubusercontent.com/openshift/installer/release-4.9/upi/openshift/down-
containers.yaml'

```

The playbooks are downloaded to your machine.



### IMPORTANT

During the installation process, you can modify the playbooks to configure your deployment.

Retain all playbooks for the life of your cluster. You must have the playbooks to remove your OpenShift Container Platform cluster from RHOSP.



### IMPORTANT

You must match any edits you make in the **bootstrap.yaml**, **compute-nodes.yaml**, **control-plane.yaml**, **network.yaml**, and **security-groups.yaml** files to the corresponding playbooks that are prefixed with **down-**. For example, edits to the **bootstrap.yaml** file must be reflected in the **down-bootstrap.yaml** file, too. If you do not edit both files, the supported cluster removal process will fail.

## 15.7.6. Obtaining the installation program

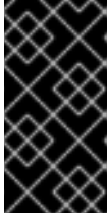
Before you install OpenShift Container Platform, download the installation file on a local computer.

### Prerequisites

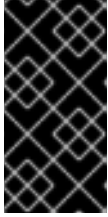
- You have a computer that runs Linux or macOS, with 500 MB of local disk space

### Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.

**IMPORTANT**

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.

**IMPORTANT**

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#) . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

### 15.7.7. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.

**IMPORTANT**

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

**NOTE**

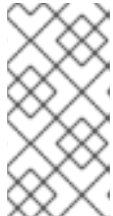
You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

**Procedure**

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.



#### NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

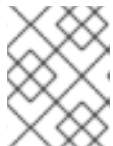
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.



#### NOTE

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

#### Example output

```
Agent pid 31874
```



#### NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1 Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

### Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

### Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

## 15.7.8. Creating the Red Hat Enterprise Linux CoreOS (RHCOS) image

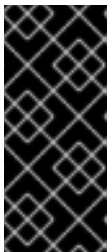
The OpenShift Container Platform installation program requires that a Red Hat Enterprise Linux CoreOS (RHCOS) image be present in the Red Hat OpenStack Platform (RHOSP) cluster. Retrieve the latest RHCOS image, then upload it using the RHOSP CLI.

### Prerequisites

- The RHOSP CLI is installed.

### Procedure

1. Log in to the Red Hat Customer Portal's [Product Downloads page](#).
2. Under **Version**, select the most recent release of OpenShift Container Platform 4.9 for Red Hat Enterprise Linux (RHEL) 8.



### IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image versions that match your OpenShift Container Platform version if they are available.

3. Download the *Red Hat Enterprise Linux CoreOS (RHCOS) - OpenStack Image (QCOW)*.
4. Decompress the image.



### NOTE

You must decompress the RHOSP image before the cluster can use it. The name of the downloaded file might not contain a compression extension, like **.gz** or **.tgz**. To find out if or how the file is compressed, in a command line, enter:

```
$ file <name_of_downloaded_file>
```

5. From the image that you downloaded, create an image that is named **rhcos** in your cluster by using the RHOSP CLI:

```
$ openstack image create --container-format=bare --disk-format=qcow2 --file rhcos-
${RHCOS_VERSION}-openstack.qcow2 rhcos
```



### IMPORTANT

Depending on your RHOSP environment, you might be able to upload the image in either [.raw](#) or [.qcow2](#) formats. If you use Ceph, you must use the [.raw](#) format.



### WARNING

If the installation program finds multiple images with the same name, it chooses one of them at random. To avoid this behavior, create unique names for resources in RHOSP.

After you upload the image to RHOSP, it is usable in the installation process.

## 15.7.9. Verifying external network access

The OpenShift Container Platform installation process requires external network access. You must provide an external network value to it, or deployment fails. Before you begin the process, verify that a network with the external router type exists in Red Hat OpenStack Platform (RHOSP).

### Prerequisites

- [Configure OpenStack's networking service to have DHCP agents forward instances' DNS queries](#)

### Procedure

1. Using the RHOSP CLI, verify the name and ID of the 'External' network:

```
$ openstack network list --long -c ID -c Name -c "Router Type"
```

### Example output

```
+-----+-----+-----+
| ID                | Name          | Router Type |
+-----+-----+-----+
| 148a8023-62a7-4672-b018-003462f8d7dc | public_network | External    |
+-----+-----+-----+
```

A network with an external router type appears in the network list. If at least one does not, see [Creating a default floating IP network](#) and [Creating a default provider network](#).



### NOTE

If the Neutron trunk service plugin is enabled, a trunk port is created by default. For more information, see [Neutron trunk port](#).



## 15.7.10. Enabling access to the environment

At deployment, all OpenShift Container Platform machines are created in a Red Hat OpenStack Platform (RHOSP)-tenant network. Therefore, they are not accessible directly in most RHOSP deployments.

You can configure OpenShift Container Platform API and application access by using floating IP addresses (FIPs) during installation. You can also complete an installation without configuring FIPs, but the installer will not configure a way to reach the API or applications externally.

### 15.7.10.1. Enabling access with floating IP addresses

Create floating IP (FIP) addresses for external access to the OpenShift Container Platform API, cluster applications, and the bootstrap process.

#### Procedure

1. Using the Red Hat OpenStack Platform (RHOSP) CLI, create the API FIP:

```
$ openstack floating ip create --description "API <cluster_name>.<base_domain>"
<external_network>
```

2. Using the Red Hat OpenStack Platform (RHOSP) CLI, create the apps, or Ingress, FIP:

```
$ openstack floating ip create --description "Ingress <cluster_name>.<base_domain>"
<external_network>
```

3. By using the Red Hat OpenStack Platform (RHOSP) CLI, create the bootstrap FIP:

```
$ openstack floating ip create --description "bootstrap machine" <external_network>
```

4. Add records that follow these patterns to your DNS server for the API and Ingress FIPs:

```
api.<cluster_name>.<base_domain>. IN A <API_FIP>
*.apps.<cluster_name>.<base_domain>. IN A <apps_FIP>
```



## NOTE

If you do not control the DNS server, you can access the cluster by adding the cluster domain names such as the following to your `/etc/hosts` file:

- `<api_floating_ip> api.<cluster_name>.<base_domain>`
- `<application_floating_ip> grafana-openshift-monitoring.apps.<cluster_name>.<base_domain>`
- `<application_floating_ip> prometheus-k8s-openshift-monitoring.apps.<cluster_name>.<base_domain>`
- `<application_floating_ip> oauth-openshift.apps.<cluster_name>.<base_domain>`
- `<application_floating_ip> console-openshift-console.apps.<cluster_name>.<base_domain>`
- `application_floating_ip integrated-oauth-server-openshift-authentication.apps.<cluster_name>.<base_domain>`

The cluster domain names in the `/etc/hosts` file grant access to the web console and the monitoring interface of your cluster locally. You can also use the `kubectl` or `oc`. You can access the user applications by using the additional entries pointing to the `<application_floating_ip>`. This action makes the API and applications accessible to only you, which is not suitable for production deployment, but does allow installation for development and testing.

5. Add the FIPs to the `inventory.yaml` file as the values of the following variables:

- `os_api_fip`
- `os_bootstrap_fip`
- `os_ingress_fip`

If you use these values, you must also enter an external network as the value of the `os_external_network` variable in the `inventory.yaml` file.

## TIP

You can make OpenShift Container Platform resources available outside of the cluster by assigning a floating IP address and updating your firewall configuration.

### 15.7.10.2. Completing installation without floating IP addresses

You can install OpenShift Container Platform on Red Hat OpenStack Platform (RHOSP) without providing floating IP addresses.

In the `inventory.yaml` file, do not define the following variables:

- `os_api_fip`
- `os_bootstrap_fip`

- **os\_ingress\_fip**

If you cannot provide an external network, you can also leave **os\_external\_network** blank. If you do not provide a value for **os\_external\_network**, a router is not created for you, and, without additional action, the installer will fail to retrieve an image from Glance. Later in the installation process, when you create network resources, you must configure external connectivity on your own.

If you run the installer with the **wait-for** command from a system that cannot reach the cluster API due to a lack of floating IP addresses or name resolution, installation fails. To prevent installation failure in these cases, you can use a proxy network or run the installer from a system that is on the same network as your machines.



#### NOTE

You can enable name resolution by creating DNS records for the API and Ingress ports. For example:

```
api.<cluster_name>.<base_domain>. IN A <api_port_IP>
*.apps.<cluster_name>.<base_domain>. IN A <ingress_port_IP>
```

If you do not control the DNS server, you can add the record to your **/etc/hosts** file. This action makes the API accessible to only you, which is not suitable for production deployment but does allow installation for development and testing.

### 15.7.11. Defining parameters for the installation program

The OpenShift Container Platform installation program relies on a file that is called **clouds.yaml**. The file describes Red Hat OpenStack Platform (RHOSP) configuration parameters, including the project name, log in information, and authorization service URLs.

#### Procedure

1. Create the **clouds.yaml** file:
  - If your RHOSP distribution includes the Horizon web UI, generate a **clouds.yaml** file in it.



#### IMPORTANT

Remember to add a password to the **auth** field. You can also keep secrets in [a separate file](#) from **clouds.yaml**.

- If your RHOSP distribution does not include the Horizon web UI, or you do not want to use Horizon, create the file yourself. For detailed information about **clouds.yaml**, see [Config files](#) in the RHOSP documentation.

```
clouds:
  shiftstack:
    auth:
      auth_url: http://10.10.14.42:5000/v3
      project_name: shiftstack
      username: shiftstack_user
      password: XXX
      user_domain_name: Default
      project_domain_name: Default
```

```
dev-env:
  region_name: RegionOne
  auth:
    username: 'devuser'
    password: XXX
    project_name: 'devonly'
    auth_url: 'https://10.10.14.22:5001/v2.0'
```

2. If your RHOSP installation uses self-signed certificate authority (CA) certificates for endpoint authentication:
  - a. Copy the certificate authority file to your machine.
  - b. Add the **cacerts** key to the **clouds.yaml** file. The value must be an absolute, non-root-accessible path to the CA certificate:

```
clouds:
  shiftstack:
  ...
  cacert: "/etc/pki/ca-trust/source/anchors/ca.crt.pem"
```

### TIP

After you run the installer with a custom CA certificate, you can update the certificate by editing the value of the **ca-cert.pem** key in the **cloud-provider-config** keymap. On a command line, run:

```
$ oc edit configmap -n openshift-config cloud-provider-config
```

3. Place the **clouds.yaml** file in one of the following locations:
  - a. The value of the **OS\_CLIENT\_CONFIG\_FILE** environment variable
  - b. The current directory
  - c. A Unix-specific user configuration directory, for example **~/.config/openstack/clouds.yaml**
  - d. A Unix-specific site configuration directory, for example **/etc/openstack/clouds.yaml**  
The installation program searches for **clouds.yaml** in that order.

## 15.7.12. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Red Hat OpenStack Platform (RHOSP).

### Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

### Procedure

1. Create the **install-config.yaml** file.
  - a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

- 1** For **<installation\_directory>**, specify the directory name to store the files that the installation program creates.



### IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

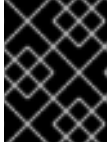
- b. At the prompts, provide the configuration details for your cloud:
    - i. Optional: Select an SSH key to use to access your cluster machines.



### NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

- ii. Select **openstack** as the platform to target.
        - iii. Specify the Red Hat OpenStack Platform (RHOSP) external network name to use for installing the cluster.
        - iv. Specify the floating IP address to use for external access to the OpenShift API.
        - v. Specify a RHOSP flavor with at least 16 GB RAM to use for control plane nodes and 8 GB RAM for compute nodes.
        - vi. Select the base domain to deploy the cluster to. All DNS records will be sub-domains of this base and will also include the cluster name.
        - vii. Enter a name for your cluster. The name must be 14 or fewer characters long.
        - viii. Paste the [pull secret from the Red Hat OpenShift Cluster Manager](#) .
2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.
  3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

**IMPORTANT**

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

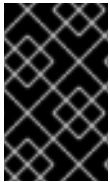
You now have the file **install-config.yaml** in the directory that you specified.

**15.7.13. Installation configuration parameters**

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.

**NOTE**

After installation, you cannot modify these parameters in the **install-config.yaml** file.

**IMPORTANT**

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

**15.7.13.1. Required configuration parameters**

Required installation configuration parameters are described in the following table:

**Table 15.30. Required parameters**

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;</b> . <b>&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .


Parameter	Description	Values
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}</b> . <b>{{.baseDomain}}</b> .	String of lowercase letters, hyphens (-), and periods (.), such as <b>dev</b> . The string must be 14 characters or fewer long.
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws, baremetal, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } }</pre>

### 15.7.13.2. Network configuration parameters


You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

**Table 15.31. Network parameters**

Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	Object  <b>NOTE</b> You cannot modify parameters specified by the <b>networking</b> object after installation.
<b>networking.networkType</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .
<b>networking.clusterNetwork</b>	The IP address blocks for pods.  The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b> .  If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example:  <pre>networking:   clusterNetwork:   - cidr: 10.128.0.0/14     hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	Required if you use <b>networking.clusterNetwork</b> . An IP address block.  An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b> .
<b>networking.clusterNetwork.hostPrefix</b>	The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b> . A <b>hostPrefix</b> value of <b>23</b> provides 510 ( $2^{(32 - 23)} - 2$ ) pod IP addresses.	A subnet prefix.  The default value is <b>23</b> .
<b>networking.serviceNetwork</b>	The IP address block for services. The default value is <b>172.30.0.0/16</b> .  The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example:  <pre>networking:   serviceNetwork:   - 172.30.0.0/16</pre>




Parameter	Description	Values
<b>networking.machineNetwork</b>	The IP address blocks for machines.  If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example:  <pre>networking:   machineNetwork:   - cidr: 10.0.0.0/16</pre>
<b>networking.machineNetwork.cidr</b>	Required if you use <b>networking.machineNetwork</b> . An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b> .	An IP network block in CIDR notation.  For example, <b>10.0.0.0/16</b> .   <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p>


### 15.7.13.3. Optional configuration parameters



Optional installation configuration parameters are described in the following table:

Table 15.32. Optional parameters


Parameter	Description	Values
<b>additionalTrustBundle</b>	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
<b>compute</b>	The configuration for the machines that comprise the compute nodes.	Array of <b>MachinePool</b> objects.
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String

Parameter	Description	Values
<b>compute.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b>
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String

Parameter	Description	Values
<b>controlPlane.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platform</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>controlPlane.replicas</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.

Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.</p> <p> <b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators reference content</i>.</p> <p> <b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p>	<b>Mint, Passthrough, Manual</b> or an empty string ("").

Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start;"> <div style="width: 30px; height: 30px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 30px; height: 30px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<p><b>Internal</b> or <b>External</b>. The default value is <b>External</b>.</p> <p>Setting this field to <b>Internal</b> is not supported on non-cloud platforms.</p>

Parameter	Description	Values
<b>sshKey</b>	<p>The SSH key or keys to authenticate access your cluster machines.</p>  <p><b>NOTE</b></p> <p>For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.</p>	<p>One or more keys. For example:</p> <pre>sshKey:   &lt;key1&gt;   &lt;key2&gt;   &lt;key3&gt;</pre>

#### 15.7.13.4. Additional Red Hat OpenStack Platform (RHOSP) configuration parameters

Additional RHOSP configuration parameters are described in the following table:

Table 15.33. Additional RHOSP parameters

Parameter	Description	Values
<b>compute.platform.openstack.rootVolume.size</b>	For compute machines, the size in gigabytes of the root volume. If you do not set this value, machines use ephemeral storage.	Integer, for example <b>30</b> .
<b>compute.platform.openstack.rootVolume.type</b>	For compute machines, the root volume's type.	String, for example <b>performance</b> .
<b>controlPlane.platform.openstack.rootVolume.size</b>	For control plane machines, the size in gigabytes of the root volume. If you do not set this value, machines use ephemeral storage.	Integer, for example <b>30</b> .
<b>controlPlane.platform.openstack.rootVolume.type</b>	For control plane machines, the root volume's type.	String, for example <b>performance</b> .
<b>platform.openstack.cloud</b>	The name of the RHOSP cloud to use from the list of clouds in the <b>clouds.yaml</b> file.	String, for example <b>MyCloud</b> .

Parameter	Description	Values
<b>platform.openstack.externalNetwork</b>	The RHOSP external network name to be used for installation.	String, for example <b>external</b> .
<b>platform.openstack.computeFlavor</b>	<p>The RHOSP flavor to use for control plane and compute machines.</p> <p>This property is deprecated. To use a flavor as the default for all machine pools, add it as the value of the <b>type</b> key in the <b>platform.openstack.defaultMachinePlatform</b> property. You can also set a flavor value for each machine pool individually.</p>	String, for example <b>m1.xlarge</b> .

#### 15.7.13.5. Optional RHOSP configuration parameters

Optional RHOSP configuration parameters are described in the following table:

Table 15.34. Optional RHOSP parameters

Parameter	Description	Values
<b>compute.platform.openstack.additionalNetworkIDs</b>	Additional networks that are associated with compute machines. Allowed address pairs are not created for additional networks.	A list of one or more UUIDs as strings. For example, <b>fa806b2f-ac49-4bce-b9db-124bc64209bf</b> .
<b>compute.platform.openstack.additionalSecurityGroupIDs</b>	Additional security groups that are associated with compute machines.	A list of one or more UUIDs as strings. For example, <b>7ee219f3-d2e9-48a1-96c2-e7429f1b0da7</b> .

Parameter	Description	Values
<b>compute.platform.openstack.zones</b>	<p>RHOSP Compute (Nova) availability zones (AZs) to install machines on. If this parameter is not set, the installer relies on the default settings for Nova that the RHOSP administrator configured.</p> <p>On clusters that use Kuryr, RHOSP Octavia does not support availability zones. Load balancers and, if you are using the Amphora provider driver, OpenShift Container Platform services that rely on Amphora VMs, are not created according to the value of this property.</p>	A list of strings. For example, <b>["zone-1", "zone-2"]</b> .
<b>compute.platform.openstack.rootVolume.zones</b>	For compute machines, the availability zone to install root volumes on. If you do not set a value for this parameter, the installer selects the default availability zone.	A list of strings, for example <b>["zone-1", "zone-2"]</b> .
<b>controlPlane.platform.openstack.additionalNetworkIDs</b>	Additional networks that are associated with control plane machines. Allowed address pairs are not created for additional networks.	A list of one or more UUIDs as strings. For example, <b>fa806b2f-ac49-4bce-b9db-124bc64209bf</b> .
<b>controlPlane.platform.openstack.additionalSecurityGroupIDs</b>	Additional security groups that are associated with control plane machines.	A list of one or more UUIDs as strings. For example, <b>7ee219f3-d2e9-48a1-96c2-e7429f1b0da7</b> .



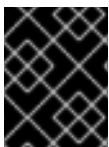
Parameter	Description	Values
<b>controlPlane.platform.openstack.zones</b>	<p>RHOSP Compute (Nova) availability zones (AZs) to install machines on. If this parameter is not set, the installer relies on the default settings for Nova that the RHOSP administrator configured.</p> <p>On clusters that use Kuryr, RHOSP Octavia does not support availability zones. Load balancers and, if you are using the Amphora provider driver, OpenShift Container Platform services that rely on Amphora VMs, are not created according to the value of this property.</p>	A list of strings. For example, <b>["zone-1", "zone-2"]</b> .
<b>controlPlane.platform.openstack.rootVolume.zones</b>	For control plane machines, the availability zone to install root volumes on. If you do not set this value, the installer selects the default availability zone.	A list of strings, for example <b>["zone-1", "zone-2"]</b> .
<b>platform.openstack.clusterOSImage</b>	<p>The location from which the installer downloads the RHCOS image.</p> <p>You must set this parameter to perform an installation in a restricted network.</p>	<p>An HTTP or HTTPS URL, optionally with an SHA-256 checksum.</p> <p>For example,  <b>http://mirror.example.com/images/rhcos-43.81.201912131630.0-openstack.x86_64.qcow2.gz?sha256=ffebbd68e8a1f2a245ca19522c16c86f67f9ac8e4e0c1f0a812b068b16f7265d</b>. The value can also be the name of an existing Glance image, for example <b>my-rhcos</b>.</p>

Parameter	Description	Values
<b>platform.openstack.clusterOSImageProperties</b>	<p>Properties to add to the installer-uploaded ClusterOSImage in Glance. This property is ignored if <b>platform.openstack.clusterOSImage</b> is set to an existing Glance image.</p> <p>You can use this property to exceed the default persistent volume (PV) limit for RHOSP of 26 PVs per node. To exceed the limit, set the <b>hw_scsi_model</b> property value to <b>virtio-scsi</b> and the <b>hw_disk_bus</b> value to <b>scsi</b>.</p> <p>You can also use this property to enable the QEMU guest agent by including the <b>hw_qemu_guest_agent</b> property with a value of <b>yes</b>.</p>	A list of key-value string pairs. For example, <b>["hw_scsi_model": "virtio-scsi", "hw_disk_bus": "scsi"]</b> .
<b>platform.openstack.defaultMachinePlatform</b>	The default machine pool platform configuration.	<pre>{   "type": "ml.large",   "rootVolume": {     "size": 30,     "type": "performance"   } }</pre>
<b>platform.openstack.ingressFloatingIP</b>	An existing floating IP address to associate with the Ingress port. To use this property, you must also define the <b>platform.openstack.externalNetwork</b> property.	An IP address, for example <b>128.0.0.1</b> .
<b>platform.openstack.apiFloatingIP</b>	An existing floating IP address to associate with the API load balancer. To use this property, you must also define the <b>platform.openstack.externalNetwork</b> property.	An IP address, for example <b>128.0.0.1</b> .
<b>platform.openstack.externalDNS</b>	IP addresses for external DNS servers that cluster instances use for DNS resolution.	A list of IP addresses as strings. For example, <b>["8.8.8.8", "192.168.1.12"]</b> .

Parameter	Description	Values
<b>platform.openstack.machinesSubnet</b>	<p>The UUID of a RHOSP subnet that the cluster's nodes use. Nodes and virtual IP (VIP) ports are created on this subnet.</p> <p>The first item in <b>networking.machineNetwork</b> must match the value of <b>machinesSubnet</b>.</p> <p>If you deploy to a custom subnet, you cannot specify an external DNS server to the OpenShift Container Platform installer. Instead, <a href="#">add DNS to the subnet in RHOSP</a>.</p>	A UUID as a string. For example, <b>fa806b2f-ac49-4bce-b9db-124bc64209bf</b> .

#### 15.7.13.6. Sample customized `install-config.yaml` file for RHOSP

This sample **`install-config.yaml`** demonstrates all of the possible Red Hat OpenStack Platform (RHOSP) customization options.



#### IMPORTANT

This sample file is provided for reference only. You must obtain your **`install-config.yaml`** file by using the installation program.

```

apiVersion: v1
baseDomain: example.com
controlPlane:
  name: master
  platform: {}
  replicas: 3
compute:
- name: worker
  platform:
    openstack:
      type: ml.large
    replicas: 3
metadata:
  name: example
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  serviceNetwork:
  - 172.30.0.0/16
networkType: OpenShiftSDN

```

```

platform:
  openstack:
    cloud: mycloud
    externalNetwork: external
    computeFlavor: m1.xlarge
    apiFloatingIP: 128.0.0.1
  fips: false
  pullSecret: '{"auths": ...}'
  sshKey: ssh-ed25519 AAAA...

```

### 15.7.13.7. Custom subnets in RHOSP deployments

Optionally, you can deploy a cluster on a Red Hat OpenStack Platform (RHOSP) subnet of your choice. The subnet's GUID is passed as the value of **platform.openstack.machinesSubnet** in the **install-config.yaml** file.

This subnet is used as the cluster's primary subnet. By default, nodes and ports are created on it. You can create nodes and ports on a different RHOSP subnet by setting the value of the **platform.openstack.machinesSubnet** property to the subnet's UUID.

Before you run the OpenShift Container Platform installer with a custom subnet, verify that your configuration meets the following requirements:

- The subnet that is used by **platform.openstack.machinesSubnet** has DHCP enabled.
- The CIDR of **platform.openstack.machinesSubnet** matches the CIDR of **networking.machineNetwork**.
- The installation program user has permission to create ports on this network, including ports with fixed IP addresses.

Clusters that use custom subnets have the following limitations:

- If you plan to install a cluster that uses floating IP addresses, the **platform.openstack.machinesSubnet** subnet must be attached to a router that is connected to the **externalNetwork** network.
- If the **platform.openstack.machinesSubnet** value is set in the **install-config.yaml** file, the installation program does not create a private network or subnet for your RHOSP machines.
- You cannot use the **platform.openstack.externalDNS** property at the same time as a custom subnet. To add DNS to a cluster that uses a custom subnet, configure DNS on the RHOSP network.



#### NOTE

By default, the API VIP takes x.x.x.5 and the Ingress VIP takes x.x.x.7 from your network's CIDR block. To override these default values, set values for **platform.openstack.apiVIP** and **platform.openstack.ingressVIP** that are outside of the DHCP allocation pool.

### 15.7.13.8. Setting a custom subnet for machines

The IP range that the installation program uses by default might not match the Neutron subnet that you create when you install OpenShift Container Platform. If necessary, update the CIDR value for new machines by editing the installation configuration file.

## Prerequisites

- You have the **install-config.yaml** file that was generated by the OpenShift Container Platform installation program.

## Procedure

1. On a command line, browse to the directory that contains **install-config.yaml**.
2. From that directory, either run a script to edit the **install-config.yaml** file or update the file manually:
  - To set the value by using a script, run:

```
$ python -c '
import yaml;
path = "install-config.yaml";
data = yaml.safe_load(open(path));
data["networking"]["machineNetwork"] = [{"cidr": "192.168.0.0/18"}]; 1
open(path, "w").write(yaml.dump(data, default_flow_style=False))'
```

- 1** Insert a value that matches your intended Neutron subnet, e.g. **192.0.2.0/24**.

- To set the value manually, open the file and set the value of **networking.machineCIDR** to something that matches your intended Neutron subnet.

### 15.7.13.9. Emptying compute machine pools

To proceed with an installation that uses your own infrastructure, set the number of compute machines in the installation configuration file to zero. Later, you create these machines manually.

## Prerequisites

- You have the **install-config.yaml** file that was generated by the OpenShift Container Platform installation program.

## Procedure

1. On a command line, browse to the directory that contains **install-config.yaml**.
2. From that directory, either run a script to edit the **install-config.yaml** file or update the file manually:
  - To set the value by using a script, run:

```
$ python -c '
import yaml;
path = "install-config.yaml";
data = yaml.safe_load(open(path));
data["compute"][0]["replicas"] = 0;
open(path, "w").write(yaml.dump(data, default_flow_style=False))'
```

- To set the value manually, open the file and set the value of **compute.<first entry>.replicas** to **0**.

### 15.7.14. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.



#### IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

#### Prerequisites

- You obtained the OpenShift Container Platform installation program.
- You created the **install-config.yaml** installation configuration file.

#### Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

- 1 For **<installation\_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

2. Remove the Kubernetes manifest files that define the control plane machines and compute machine sets:

```
$ rm -f openshift/99_openshift-cluster-api_master-machines-*.yaml openshift/99_openshift-cluster-api_worker-machineset-*.yaml
```

Because you create and manage these resources yourself, you do not have to initialize them.

- You can preserve the machine set files to create compute machines by using the machine API, but you must update references to them to match your environment.
3. Check that the **mastersSchedulable** parameter in the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest

file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:

- a. Open the `<installation_directory>/manifests/cluster-scheduler-02-config.yml` file.
  - b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.
  - c. Save and exit the file.
4. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

- 1 For `<installation_directory>`, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the `./<installation_directory>/auth` directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

5. Export the metadata file's **infraID** key as an environment variable:

```
$ export INFRA_ID=$(jq -r .infraID metadata.json)
```

## TIP

Extract the **infraID** key from **metadata.json** and use it as a prefix for all of the RHOSP resources that you create. By doing so, you avoid name conflicts when making multiple deployments in the same project.

### 15.7.15. Preparing the bootstrap Ignition files

The OpenShift Container Platform installation process relies on bootstrap machines that are created from a bootstrap Ignition configuration file.

Edit the file and upload it. Then, create a secondary bootstrap Ignition configuration file that Red Hat OpenStack Platform (RHOSP) uses to download the primary file.

#### Prerequisites

- You have the bootstrap Ignition file that the installer program generates, **bootstrap.ign**.
- The infrastructure ID from the installer's metadata file is set as an environment variable (**\$INFRA\_ID**).

- If the variable is not set, see **Creating the Kubernetes manifest and Ignition config files**
- You have an HTTP(S)-accessible way to store the bootstrap Ignition file.
  - The documented procedure uses the RHOSP image service (Glance), but you can also use the RHOSP storage service (Swift), Amazon S3, an internal HTTP server, or an ad hoc Nova server.

## Procedure

1. Run the following Python script. The script modifies the bootstrap Ignition file to set the hostname and, if available, CA certificate file when it runs:

```
import base64
import json
import os

with open('bootstrap.ign', 'r') as f:
    ignition = json.load(f)

files = ignition['storage'].get('files', [])

infra_id = os.environ.get('INFRA_ID', 'openshift').encode()
hostname_b64 = base64.standard_b64encode(infra_id + b'-bootstrap\n').decode().strip()
files.append(
{
    'path': '/etc/hostname',
    'mode': 420,
    'contents': {
        'source': 'data:text/plain;charset=utf-8;base64,' + hostname_b64
    }
})

ca_cert_path = os.environ.get('OS_CACERT', "")
if ca_cert_path:
    with open(ca_cert_path, 'r') as f:
        ca_cert = f.read().encode()
        ca_cert_b64 = base64.standard_b64encode(ca_cert).decode().strip()

files.append(
{
    'path': '/opt/openshift/tls/cloud-ca-cert.pem',
    'mode': 420,
    'contents': {
        'source': 'data:text/plain;charset=utf-8;base64,' + ca_cert_b64
    }
})

ignition['storage']['files'] = files;

with open('bootstrap.ign', 'w') as f:
    json.dump(ignition, f)
```

2. Using the RHOSP CLI, create an image that uses the bootstrap Ignition file:

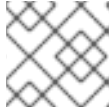


```
$ openstack image create --disk-format=raw --container-format=bare --file bootstrap.ign
<image_name>
```

3. Get the image's details:

```
$ openstack image show <image_name>
```

Make a note of the **file** value; it follows the pattern **v2/images/<image\_ID>/file**.



#### NOTE

Verify that the image you created is active.

4. Retrieve the image service's public address:

```
$ openstack catalog show image
```

5. Combine the public address with the image **file** value and save the result as the storage location. The location follows the pattern

**<image\_service\_public\_URL>/v2/images/<image\_ID>/file**.

6. Generate an auth token and save the token ID:

```
$ openstack token issue -c id -f value
```

7. Insert the following content into a file called **\$INFRA\_ID-bootstrap-ignition.json** and edit the placeholders to match your own values:

```
{
  "ignition": {
    "config": {
      "merge": [{
        "source": "<storage_url>", 1
        "httpHeaders": [{
          "name": "X-Auth-Token", 2
          "value": "<token_ID>" 3
        }]
      }]
    },
    "security": {
      "tls": {
        "certificateAuthorities": [{
          "source": "data:text/plain;charset=utf-8;base64,<base64_encoded_certificate>" 4
        }]
      }
    },
    "version": "3.2.0"
  }
}
```

- 1 Replace the value of **ignition.config.merge.source** with the bootstrap Ignition file storage URL.

- 2 Set **name** in **httpHeaders** to **"X-Auth-Token"**.
- 3 Set **value** in **httpHeaders** to your token's ID.
- 4 If the bootstrap Ignition file server uses a self-signed certificate, include the base64-encoded certificate.

8. Save the secondary Ignition config file.

The bootstrap Ignition data will be passed to RHOSP during installation.



### WARNING

The bootstrap Ignition file contains sensitive information, like **clouds.yaml** credentials. Ensure that you store it in a secure place, and delete it after you complete the installation process.

## 15.7.16. Creating control plane Ignition config files on RHOSP

Installing OpenShift Container Platform on Red Hat OpenStack Platform (RHOSP) on your own infrastructure requires control plane Ignition config files. You must create multiple config files.



### NOTE

As with the bootstrap Ignition configuration, you must explicitly define a hostname for each control plane machine.

### Prerequisites

- The infrastructure ID from the installation program's metadata file is set as an environment variable (**\$INFRA\_ID**).
  - If the variable is not set, see "Creating the Kubernetes manifest and Ignition config files".

### Procedure

- On a command line, run the following Python script:

```
$ for index in $(seq 0 2); do
  MASTER_HOSTNAME="$INFRA_ID-master-$index\n"
  python -c "import base64, json, sys;
  ignition = json.load(sys.stdin);
  storage = ignition.get('storage', {});
  files = storage.get('files', []);
  files.append({'path': '/etc/hostname', 'mode': 420, 'contents': {'source':
'data:text/plain;charset=utf-8;base64,' +
base64.standard_b64encode(b'$MASTER_HOSTNAME').decode().strip(), 'verification': {}},
'filesystem': 'root'});
  storage['files'] = files;
```

```

ignition['storage'] = storage
json.dump(ignition, sys.stdout) <master.ign >"$INFRA_ID-master-$index-ignition.json"
done

```

You now have three control plane Ignition files: **<INFRA\_ID>-master-0-ignition.json**, **<INFRA\_ID>-master-1-ignition.json**, and **<INFRA\_ID>-master-2-ignition.json**.

### 15.7.17. Creating network resources on RHOSP

Create the network resources that an OpenShift Container Platform on Red Hat OpenStack Platform (RHOSP) installation on your own infrastructure requires. To save time, run supplied Ansible playbooks that generate security groups, networks, subnets, routers, and ports.

#### Prerequisites

- Python 3 is installed on your machine.
- You downloaded the modules in "Downloading playbook dependencies".
- You downloaded the playbooks in "Downloading the installation playbooks".

#### Procedure

1. Optional: Add an external network value to the **inventory.yaml** playbook:

#### Example external network value in the inventory.yaml Ansible playbook

```

...
# The public network providing connectivity to the cluster. If not
# provided, the cluster external connectivity must be provided in another
# way.

# Required for os_api_fip, os_ingress_fip, os_bootstrap_fip.
os_external_network: 'external'
...

```



#### IMPORTANT

If you did not provide a value for **os\_external\_network** in the **inventory.yaml** file, you must ensure that VMs can access Glance and an external connection yourself.

2. Optional: Add external network and floating IP (FIP) address values to the **inventory.yaml** playbook:

#### Example FIP values in the inventory.yaml Ansible playbook

```

...
# OpenShift API floating IP address. If this value is non-empty, the
# corresponding floating IP will be attached to the Control Plane to
# serve the OpenShift API.
os_api_fip: '203.0.113.23'

# OpenShift Ingress floating IP address. If this value is non-empty, the

```

```
# corresponding floating IP will be attached to the worker nodes to serve
# the applications.
```

```
os_ingress_fip: '203.0.113.19'
```

```
# If this value is non-empty, the corresponding floating IP will be
# attached to the bootstrap machine. This is needed for collecting logs
# in case of install failure.
```

```
os_bootstrap_fip: '203.0.113.20'
```



### IMPORTANT

If you do not define values for **os\_api\_fip** and **os\_ingress\_fip**, you must perform post-installation network configuration.

If you do not define a value for **os\_bootstrap\_fip**, the installer cannot download debugging information from failed installations.

See "Enabling access to the environment" for more information.

3. On a command line, create security groups by running the **security-groups.yaml** playbook:

```
$ ansible-playbook -i inventory.yaml security-groups.yaml
```

4. On a command line, create a network, subnet, and router by running the **network.yaml** playbook:

```
$ ansible-playbook -i inventory.yaml network.yaml
```

5. Optional: If you want to control the default resolvers that Nova servers use, run the RHOSP CLI command:

```
$ openstack subnet set --dns-nameserver <server_1> --dns-nameserver <server_2>
"$INFRA_ID-nodes"
```

Optionally, you can use the **inventory.yaml** file that you created to customize your installation. For example, you can deploy a cluster that uses bare metal machines.

#### 15.7.17.1. Deploying a cluster with bare metal machines

If you want your cluster to use bare metal machines, modify the **inventory.yaml** file. Your cluster can have both control plane and compute machines running on bare metal, or just compute machines.

Bare-metal compute machines are not supported on clusters that use Kuryr.



### NOTE

Be sure that your **install-config.yaml** file reflects whether the RHOSP network that you use for bare metal workers supports floating IP addresses or not.

### Prerequisites

- The RHOSP [Bare Metal service \(Ironic\)](#) is enabled and accessible via the RHOSP Compute API.

- Bare metal is available as a [RHOSP flavor](#).
- The RHOSP network supports both VM and bare metal server attachment.
- Your network configuration does not rely on a provider network. Provider networks are not supported.
- If you want to deploy the machines on a pre-existing network, a RHOSP subnet is provisioned.
- If you want to deploy the machines on an installer-provisioned network, the RHOSP Bare Metal service (Ironic) is able to listen for and interact with Preboot eXecution Environment (PXE) boot machines that run on tenant networks.
- You created an **inventory.yaml** file as part of the OpenShift Container Platform installation process.

## Procedure

1. In the **inventory.yaml** file, edit the flavors for machines:
  - a. If you want to use bare-metal control plane machines, change the value of **os\_flavor\_master** to a bare metal flavor.
  - b. Change the value of **os\_flavor\_worker** to a bare metal flavor.

### An example bare metal inventory.yaml file

```
all:
  hosts:
    localhost:
      ansible_connection: local
      ansible_python_interpreter: "{{ansible_playbook_python}}"

      # User-provided values
      os_subnet_range: '10.0.0.0/16'
      os_flavor_master: 'my-bare-metal-flavor' 1
      os_flavor_worker: 'my-bare-metal-flavor' 2
      os_image_rhcos: 'rhcos'
      os_external_network: 'external'

  ...
```

- 1 If you want to have bare-metal control plane machines, change this value to a bare metal flavor.
- 2 Change this value to a bare metal flavor to use for compute machines.

Use the updated **inventory.yaml** file to complete the installation process. Machines that are created during deployment use the flavor that you added to the file.



## NOTE

The installer may time out while waiting for bare metal machines to boot.

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
./openshift-install wait-for install-complete --log-level debug
```

### 15.7.18. Creating the bootstrap machine on RHOSP

Create a bootstrap machine and give it the network access it needs to run on Red Hat OpenStack Platform (RHOSP). Red Hat provides an Ansible playbook that you run to simplify this process.

#### Prerequisites

- You downloaded the modules in "Downloading playbook dependencies".
- You downloaded the playbooks in "Downloading the installation playbooks".
- The **inventory.yaml**, **common.yaml**, and **bootstrap.yaml** Ansible playbooks are in a common directory.
- The **metadata.json** file that the installation program created is in the same directory as the Ansible playbooks.

#### Procedure

1. On a command line, change the working directory to the location of the playbooks.
2. On a command line, run the **bootstrap.yaml** playbook:

```
$ ansible-playbook -i inventory.yaml bootstrap.yaml
```

3. After the bootstrap server is active, view the logs to verify that the Ignition files were received:

```
$ openstack console log show "$INFRA_ID-bootstrap"
```

### 15.7.19. Creating the control plane machines on RHOSP

Create three control plane machines by using the Ignition config files that you generated. Red Hat provides an Ansible playbook that you run to simplify this process.

#### Prerequisites

- You downloaded the modules in "Downloading playbook dependencies".
- You downloaded the playbooks in "Downloading the installation playbooks".
- The infrastructure ID from the installation program's metadata file is set as an environment variable (**\$INFRA\_ID**).
- The **inventory.yaml**, **common.yaml**, and **control-plane.yaml** Ansible playbooks are in a common directory.

- You have the three Ignition files that were created in "Creating control plane Ignition config files".

### Procedure

1. On a command line, change the working directory to the location of the playbooks.
2. If the control plane Ignition config files aren't already in your working directory, copy them into it.
3. On a command line, run the **control-plane.yaml** playbook:

```
$ ansible-playbook -i inventory.yaml control-plane.yaml
```

4. Run the following command to monitor the bootstrapping process:

```
$ openshift-install wait-for bootstrap-complete
```

You will see messages that confirm that the control plane machines are running and have joined the cluster:

```
INFO API v1.22.1 up
INFO Waiting up to 30m0s for bootstrapping to complete...
...
INFO It is now safe to remove the bootstrap resources
```

### 15.7.20. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

#### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

#### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

## Example output

```
system:admin
```

### 15.7.21. Deleting bootstrap resources from RHOSP

Delete the bootstrap resources that you no longer need.

#### Prerequisites

- You downloaded the modules in "Downloading playbook dependencies".
- You downloaded the playbooks in "Downloading the installation playbooks".
- The **inventory.yaml**, **common.yaml**, and **down-bootstrap.yaml** Ansible playbooks are in a common directory.
- The control plane machines are running.
  - If you do not know the status of the machines, see "Verifying cluster status".

#### Procedure

1. On a command line, change the working directory to the location of the playbooks.
2. On a command line, run the **down-bootstrap.yaml** playbook:

```
$ ansible-playbook -i inventory.yaml down-bootstrap.yaml
```

The bootstrap port, server, and floating IP address are deleted.

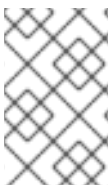


#### WARNING

If you did not disable the bootstrap Ignition file URL earlier, do so now.

### 15.7.22. Creating SR-IOV networks for compute machines

If your Red Hat OpenStack Platform (RHOSP) deployment supports [single root I/O virtualization \(SR-IOV\)](#), you can provision SR-IOV networks that compute machines run on.



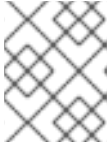
#### NOTE

The following instructions entail creating an external flat network and an external, VLAN-based network that can be attached to a compute machine. Depending on your RHOSP deployment, other network types might be required.

#### Prerequisites

- Your cluster supports SR-IOV.



**NOTE**

If you are unsure about what your cluster supports, review the OpenShift Container Platform SR-IOV hardware networks documentation.

- You created radio and uplink provider networks as part of your RHOSP deployment. The names **radio** and **uplink** are used in all example commands to represent these networks.

**Procedure**

1. On a command line, create a radio RHOSP network:

```
$ openstack network create radio --provider-physical-network radio --provider-network-type flat --external
```

2. Create an uplink RHOSP network:

```
$ openstack network create uplink --provider-physical-network uplink --provider-network-type vlan --external
```

3. Create a subnet for the radio network:

```
$ openstack subnet create --network radio --subnet-range <radio_network_subnet_range> radio
```

4. Create a subnet for the uplink network:

```
$ openstack subnet create --network uplink --subnet-range <uplink_network_subnet_range> uplink
```

**15.7.23. Creating compute machines that run on SR-IOV networks**

After standing up the control plane, create compute machines that run on the SR-IOV networks that you created in "Creating SR-IOV networks for compute machines".

**Prerequisites**

- You downloaded the modules in "Downloading playbook dependencies".
- You downloaded the playbooks in "Downloading the installation playbooks".
- The **metadata.yaml** file that the installation program created is in the same directory as the Ansible playbooks.
- The control plane is active.
- You created **radio** and **uplink** SR-IOV networks as described in "Creating SR-IOV networks for compute machines".

**Procedure**

1. On a command line, change the working directory to the location of the **inventory.yaml** and **common.yaml** files.

2. Add the **radio** and **uplink** networks to the end of the **inventory.yaml** file by using the **additionalNetworks** parameter:

```
....
# If this value is non-empty, the corresponding floating IP will be
# attached to the bootstrap machine. This is needed for collecting logs
# in case of install failure.
os_bootstrap_fip: '203.0.113.20'

additionalNetworks:
- id: radio
  count: 4 1
  type: direct
  port_security_enabled: no
- id: uplink
  count: 4 2
  type: direct
  port_security_enabled: no
```

- 1** **2** The **count** parameter defines the number of SR-IOV virtual functions (VFs) to attach to each worker node. In this case, each network has four VFs.

3. Replace the content of the **compute-nodes.yaml** file with the following text:

#### Example 15.1. compute-nodes.yaml

```
- import_playbook: common.yaml

- hosts: all
  gather_facts: no

  vars:
    worker_list: []
    port_name_list: []
    nic_list: []

  tasks:
    # Create the SDN/primary port for each worker node
    - name: 'Create the Compute ports'
      os_port:
        name: "{{ item.1 }}-{{ item.0 }}"
        network: "{{ os_network }}"
        security_groups:
          - "{{ os_sg_worker }}"
        allowed_address_pairs:
          - ip_address: "{{ os_ingressVIP }}"
      with_indexed_items: "{{ [os_port_worker] * os_compute_nodes_number }}"
      register: ports

    # Tag each SDN/primary port with cluster name
    - name: 'Set Compute ports tag'
      command:
        cmd: "openstack port set --tag {{ cluster_id_tag }} {{ item.1 }}-{{ item.0 }}"
      with_indexed_items: "{{ [os_port_worker] * os_compute_nodes_number }}"
```

```

- name: 'List the Compute Trunks'
  command:
    cmd: "openstack network trunk list"
  when: os_networking_type == "Kuryr"
  register: compute_trunks

- name: 'Create the Compute trunks'
  command:
    cmd: "openstack network trunk create --parent-port {{ item.1.id }} {{
os_compute_trunk_name }}-{{ item.0 }}"
  with_indexed_items: "{{ ports.results }}"
  when:
    - os_networking_type == "Kuryr"
    - "os_compute_trunk_name|string not in compute_trunks.stdout"

- name: 'Call additional-port processing'
  include_tasks: additional-ports.yaml

# Create additional ports in OpenStack
- name: 'Create additionalNetworks ports'
  os_port:
    name: "{{ item.0 }}-{{ item.1.name }}"
    vnic_type: "{{ item.1.type }}"
    network: "{{ item.1.uuid }}"
    port_security_enabled: "{{ item.1.port_security_enabled|default(omit) }}"
    no_security_groups: "{{ 'true' if item.1.security_groups is not defined else omit }}"
    security_groups: "{{ item.1.security_groups | default(omit) }}"
  with_nested:
    - "{{ worker_list }}"
    - "{{ port_name_list }}"

# Tag the ports with the cluster info
- name: 'Set additionalNetworks ports tag'
  command:
    cmd: "openstack port set --tag {{ cluster_id_tag }} {{ item.0 }}-{{ item.1.name }}"
  with_nested:
    - "{{ worker_list }}"
    - "{{ port_name_list }}"

# Build the nic list to use for server create
- name: Build nic list
  set_fact:
    nic_list: "{{ nic_list | default([]) + [ item.name ] }}"
  with_items: "{{ port_name_list }}"

# Create the servers
- name: 'Create the Compute servers'
  vars:
    worker_nics: "{{ [ item.1 ] | product(nic_list) | map('join','-') | map('regex_replace', '(.*)',
'port-name=\\1') | list }}"
  os_server:
    name: "{{ item.1 }}"
    image: "{{ os_image_rhcos }}"
    flavor: "{{ os_flavor_worker }}"
    auto_ip: no
    userdata: "{{ lookup('file', 'worker.ign') | string }}"

```

```

security_groups: []
nics: "{{ [ 'port-name=' + os_port_worker + '-' + item.0|string ] + worker_nics }}"
config_drive: yes
with_indexed_items: "{{ worker_list }}"

```

4. Insert the following content into a local file that is called **additional-ports.yaml**:

#### Example 15.2. additional-ports.yaml

```

# Build a list of worker nodes with indexes
- name: 'Build worker list'
  set_fact:
    worker_list: "{{ worker_list | default([]) + [ item.1 + '-' + item.0 | string ] }}"
    with_indexed_items: "{{ [ os_compute_server_name ] * os_compute_nodes_number }}"

# Ensure that each network specified in additionalNetworks exists
- name: 'Verify additionalNetworks'
  os_networks_info:
    name: "{{ item.id }}"
    with_items: "{{ additionalNetworks }}"
  register: network_info

# Expand additionalNetworks by the count parameter in each network definition
- name: 'Build port and port index list for additionalNetworks'
  set_fact:
    port_list: "{{ port_list | default([]) + [ {
      'net_name' : item.1.id,
      'uuid' : network_info.results[item.0].openstack_networks[0].id,
      'type' : item.1.type|default('normal'),
      'security_groups' : item.1.security_groups|default(omit),
      'port_security_enabled' : item.1.port_security_enabled|default(omit)
    } ] * item.1.count|default(1) }}"
    index_list: "{{ index_list | default([]) + range(item.1.count|default(1)) | list }}"
    with_indexed_items: "{{ additionalNetworks }}"

# Calculate and save the name of the port
# The format of the name is cluster_name-worker-workerID-networkUUID(partial)-count
# i.e. fdp-nz995-worker-1-99bcd111-1
- name: 'Calculate port name'
  set_fact:
    port_name_list: "{{ port_name_list | default([]) + [ item.1 | combine( {'name' : item.1.uuid
| regex_search('[^~+)]' + '-' + index_list[item.0]|string } ) ] }}"
    with_indexed_items: "{{ port_list }}"
  when: port_list is defined

```

5. On a command line, run the **compute-nodes.yaml** playbook:

```
$ ansible-playbook -i inventory.yaml compute-nodes.yaml
```

## 15.7.24. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

## Prerequisites

- You added machines to your cluster.

## Procedure

1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

### Example output

```
NAME      STATUS  ROLES  AGE  VERSION
master-0  Ready   master 63m  v1.22.1
master-1  Ready   master 63m  v1.22.1
master-2  Ready   master 64m  v1.22.1
```

The output lists all of the machines that you created.



### NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

2. Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

### Example output

```
NAME      AGE  REQUESTOR                                     CONDITION
csr-8b2br 15m  system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper Pending
csr-8vnps 15m  system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper Pending
...
```

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

3. If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:

**NOTE**

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.

**NOTE**

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrap** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{"\n"}{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```

**NOTE**

Some Operators might not become available until some CSRs are approved.

- Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

**Example output**

```
NAME      AGE   REQUESTOR                                     CONDITION
csr-bfd72 5m26s system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv 5m26s system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

5. If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

**1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

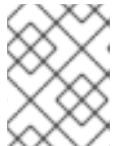
```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{\n"}\n{{end}}' | xargs oc adm certificate approve
```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

### Example output

```
NAME      STATUS  ROLES  AGE  VERSION
master-0  Ready   master 73m  v1.22.1
master-1  Ready   master 73m  v1.22.1
master-2  Ready   master 74m  v1.22.1
worker-0  Ready   worker 11m  v1.22.1
worker-1  Ready   worker 11m  v1.22.1
```



### NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

### Additional information

- For more information on CSRs, see [Certificate Signing Requests](#).

## 15.7.25. Verifying a successful installation

Verify that the OpenShift Container Platform installation is complete.

### Prerequisites

- You have the installation program (**openshift-install**)

### Procedure

- On a command line, enter:

```
$ openshift-install --log-level debug wait-for install-complete
```

The program outputs the console URL, as well as the administrator's login information.

The cluster is operational. Before you can configure it for SR-IOV networks though, you must perform additional tasks.

## 15.7.26. Preparing a cluster that runs on RHOSP for SR-IOV

Before you use [single root I/O virtualization \(SR-IOV\)](#) on a cluster that runs on Red Hat OpenStack Platform (RHOSP), make the RHOSP metadata service mountable as a drive and enable the No-IOMMU Operator for the virtual function I/O (VFIO) driver.

### 15.7.26.1. Enabling the RHOSP metadata service as a mountable drive

You can apply a machine config to your machine pool that makes the Red Hat OpenStack Platform (RHOSP) metadata service available as a mountable drive.

The following machine config enables the display of RHOSP network UUIDs from within the SR-IOV Network Operator. This configuration simplifies the association of SR-IOV resources to cluster SR-IOV resources.

#### Procedure

1. Create a machine config file from the following template:

#### A mountable metadata service machine config file

```
kind: MachineConfig
apiVersion: machineconfiguration.openshift.io/v1
metadata:
  name: 20-mount-config 1
  labels:
    machineconfiguration.openshift.io/role: worker
spec:
  config:
    ignition:
      version: 3.2.0
    systemd:
      units:
        - name: create-mountpoint-var-config.service
          enabled: true
          contents: |
            [Unit]
            Description=Create mountpoint /var/config
            Before=kubelet.service

            [Service]
            ExecStart=/bin/mkdir -p /var/config

            [Install]
            WantedBy=var-config.mount

        - name: var-config.mount
          enabled: true
          contents: |
            [Unit]
            Before=local-fs.target
            [Mount]
```



```
Where=/var/config
What=/dev/disk/by-label/config-2
[Install]
WantedBy=local-fs.target
```

1 You can substitute a name of your choice.

2. From a command line, apply the machine config:

```
$ oc apply -f <machine_config_file_name>.yaml
```

### 15.7.26.2. Enabling the No-IOMMU feature for the RHOSP VFIO driver

You can apply a machine config to your machine pool that enables the No-IOMMU feature for the Red Hat OpenStack Platform (RHOSP) virtual function I/O (VFIO) driver. The RHOSP vfio-pci driver requires this feature.

#### Procedure

1. Create a machine config file from the following template:

#### A No-IOMMU VFIO machine config file

```
kind: MachineConfig
apiVersion: machineconfiguration.openshift.io/v1
metadata:
  name: 99-vfio-noiommu 1
  labels:
    machineconfiguration.openshift.io/role: worker
spec:
  config:
    ignition:
      version: 3.2.0
    storage:
      files:
        - path: /etc/modprobe.d/vfio-noiommu.conf
          mode: 0644
          contents:
            source:
              data:;base64,b3B0aW9ucyB2ZmlvIGVuYWJsZV91bnNhZmVfbm9pb21tdV9tb2RIPTEK
```

1 You can substitute a name of your choice.

2. From a command line, apply the machine config:

```
$ oc apply -f <machine_config_file_name>.yaml
```



#### NOTE

After you apply the machine config to the machine pool, you can [watch the machine config pool status](#) to see when the machines are available.

The cluster is installed and prepared for SR-IOV configuration. You must now perform the SR-IOV configuration tasks in "Next steps".

### 15.7.27. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

#### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

### 15.7.28. Additional resources

- See [Performance Addon Operator for low latency nodes](#) for information about configuring your deployment for real-time running and low latency.

### 15.7.29. Next steps

- To complete SR-IOV configuration for your cluster:
  - [Install the Performance Addon Operator](#).
  - [Configure the Performance Addon Operator with huge pages support](#).
  - [Install the SR-IOV Operator](#).
  - [Configure your SR-IOV network device](#).
- [Customize your cluster](#).
- If necessary, you can [opt out of remote health reporting](#).
- If you need to enable external access to node ports, [configure ingress cluster traffic by using a node port](#).
- If you did not configure RHOSP to accept application traffic over floating IP addresses, [configure RHOSP access with floating IP addresses](#).

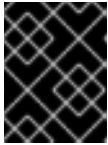
## 15.8. INSTALLING A CLUSTER ON OPENSTACK IN A RESTRICTED NETWORK

In OpenShift Container Platform 4.9, you can install a cluster on Red Hat OpenStack Platform (RHOSP) in a restricted network by creating an internal mirror of the installation release content.

### 15.8.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.

- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You verified that OpenShift Container Platform 4.9 is compatible with your RHOSP version by using the [Supported platforms for OpenShift clusters](#) section. You can also compare platform support across different versions by viewing the [OpenShift Container Platform on RHOSP support matrix](#).
- You [created a registry on your mirror host](#) and obtained the **imageContentSources** data for your version of OpenShift Container Platform.



### IMPORTANT

Because the installation media is on the mirror host, you can use that computer to complete all installation steps.

- You have the metadata service enabled in RHOSP.

## 15.8.2. About installations in restricted networks

In OpenShift Container Platform 4.9, you can perform an installation that does not require an active connection to the internet to obtain software components. Restricted network installations can be completed using installer-provisioned infrastructure or user-provisioned infrastructure, depending on the cloud platform to which you are installing the cluster.

If you choose to perform a restricted network installation on a cloud platform, you still require access to its cloud APIs. Some cloud functions, like Amazon Web Service's Route 53 DNS and IAM services, require internet access. Depending on your network, you might require less internet access for an installation on bare metal hardware or on VMware vSphere.

To complete a restricted network installation, you must create a registry that mirrors the contents of the OpenShift Container Platform registry and contains the installation media. You can create this registry on a mirror host, which can access both the internet and your closed network, or by using other methods that meet your restrictions.

### 15.8.2.1. Additional limits

Clusters in restricted networks have the following additional limitations and restrictions:

- The **ClusterVersion** status includes an **Unable to retrieve available updates** error.
- By default, you cannot use the contents of the Developer Catalog because you cannot access the required image stream tags.

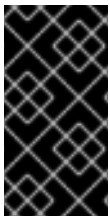
## 15.8.3. Resource guidelines for installing OpenShift Container Platform on RHOSP

To support an OpenShift Container Platform installation, your Red Hat OpenStack Platform (RHOSP) quota must meet the following requirements:

**Table 15.35. Recommended resources for a default OpenShift Container Platform cluster on RHOSP**

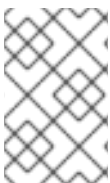
Resource	Value
Floating IP addresses	3
Ports	15
Routers	1
Subnets	1
RAM	88 GB
vCPUs	22
Volume storage	275 GB
Instances	7
Security groups	3
Security group rules	60

A cluster might function with fewer than recommended resources, but its performance is not guaranteed.



### IMPORTANT

If RHOSP object storage (Swift) is available and operated by a user account with the **swiftoperator** role, it is used as the default backend for the OpenShift Container Platform image registry. In this case, the volume storage requirement is 175 GB. Swift space requirements vary depending on the size of the image registry.



### NOTE

By default, your security group and security group rule quotas might be low. If you encounter problems, run **openstack quota set --secgroups 3 --secgroup-rules 60 <project>** as an administrator to increase them.

An OpenShift Container Platform deployment comprises control plane machines, compute machines, and a bootstrap machine.

#### 15.8.3.1. Control plane machines

By default, the OpenShift Container Platform installation process creates three control plane machines.

Each machine requires:

- An instance from the RHOSP quota
- A port from the RHOSP quota

- A flavor with at least 16 GB memory and 4 vCPUs
- At least 100 GB storage space from the RHOSP quota

### 15.8.3.2. Compute machines

By default, the OpenShift Container Platform installation process creates three compute machines.

Each machine requires:

- An instance from the RHOSP quota
- A port from the RHOSP quota
- A flavor with at least 8 GB memory and 2 vCPUs
- At least 100 GB storage space from the RHOSP quota

#### TIP

Compute machines host the applications that you run on OpenShift Container Platform; aim to run as many as you can.

### 15.8.3.3. Bootstrap machine

During installation, a bootstrap machine is temporarily provisioned to stand up the control plane. After the production control plane is ready, the bootstrap machine is deprovisioned.

The bootstrap machine requires:

- An instance from the RHOSP quota
- A port from the RHOSP quota
- A flavor with at least 16 GB memory and 4 vCPUs
- At least 100 GB storage space from the RHOSP quota

## 15.8.4. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to obtain the images that are necessary to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



## IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

### 15.8.5. Enabling Swift on RHOSP

Swift is operated by a user account with the **swiftoperator** role. Add the role to an account before you run the installation program.



## IMPORTANT

If [the Red Hat OpenStack Platform \(RHOSP\) object storage service](#), commonly known as Swift, is available, OpenShift Container Platform uses it as the image registry storage. If it is unavailable, the installation program relies on the RHOSP block storage service, commonly known as Cinder.

If Swift is present and you want to use it, you must enable access to it. If it is not present, or if you do not want to use it, skip this section.

#### Prerequisites

- You have a RHOSP administrator account on the target environment.
- The Swift service is installed.
- On [Ceph RGW](#), the **account in url** option is enabled.

#### Procedure

To enable Swift on RHOSP:

1. As an administrator in the RHOSP CLI, add the **swiftoperator** role to the account that will access Swift:

```
$ openstack role add --user <user> --project <project> swiftoperator
```

Your RHOSP deployment can now use Swift for the image registry.

### 15.8.6. Defining parameters for the installation program

The OpenShift Container Platform installation program relies on a file that is called **clouds.yaml**. The file describes Red Hat OpenStack Platform (RHOSP) configuration parameters, including the project name, log in information, and authorization service URLs.

#### Procedure

1. Create the **clouds.yaml** file:
  - If your RHOSP distribution includes the Horizon web UI, generate a **clouds.yaml** file in it.



## IMPORTANT

Remember to add a password to the **auth** field. You can also keep secrets in [a separate file](#) from **clouds.yaml**.

- If your RHOSP distribution does not include the Horizon web UI, or you do not want to use Horizon, create the file yourself. For detailed information about **clouds.yaml**, see [Config files](#) in the RHOSP documentation.

```
clouds:
  shiftstack:
    auth:
      auth_url: http://10.10.14.42:5000/v3
      project_name: shiftstack
      username: shiftstack_user
      password: XXX
      user_domain_name: Default
      project_domain_name: Default
  dev-env:
    region_name: RegionOne
    auth:
      username: 'devuser'
      password: XXX
      project_name: 'devonly'
      auth_url: 'https://10.10.14.22:5001/v2.0'
```

2. If your RHOSP installation uses self-signed certificate authority (CA) certificates for endpoint authentication:
  - a. Copy the certificate authority file to your machine.
  - b. Add the **cacerts** key to the **clouds.yaml** file. The value must be an absolute, non-root-accessible path to the CA certificate:

```
clouds:
  shiftstack:
    ...
    cacert: "/etc/pki/ca-trust/source/anchors/ca.crt.pem"
```

## TIP

After you run the installer with a custom CA certificate, you can update the certificate by editing the value of the **ca-cert.pem** key in the **cloud-provider-config** keymap. On a command line, run:

```
$ oc edit configmap -n openshift-config cloud-provider-config
```

3. Place the **clouds.yaml** file in one of the following locations:
  - a. The value of the **OS\_CLIENT\_CONFIG\_FILE** environment variable
  - b. The current directory
  - c. A Unix-specific user configuration directory, for example **~/.config/openstack/clouds.yaml**

- d. A Unix-specific site configuration directory, for example `/etc/openstack/clouds.yaml`  
The installation program searches for **clouds.yaml** in that order.

### 15.8.7. Setting cloud provider options

Optionally, you can edit the cloud provider configuration for your cluster. The cloud provider configuration controls how OpenShift Container Platform interacts with Red Hat OpenStack Platform (RHOSP).

For a complete list of cloud provider configuration parameters, see the "OpenStack cloud configuration reference guide" page in the "Installing on OpenStack" documentation.

#### Procedure

1. If you have not already generated manifest files for your cluster, generate them by running the following command:

```
$ openshift-install --dir <destination_directory> create manifests
```

2. In a text editor, open the cloud-provider configuration manifest file. For example:

```
$ vi openshift/manifests/cloud-provider-config.yaml
```

3. Modify the options based on the cloud configuration specification.

Configuring Octavia for load balancing is a common case for clusters that do not use Kuryr. For example:

```
#...
[LoadBalancer]
use-octavia=true 1
lb-provider = "amphora" 2
floating-network-id="d3deb660-4190-40a3-91f1-37326fe6ec4a" 3
#...
```

1 This property enables Octavia integration.

2 This property sets the Octavia provider that your load balancer uses. It accepts "ovn" or "amphora" as values. If you choose to use OVN, you must also set **lb-method** to **SOURCE\_IP\_PORT**.

3 This property is required if you want to use multiple external networks with your cluster. The cloud provider creates floating IP addresses on the network that is specified here.



#### IMPORTANT

Prior to saving your changes, verify that the file is structured correctly. Clusters might fail if properties are not placed in the appropriate section.



#### IMPORTANT

For installations that use Kuryr, Kuryr handles relevant services. There is no need to configure Octavia load balancing in the cloud provider.



4. Save the changes to the file and proceed with installation.

### TIP

You can update your cloud provider configuration after you run the installer. On a command line, run:

```
$ oc edit configmap -n openshift-config cloud-provider-config
```

After you save your changes, your cluster will take some time to reconfigure itself. The process is complete if none of your nodes have a **SchedulingDisabled** status.

### Additional resources

- For more information about cloud provider configuration, see [OpenStack cloud provider options](#).

## 15.8.8. Creating the RHCOS image for restricted network installations

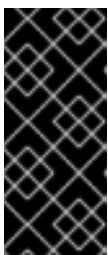
Download the Red Hat Enterprise Linux CoreOS (RHCOS) image to install OpenShift Container Platform on a restricted network Red Hat OpenStack Platform (RHOSP) environment.

### Prerequisites

- Obtain the OpenShift Container Platform installation program. For a restricted network installation, the program is on your mirror registry host.

### Procedure

1. Log in to the Red Hat Customer Portal's [Product Downloads page](#).
2. Under **Version**, select the most recent release of OpenShift Container Platform 4.9 for RHEL 8.



### IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image versions that match your OpenShift Container Platform version if they are available.

3. Download the **Red Hat Enterprise Linux CoreOS (RHCOS) - OpenStack Image (QCOW)** image.
4. Decompress the image.



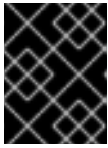
### NOTE

You must decompress the image before the cluster can use it. The name of the downloaded file might not contain a compression extension, like **.gz** or **.tgz**. To find out if or how the file is compressed, in a command line, enter:

```
$ file <name_of_downloaded_file>
```

5. Upload the image that you decompressed to a location that is accessible from the bastion server, like Glance. For example:

```
$ openstack image create --file rhcos-44.81.202003110027-0-openstack.x86_64.qcow2 --
disk-format qcow2 rhcos-${RHCOS_VERSION}
```



### IMPORTANT

Depending on your RHOSP environment, you might be able to upload the image in either [.raw](#) or [.qcow2](#) formats. If you use Ceph, you must use the **.raw** format.



### WARNING

If the installation program finds multiple images with the same name, it chooses one of them at random. To avoid this behavior, create unique names for resources in RHOSP.

The image is now available for a restricted installation. Note the image name or location for use in OpenShift Container Platform deployment.

## 15.8.9. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Red Hat OpenStack Platform (RHOSP).

### Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster. For a restricted network installation, these files are on your mirror host.
- Have the **imageContentSources** values that were generated during mirror registry creation.
- Obtain the contents of the certificate for your mirror registry.
- Retrieve a Red Hat Enterprise Linux CoreOS (RHCOS) image and upload it to an accessible location.
- Obtain service principal permissions at the subscription level.

### Procedure

1. Create the **install-config.yaml** file.
  - a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

- 1 For `<installation_directory>`, specify the directory name to store the files that the installation program creates.



### IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

- b. At the prompts, provide the configuration details for your cloud:
  - i. Optional: Select an SSH key to use to access your cluster machines.



### NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

- ii. Select **openstack** as the platform to target.
  - iii. Specify the Red Hat OpenStack Platform (RHOSP) external network name to use for installing the cluster.
  - iv. Specify the floating IP address to use for external access to the OpenShift API.
  - v. Specify a RHOSP flavor with at least 16 GB RAM to use for control plane nodes and 8 GB RAM for compute nodes.
  - vi. Select the base domain to deploy the cluster to. All DNS records will be sub-domains of this base and will also include the cluster name.
  - vii. Enter a name for your cluster. The name must be 14 or fewer characters long.
  - viii. Paste the [pull secret from the Red Hat OpenShift Cluster Manager](#) .
2. In the **install-config.yaml** file, set the value of **platform.openstack.clusterOSImage** to the image location or name. For example:

```
platform:
  openstack:
    clusterOSImage: http://mirror.example.com/images/rhcos-43.81.201912131630.0-
    openstack.x86_64.qcow2.gz?
    sha256=ffebbd68e8a1f2a245ca19522c16c86f67f9ac8e4e0c1f0a812b068b16f7265d
```

3. Edit the **install-config.yaml** file to provide the additional information that is required for an installation in a restricted network.
  - a. Update the **pullSecret** value to contain the authentication information for your registry:



- For Kuryr installations on restricted networks that use the **Proxy** object, the proxy must be able to reply to the router that the cluster uses. To add a static route for the proxy configuration, from a command line as the root user, enter:

```
$ ip route add <cluster_network_cidr> via <installer_subnet_gateway>
```

- The restricted subnet must have a gateway that is defined and available to be linked to the **Router** resource that Kuryr creates.
- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



## NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

## Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
  additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
  ...
```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations.
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide

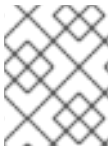
**additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

**NOTE**

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

**NOTE**

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

### 15.8.9.2. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.

**NOTE**

After installation, you cannot modify these parameters in the **install-config.yaml** file.

**IMPORTANT**

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

#### 15.8.9.2.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 15.36. Required parameters

Parameter	Description	Values
-----------	-------------	--------

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;</b> . <b>&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}</b> . <b>{{.baseDomain}}</b> .	String of lowercase letters, hyphens (-), and periods (.), such as <b>dev</b> . The string must be 14 characters or fewer long.
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws, baremetal, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object


Parameter	Description	Values
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } }</pre>

### 15.8.9.2.2. Network configuration parameters


You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

Table 15.37. Network parameters

Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	Object <div style="display: flex; align-items: center; margin-top: 10px;">  <div> <p><b>NOTE</b></p> <p>You cannot modify parameters specified by the <b>networking</b> object after installation.</p> </div> </div>
<b>networking.networkType</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .




Parameter	Description	Values
<b>networking.clusterNetwork</b>	<p>The IP address blocks for pods.</p> <p>The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b>.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   clusterNetwork:     - cidr: 10.128.0.0/14       hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	<p>Required if you use <b>networking.clusterNetwork</b>. An IP address block.</p> <p>An IPv4 network.</p>	<p>An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b>.</p>
<b>networking.clusterNetwork.hostPrefix</b>	<p>The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b>. A <b>hostPrefix</b> value of <b>23</b> provides 510 (<math>2^{(32 - 23)} - 2</math>) pod IP addresses.</p>	<p>A subnet prefix.</p> <p>The default value is <b>23</b>.</p>
<b>networking.serviceNetwork</b>	<p>The IP address block for services. The default value is <b>172.30.0.0/16</b>.</p> <p>The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.</p>	<p>An array with an IP address block in CIDR format. For example:</p> <pre>networking:   serviceNetwork:     - 172.30.0.0/16</pre>
<b>networking.machineNetwork</b>	<p>The IP address blocks for machines.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   machineNetwork:     - cidr: 10.0.0.0/16</pre>
<b>networking.machineNetwork.cidr</b>	<p>Required if you use <b>networking.machineNetwork</b>. An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b>.</p>	<p>An IP network block in CIDR notation.</p> <p>For example, <b>10.0.0.0/16</b>.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p> </div> </div>



## 15.8.9.2.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:


Table 15.38. Optional parameters

Parameter	Description	Values
<b>additionalTrustBundle</b>	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
<b>compute</b>	The configuration for the machines that comprise the compute nodes.	Array of <b>MachinePool</b> objects.
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String
<b>compute.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>

Parameter	Description	Values
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String
<b>controlPlane.hypertreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: flex-start;"> <div style="background-color: black; width: 20px; height: 100px; margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platform</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>controlPlane.replicas</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.

Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.</p> <p> <b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators reference content</i>.</p> <p> <b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p>	<b>Mint, Passthrough, Manual</b> or an empty string ("").

Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start;"> <div style="width: 30px; height: 30px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 30px; height: 30px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<b>Internal</b> or <b>External</b> . The default value is <b>External</b> .  Setting this field to <b>Internal</b> is not supported on non-cloud platforms.

Parameter	Description	Values
<b>sshKey</b>	<p>The SSH key or keys to authenticate access your cluster machines.</p>  <p><b>NOTE</b></p> <p>For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.</p>	<p>One or more keys. For example:</p> <pre>sshKey:   &lt;key1&gt;   &lt;key2&gt;   &lt;key3&gt;</pre>

#### 15.8.9.2.4. Additional Red Hat OpenStack Platform (RHOSP) configuration parameters

Additional RHOSP configuration parameters are described in the following table:

Table 15.39. Additional RHOSP parameters

Parameter	Description	Values
<b>compute.platform.openstack.rootVolume.size</b>	For compute machines, the size in gigabytes of the root volume. If you do not set this value, machines use ephemeral storage.	Integer, for example <b>30</b> .
<b>compute.platform.openstack.rootVolume.type</b>	For compute machines, the root volume's type.	String, for example <b>performance</b> .
<b>controlPlane.platform.openstack.rootVolume.size</b>	For control plane machines, the size in gigabytes of the root volume. If you do not set this value, machines use ephemeral storage.	Integer, for example <b>30</b> .
<b>controlPlane.platform.openstack.rootVolume.type</b>	For control plane machines, the root volume's type.	String, for example <b>performance</b> .
<b>platform.openstack.cloud</b>	The name of the RHOSP cloud to use from the list of clouds in the <b>clouds.yaml</b> file.	String, for example <b>MyCloud</b> .

Parameter	Description	Values
<b>platform.openstack.externalNetwork</b>	The RHOSP external network name to be used for installation.	String, for example <b>external</b> .
<b>platform.openstack.computeFlavor</b>	<p>The RHOSP flavor to use for control plane and compute machines.</p> <p>This property is deprecated. To use a flavor as the default for all machine pools, add it as the value of the <b>type</b> key in the <b>platform.openstack.defaultMachinePlatform</b> property. You can also set a flavor value for each machine pool individually.</p>	String, for example <b>m1.xlarge</b> .

#### 15.8.9.2.5. Optional RHOSP configuration parameters

Optional RHOSP configuration parameters are described in the following table:

Table 15.40. Optional RHOSP parameters

Parameter	Description	Values
<b>compute.platform.openstack.additionalNetworkIDs</b>	Additional networks that are associated with compute machines. Allowed address pairs are not created for additional networks.	A list of one or more UUIDs as strings. For example, <b>fa806b2f-ac49-4bce-b9db-124bc64209bf</b> .
<b>compute.platform.openstack.additionalSecurityGroupIDs</b>	Additional security groups that are associated with compute machines.	A list of one or more UUIDs as strings. For example, <b>7ee219f3-d2e9-48a1-96c2-e7429f1b0da7</b> .

Parameter	Description	Values
<b>compute.platform.openstack.zones</b>	<p>RHOSP Compute (Nova) availability zones (AZs) to install machines on. If this parameter is not set, the installer relies on the default settings for Nova that the RHOSP administrator configured.</p> <p>On clusters that use Kuryr, RHOSP Octavia does not support availability zones. Load balancers and, if you are using the Amphora provider driver, OpenShift Container Platform services that rely on Amphora VMs, are not created according to the value of this property.</p>	A list of strings. For example, <b>["zone-1", "zone-2"]</b> .
<b>compute.platform.openstack.rootVolume.zones</b>	For compute machines, the availability zone to install root volumes on. If you do not set a value for this parameter, the installer selects the default availability zone.	A list of strings, for example <b>["zone-1", "zone-2"]</b> .
<b>controlPlane.platform.openstack.additionalNetworkIDs</b>	Additional networks that are associated with control plane machines. Allowed address pairs are not created for additional networks.	A list of one or more UUIDs as strings. For example, <b>fa806b2f-ac49-4bce-b9db-124bc64209bf</b> .
<b>controlPlane.platform.openstack.additionalSecurityGroupIDs</b>	Additional security groups that are associated with control plane machines.	A list of one or more UUIDs as strings. For example, <b>7ee219f3-d2e9-48a1-96c2-e7429f1b0da7</b> .



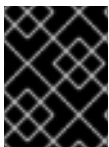
Parameter	Description	Values
<b>controlPlane.platform.openstack.zones</b>	<p>RHOSP Compute (Nova) availability zones (AZs) to install machines on. If this parameter is not set, the installer relies on the default settings for Nova that the RHOSP administrator configured.</p> <p>On clusters that use Kuryr, RHOSP Octavia does not support availability zones. Load balancers and, if you are using the Amphora provider driver, OpenShift Container Platform services that rely on Amphora VMs, are not created according to the value of this property.</p>	A list of strings. For example, <b>["zone-1", "zone-2"]</b> .
<b>controlPlane.platform.openstack.rootVolume.zones</b>	For control plane machines, the availability zone to install root volumes on. If you do not set this value, the installer selects the default availability zone.	A list of strings, for example <b>["zone-1", "zone-2"]</b> .
<b>platform.openstack.clusterOSImage</b>	<p>The location from which the installer downloads the RHCOS image.</p> <p>You must set this parameter to perform an installation in a restricted network.</p>	<p>An HTTP or HTTPS URL, optionally with an SHA-256 checksum.</p> <p>For example,  <b>http://mirror.example.com/images/rhcos-43.81.201912131630.0-openstack.x86_64.qcow2.gz?sha256=ffebbd68e8a1f2a245ca19522c16c86f67f9ac8e4e0c1f0a812b068b16f7265d</b>. The value can also be the name of an existing Glance image, for example <b>my-rhcos</b>.</p>

Parameter	Description	Values
<b>platform.openstack.clusterOSImageProperties</b>	<p>Properties to add to the installer-uploaded ClusterOSImage in Glance. This property is ignored if <b>platform.openstack.clusterOSImage</b> is set to an existing Glance image.</p> <p>You can use this property to exceed the default persistent volume (PV) limit for RHOSP of 26 PVs per node. To exceed the limit, set the <b>hw_scsi_model</b> property value to <b>virtio-scsi</b> and the <b>hw_disk_bus</b> value to <b>scsi</b>.</p> <p>You can also use this property to enable the QEMU guest agent by including the <b>hw_qemu_guest_agent</b> property with a value of <b>yes</b>.</p>	A list of key-value string pairs. For example, <b>["hw_scsi_model": "virtio-scsi", "hw_disk_bus": "scsi"]</b> .
<b>platform.openstack.defaultMachinePlatform</b>	The default machine pool platform configuration.	<pre>{   "type": "ml.large",   "rootVolume": {     "size": 30,     "type": "performance"   } }</pre>
<b>platform.openstack.ingressFloatingIP</b>	An existing floating IP address to associate with the Ingress port. To use this property, you must also define the <b>platform.openstack.externalNetwork</b> property.	An IP address, for example <b>128.0.0.1</b> .
<b>platform.openstack.apiFloatingIP</b>	An existing floating IP address to associate with the API load balancer. To use this property, you must also define the <b>platform.openstack.externalNetwork</b> property.	An IP address, for example <b>128.0.0.1</b> .
<b>platform.openstack.externalDNS</b>	IP addresses for external DNS servers that cluster instances use for DNS resolution.	A list of IP addresses as strings. For example, <b>["8.8.8.8", "192.168.1.12"]</b> .

Parameter	Description	Values
<b>platform.openstack.machinesSubnet</b>	<p>The UUID of a RHOSP subnet that the cluster's nodes use. Nodes and virtual IP (VIP) ports are created on this subnet.</p> <p>The first item in <b>networking.machineNetwork</b> must match the value of <b>machinesSubnet</b>.</p> <p>If you deploy to a custom subnet, you cannot specify an external DNS server to the OpenShift Container Platform installer. Instead, <a href="#">add DNS to the subnet in RHOSP</a>.</p>	A UUID as a string. For example, <b>fa806b2f-ac49-4bce-b9db-124bc64209bf</b> .

### 15.8.9.3. Sample customized `install-config.yaml` file for restricted OpenStack installations

This sample **`install-config.yaml`** demonstrates all of the possible Red Hat OpenStack Platform (RHOSP) customization options.



#### IMPORTANT

This sample file is provided for reference only. You must obtain your **`install-config.yaml`** file by using the installation program.

```

apiVersion: v1
baseDomain: example.com
controlPlane:
  name: master
  platform: {}
  replicas: 3
compute:
- name: worker
  platform:
    openstack:
      type: ml.large
    replicas: 3
metadata:
  name: example
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  serviceNetwork:
  - 172.30.0.0/16
networkType: OpenShiftSDN

```

```

platform:
  openstack:
    region: region1
    cloud: mycloud
    externalNetwork: external
    computeFlavor: m1.xlarge
    apiFloatingIP: 128.0.0.1
  fips: false
  pullSecret: '{"auths": ...}'
  sshKey: ssh-ed25519 AAAA...
  additionalTrustBundle: |

  -----BEGIN CERTIFICATE-----

  /-----END CERTIFICATE-----

imageContentSources:
- mirrors:
  - <mirror_registry>/<repo_name>/release
  source: quay.io/openshift-release-dev/ocp-release
- mirrors:
  - <mirror_registry>/<repo_name>/release
  source: quay.io/openshift-release-dev/ocp-v4.0-art-dev

```

### 15.8.10. Setting compute machine affinity

Optionally, you can set the affinity policy for compute machines during installation. The installer does not select an affinity policy for compute machines by default.

You can also create machine sets that use particular RHOSP server groups after installation.



#### NOTE

Control plane machines are created with a **soft-anti-affinity** policy.

#### TIP

You can learn more about [RHOSP instance scheduling and placement](#) in the RHOSP documentation.

#### Prerequisites

- Create the **install-config.yaml** file and complete any modifications to it.

#### Procedure

1. Using the RHOSP command-line interface, create a server group for your compute machines. For example:

```

$ openstack \
  --os-compute-api-version=2.15 \
  server group create \

```

```
--policy anti-affinity \
my-openshift-worker-group
```

For more information, see the [server group create command documentation](#).

2. Change to the directory that contains the installation program and create the manifests:

```
$ ./openshift-install create manifests --dir <installation_directory>
```

where:

### **installation\_directory**

Specifies the name of the directory that contains the **install-config.yaml** file for your cluster.

3. Open **manifests/99\_openshift-cluster-api\_worker-machineset-0.yaml**, the **MachineSet** definition file.
4. Add the property **serverGroupID** to the definition beneath the **spec.template.spec.providerSpec.value** property. For example:

```
apiVersion: machine.openshift.io/v1beta1
kind: MachineSet
metadata:
  labels:
    machine.openshift.io/cluster-api-cluster: <infrastructure_ID>
    machine.openshift.io/cluster-api-machine-role: <node_role>
    machine.openshift.io/cluster-api-machine-type: <node_role>
  name: <infrastructure_ID>-<node_role>
  namespace: openshift-machine-api
spec:
  replicas: <number_of_replicas>
  selector:
    matchLabels:
      machine.openshift.io/cluster-api-cluster: <infrastructure_ID>
      machine.openshift.io/cluster-api-machineset: <infrastructure_ID>-<node_role>
  template:
    metadata:
      labels:
        machine.openshift.io/cluster-api-cluster: <infrastructure_ID>
        machine.openshift.io/cluster-api-machine-role: <node_role>
        machine.openshift.io/cluster-api-machine-type: <node_role>
        machine.openshift.io/cluster-api-machineset: <infrastructure_ID>-<node_role>
    spec:
      providerSpec:
        value:
          apiVersion: openstackproviderconfig.openshift.io/v1alpha1
          cloudName: openstack
          cloudsSecret:
            name: openstack-cloud-credentials
            namespace: openshift-machine-api
          flavor: <nova_flavor>
          image: <glance_image_name_or_location>
          serverGroupID: aaaaaaaa-bbbb-cccc-dddd-eeeeeeeeeeee 1
          kind: OpenstackProviderSpec
```

```

networks:
- filter: {}
  subnets:
  - filter:
    name: <subnet_name>
    tags: openshiftClusterID=<infrastructure_ID>
securityGroups:
- filter: {}
  name: <infrastructure_ID>-<node_role>
serverMetadata:
  Name: <infrastructure_ID>-<node_role>
  openshiftClusterID: <infrastructure_ID>
tags:
- openshiftClusterID=<infrastructure_ID>
trunk: true
userDataSecret:
  name: <node_role>-user-data
availabilityZone: <optional_openstack_availability_zone>

```

**1** Add the UUID of your server group here.

- Optional: Back up the **manifests/99\_openshift-cluster-api\_worker-machineset-0.yaml** file. The installation program deletes the **manifests/** directory when creating the cluster.

When you install the cluster, the installer uses the **MachineSet** definition that you modified to create compute machines within your RHOSP server group.

### 15.8.11. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.



#### IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



#### NOTE

You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

#### Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.



#### NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.



#### NOTE

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

#### Example output

```
Agent pid 31874
```



#### NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1 Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

### Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

### Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

## 15.8.12. Enabling access to the environment

At deployment, all OpenShift Container Platform machines are created in a Red Hat OpenStack Platform (RHOSP)-tenant network. Therefore, they are not accessible directly in most RHOSP deployments.

You can configure OpenShift Container Platform API and application access by using floating IP addresses (FIPs) during installation. You can also complete an installation without configuring FIPs, but the installer will not configure a way to reach the API or applications externally.

### 15.8.12.1. Enabling access with floating IP addresses

Create floating IP (FIP) addresses for external access to the OpenShift Container Platform API and cluster applications.

#### Procedure

1. Using the Red Hat OpenStack Platform (RHOSP) CLI, create the API FIP:

```
$ openstack floating ip create --description "API <cluster_name>.<base_domain>"  
<external_network>
```

2. Using the Red Hat OpenStack Platform (RHOSP) CLI, create the apps, or Ingress, FIP:

```
$ openstack floating ip create --description "Ingress <cluster_name>.<base_domain>"  
<external_network>
```

3. Add records that follow these patterns to your DNS server for the API and Ingress FIPs:

```
api.<cluster_name>.<base_domain>. IN A <API_FIP>  
*.apps.<cluster_name>.<base_domain>. IN A <apps_FIP>
```





## NOTE

If you do not control the DNS server, you can access the cluster by adding the cluster domain names such as the following to your `/etc/hosts` file:

- `<api_floating_ip> api.<cluster_name>.<base_domain>`
- `<application_floating_ip> grafana-openshift-monitoring.apps.<cluster_name>.<base_domain>`
- `<application_floating_ip> prometheus-k8s-openshift-monitoring.apps.<cluster_name>.<base_domain>`
- `<application_floating_ip> oauth-openshift.apps.<cluster_name>.<base_domain>`
- `<application_floating_ip> console-openshift-console.apps.<cluster_name>.<base_domain>`
- `application_floating_ip integrated-oauth-server-openshift-authentication.apps.<cluster_name>.<base_domain>`

The cluster domain names in the `/etc/hosts` file grant access to the web console and the monitoring interface of your cluster locally. You can also use the `kubectl` or `oc`. You can access the user applications by using the additional entries pointing to the `<application_floating_ip>`. This action makes the API and applications accessible to only you, which is not suitable for production deployment, but does allow installation for development and testing.

4. Add the FIPs to the `install-config.yaml` file as the values of the following parameters:

- `platform.openstack.ingressFloatingIP`
- `platform.openstack.apiFloatingIP`

If you use these values, you must also enter an external network as the value of the `platform.openstack.externalNetwork` parameter in the `install-config.yaml` file.

## TIP

You can make OpenShift Container Platform resources available outside of the cluster by assigning a floating IP address and updating your firewall configuration.

### 15.8.12.2. Completing installation without floating IP addresses

You can install OpenShift Container Platform on Red Hat OpenStack Platform (RHOSP) without providing floating IP addresses.

In the `install-config.yaml` file, do not define the following parameters:

- `platform.openstack.ingressFloatingIP`
- `platform.openstack.apiFloatingIP`

If you cannot provide an external network, you can also leave `platform.openstack.externalNetwork` blank. If you do not provide a value for `platform.openstack.externalNetwork`, a router is not created for

you, and, without additional action, the installer will fail to retrieve an image from Glance. You must configure external connectivity on your own.

If you run the installer from a system that cannot reach the cluster API due to a lack of floating IP addresses or name resolution, installation fails. To prevent installation failure in these cases, you can use a proxy network or run the installer from a system that is on the same network as your machines.



## NOTE

You can enable name resolution by creating DNS records for the API and Ingress ports. For example:

```
api.<cluster_name>.<base_domain>. IN A <api_port_IP>
*.apps.<cluster_name>.<base_domain>. IN A <ingress_port_IP>
```

If you do not control the DNS server, you can add the record to your `/etc/hosts` file. This action makes the API accessible to only you, which is not suitable for production deployment but does allow installation for development and testing.

## 15.8.13. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



## IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

### Prerequisites

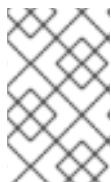
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

### Procedure

1. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
--log-level=info 2
```

- 1 For **<installation\_directory>**, specify the location of your customized `./install-config.yaml` file.
- 2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.



## NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

When the cluster deployment completes, directions for accessing your cluster, including a link to its web console and credentials for the **kubeadmin** user, display in your terminal.

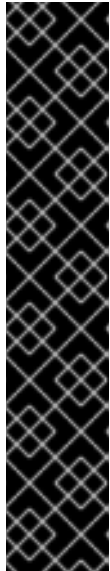
### Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Ee6gm-ymBZj-
Wt5AL"
INFO Time elapsed: 36m22s
```



### NOTE

The cluster access and credential information also outputs to **<installation\_directory>/openshift\_install.log** when an installation succeeds.



### IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.



### IMPORTANT

You must not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

## 15.8.14. Verifying cluster status

You can verify your OpenShift Container Platform cluster's status during or after installation.

### Procedure

1. In the cluster environment, export the administrator's kubeconfig file:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server.

2. View the control plane and compute machines created after a deployment:

```
$ oc get nodes
```

3. View your cluster's version:

```
$ oc get clusterversion
```

4. View your Operators' status:

```
$ oc get clusteroperator
```

5. View all running pods in the cluster:

```
$ oc get pods -A
```

### 15.8.15. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

#### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

#### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

#### Example output

```
system:admin
```

#### Additional resources

- See [Accessing the web console](#) for more details about accessing and understanding the OpenShift Container Platform web console.

### 15.8.16. Disabling the default OperatorHub sources

Operator catalogs that source content provided by Red Hat and community projects are configured for OperatorHub by default during an OpenShift Container Platform installation. In a restricted network environment, you must disable the default catalogs as a cluster administrator.

#### Procedure

- Disable the sources for the default catalogs by adding **disableAllDefaultSources: true** to the **OperatorHub** object:

```
$ oc patch OperatorHub cluster --type json \
  -p '[{"op": "add", "path": "/spec/disableAllDefaultSources", "value": true}]'
```

#### TIP

Alternatively, you can use the web console to manage catalog sources. From the **Administration** → **Cluster Settings** → **Configuration** → **OperatorHub** page, click the **Sources** tab, where you can create, delete, disable, and enable individual sources.

### 15.8.17. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

#### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

### 15.8.18. Next steps

- [Customize your cluster](#).
- If the mirror registry that you used to install your cluster has a trusted CA, add it to the cluster by [configuring additional trust stores](#).
- If necessary, you can [opt out of remote health reporting](#).
- [Configure image streams](#) for the Cluster Samples Operator and the **must-gather** tool.
- Learn how to [use Operator Lifecycle Manager \(OLM\) on restricted networks](#).
- If you did not configure RHOSP to accept application traffic over floating IP addresses, [configure RHOSP access with floating IP addresses](#).

## 15.9. OPENSTACK CLOUD CONFIGURATION REFERENCE GUIDE

A cloud provider configuration controls how OpenShift Container Platform interacts with Red Hat OpenStack Platform (RHOSP). Use the following parameters in a cloud-provider configuration manifest file to configure your cluster.

### 15.9.1. OpenStack cloud provider options

The cloud provider configuration, typically stored as a file named **cloud.conf**, controls how OpenShift Container Platform interacts with Red Hat OpenStack Platform (RHOSP).

You can create a valid **cloud.conf** file by specifying the following options in it.

#### 15.9.1.1. Global options

The following options are used for RHOSP CCM authentication with the RHOSP Identity service, also known as Keystone. They are similar to the global options that you can set by using the **openstack CLI**.

Option	Description
<b>auth-url</b>	The RHOSP Identity service URL. For example, <b>http://128.110.154.166/identity</b> .
<b>ca-file</b>	Optional. The CA certificate bundle file for communication with the RHOSP Identity service. If you use the HTTPS protocol with The Identity service URL, this option is required.
<b>domain-id</b>	The Identity service user domain ID.  Leave this option unset if you are using Identity service application credentials.
<b>domain-name</b>	The Identity service user domain name.  This option is not required if you set <b>domain-id</b> .
<b>tenant-id</b>	The Identity service project ID. Leave this option unset if you are using Identity service application credentials.  In version 3 of the Identity API, which changed the identifier <b>tenant</b> to <b>project</b> , the value of <b>tenant-id</b> is automatically mapped to the project construct in the API.
<b>tenant-name</b>	The Identity service project name.
<b>username</b>	The Identity service user name.  Leave this option unset if you are using Identity service application credentials.

Option	Description
<b>password</b>	The Identity service user password.  Leave this option unset if you are using Identity service application credentials.
<b>region</b>	The Identity service region name.
<b>trust-id</b>	The Identity service trust ID. A trust represents the authorization of a user, or trustor, to delegate roles to another user, or trustee. Optionally, a trust authorizes the trustee to impersonate the trustor. You can find available trusts by querying the <b>/v3/OS-TRUST/trusts</b> endpoint of the Identity service API.

### 15.9.1.2. Load balancer options

The cloud provider supports several load balancer options for deployments that use Octavia.

Option	Description
<b>use-octavia</b>	Whether or not to use Octavia for the <b>LoadBalancer</b> type of the service implementation rather than Neutron-LBaaS. The default value is <b>true</b> .
<b>floating-network-id</b>	Optional. The external network used to create floating IP addresses for load balancer virtual IP addresses (VIPs). If there are multiple external networks in the cloud, this option must be set or the user must specify <b>loadbalancer.openstack.org/floating-network-id</b> in the service annotation.

Option	Description
<b>lb-method</b>	<p>The load balancing algorithm used to create the load balancer pool. For the Amphora provider the value can be <b>ROUND_ROBIN</b>, <b>LEAST_CONNECTIONS</b>, or <b>SOURCE_IP</b>. The default value is <b>ROUND_ROBIN</b>.</p> <p>For the OVN provider, only the <b>SOURCE_IP_PORT</b> algorithm is supported.</p> <p>For the Amphora provider, if using the <b>LEAST_CONNECTIONS</b> or <b>SOURCE_IP</b> methods, configure the <b>create-monitor</b> option as <b>true</b> in the <b>cloud-provider-config</b> config map on the <b>openshift-config</b> namespace and <b>ETP:Local</b> on the load-balancer type service to allow balancing algorithm enforcement in the client to service endpoint connections.</p>
<b>lb-provider</b>	Optional. Used to specify the provider of the load balancer, for example, <b>amphora</b> or <b>octavia</b> . Only the Amphora and Octavia providers are supported.
<b>lb-version</b>	Optional. The load balancer API version. Only <b>"v2"</b> is supported.
<b>subnet-id</b>	The ID of the Networking service subnet on which load balancer VIPs are created.
<b>create-monitor</b>	<p>Whether or not to create a health monitor for the service load balancer. A health monitor is required for services that declare <b>externalTrafficPolicy: Local</b>. The default value is <b>false</b>.</p> <p>This option is unsupported if you use RHOSP earlier than version 17 with the <b>ovn</b> provider.</p>
<b>monitor-delay</b>	The interval in seconds by which probes are sent to members of the load balancer. The default value is <b>5</b> .
<b>monitor-max-retries</b>	The number of successful checks that are required to change the operating status of a load balancer member to <b>ONLINE</b> . The valid range is <b>1</b> to <b>10</b> , and the default value is <b>1</b> .
<b>monitor-timeout</b>	The time in seconds that a monitor waits to connect to the back end before it times out. The default value is <b>3</b> .



### 15.9.1.3. Metadata options

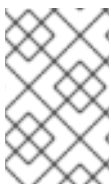
Option	Description
<b>search-order</b>	<p>This configuration key affects the way that the provider retrieves metadata that relates to the instances in which it runs. The default value of <b>configDrive,metadataService</b> results in the provider retrieving instance metadata from the configuration drive first if available, and then the metadata service. Alternative values are:</p> <ul style="list-style-type: none"> <li>● <b>configDrive</b>: Only retrieve instance metadata from the configuration drive.</li> <li>● <b>metadataService</b>: Only retrieve instance metadata from the metadata service.</li> <li>● <b>metadataService,configDrive</b>: Retrieve instance metadata from the metadata service first if available, and then retrieve instance metadata from the configuration drive.</li> </ul>

## 15.10. UNINSTALLING A CLUSTER ON OPENSTACK

You can remove a cluster that you deployed to Red Hat OpenStack Platform (RHOSP).

### 15.10.1. Removing a cluster that uses installer-provisioned infrastructure

You can remove a cluster that uses installer-provisioned infrastructure from your cloud.



#### NOTE

After uninstallation, check your cloud provider for any resources not removed properly, especially with User Provisioned Infrastructure (UPI) clusters. There might be resources that the installer did not create or that the installer is unable to access.

#### Prerequisites

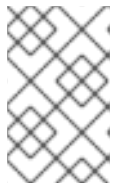
- Have a copy of the installation program that you used to deploy the cluster.
- Have the files that the installation program generated when you created your cluster.

#### Procedure

1. From the directory that contains the installation program on the computer that you used to install the cluster, run the following command:

```
$ ./openshift-install destroy cluster \
--dir <installation_directory> --log-level info 1 2
```

- 1 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.
- 2 To view different details, specify **warn**, **debug**, or **error** instead of **info**.

**NOTE**

You must specify the directory that contains the cluster definition files for your cluster. The installation program requires the **metadata.json** file in this directory to delete the cluster.

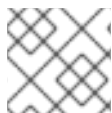
2. Optional: Delete the **<installation\_directory>** directory and the OpenShift Container Platform installation program.

## 15.11. UNINSTALLING A CLUSTER ON RHOSP FROM YOUR OWN INFRASTRUCTURE

You can remove a cluster that you deployed to Red Hat OpenStack Platform (RHOSP) on user-provisioned infrastructure.

### 15.11.1. Downloading playbook dependencies

The Ansible playbooks that simplify the removal process on user-provisioned infrastructure require several Python modules. On the machine where you will run the process, add the modules' repositories and then download them.

**NOTE**

These instructions assume that you are using Red Hat Enterprise Linux (RHEL) 8.

#### Prerequisites

- Python 3 is installed on your machine.

#### Procedure

1. On a command line, add the repositories:

- a. Register with Red Hat Subscription Manager:

```
$ sudo subscription-manager register # If not done already
```

- b. Pull the latest subscription data:

```
$ sudo subscription-manager attach --pool=$YOUR_POOLID # If not done already
```

- c. Disable the current repositories:

```
$ sudo subscription-manager repos --disable=* # If not done already
```

- d. Add the required repositories:

-

```
$ sudo subscription-manager repos \
--enable=rhel-8-for-x86_64-baseos-rpms \
--enable=openstack-16-tools-for-rhel-8-x86_64-rpms \
--enable=ansible-2.9-for-rhel-8-x86_64-rpms \
--enable=rhel-8-for-x86_64-appstream-rpms
```

2. Install the modules:

```
$ sudo yum install python3-openstackclient ansible python3-openstacksdk
```

3. Ensure that the **python** command points to **python3**:

```
$ sudo alternatives --set python /usr/bin/python3
```

### 15.11.2. Removing a cluster from RHOSP that uses your own infrastructure

You can remove an OpenShift Container Platform cluster on Red Hat OpenStack Platform (RHOSP) that uses your own infrastructure. To complete the removal process quickly, run several Ansible playbooks.

#### Prerequisites

- Python 3 is installed on your machine.
- You downloaded the modules in "Downloading playbook dependencies."
- You have the playbooks that you used to install the cluster.
- You modified the playbooks that are prefixed with **down-** to reflect any changes that you made to their corresponding installation playbooks. For example, changes to the **bootstrap.yaml** file are reflected in the **down-bootstrap.yaml** file.
- All of the playbooks are in a common directory.

#### Procedure

1. On a command line, run the playbooks that you downloaded:

```
$ ansible-playbook -i inventory.yaml \
down-bootstrap.yaml \
down-control-plane.yaml \
down-compute-nodes.yaml \
down-load-balancers.yaml \
down-network.yaml \
down-security-groups.yaml
```

2. Remove any DNS record changes you made for the OpenShift Container Platform installation.

OpenShift Container Platform is removed from your infrastructure.

## CHAPTER 16. INSTALLING ON RHV

### 16.1. PREPARING TO INSTALL ON RED HAT VIRTUALIZATION (RHV)

#### 16.1.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You have a supported combination of versions in the [Support Matrix for OpenShift Container Platform on Red Hat Virtualization \(RHV\)](#).
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).

#### 16.1.2. Choosing a method to install OpenShift Container Platform on RHV

You can install OpenShift Container Platform on installer-provisioned or user-provisioned infrastructure. The default installation type uses installer-provisioned infrastructure, where the installation program provisions the underlying infrastructure for the cluster. You can also install OpenShift Container Platform on infrastructure that you provision. If you do not use infrastructure that the installation program provisions, you must manage and maintain the cluster resources yourself.

See [Installation process](#) for more information about installer-provisioned and user-provisioned installation processes.

##### 16.1.2.1. Installing a cluster on installer-provisioned infrastructure

You can install a cluster on Red Hat Virtualization (RHV) virtual machines that are provisioned by the OpenShift Container Platform installation program, by using one of the following methods:

- **Installing a cluster quickly on RHV** You can quickly install OpenShift Container Platform on RHV virtual machines that the OpenShift Container Platform installation program provisions.
- **Installing a cluster on RHV with customizations** You can install a customized OpenShift Container Platform cluster on installer-provisioned guests on RHV. The installation program allows for some customization to be applied at the installation stage. Many other customization options are available [post-installation](#).

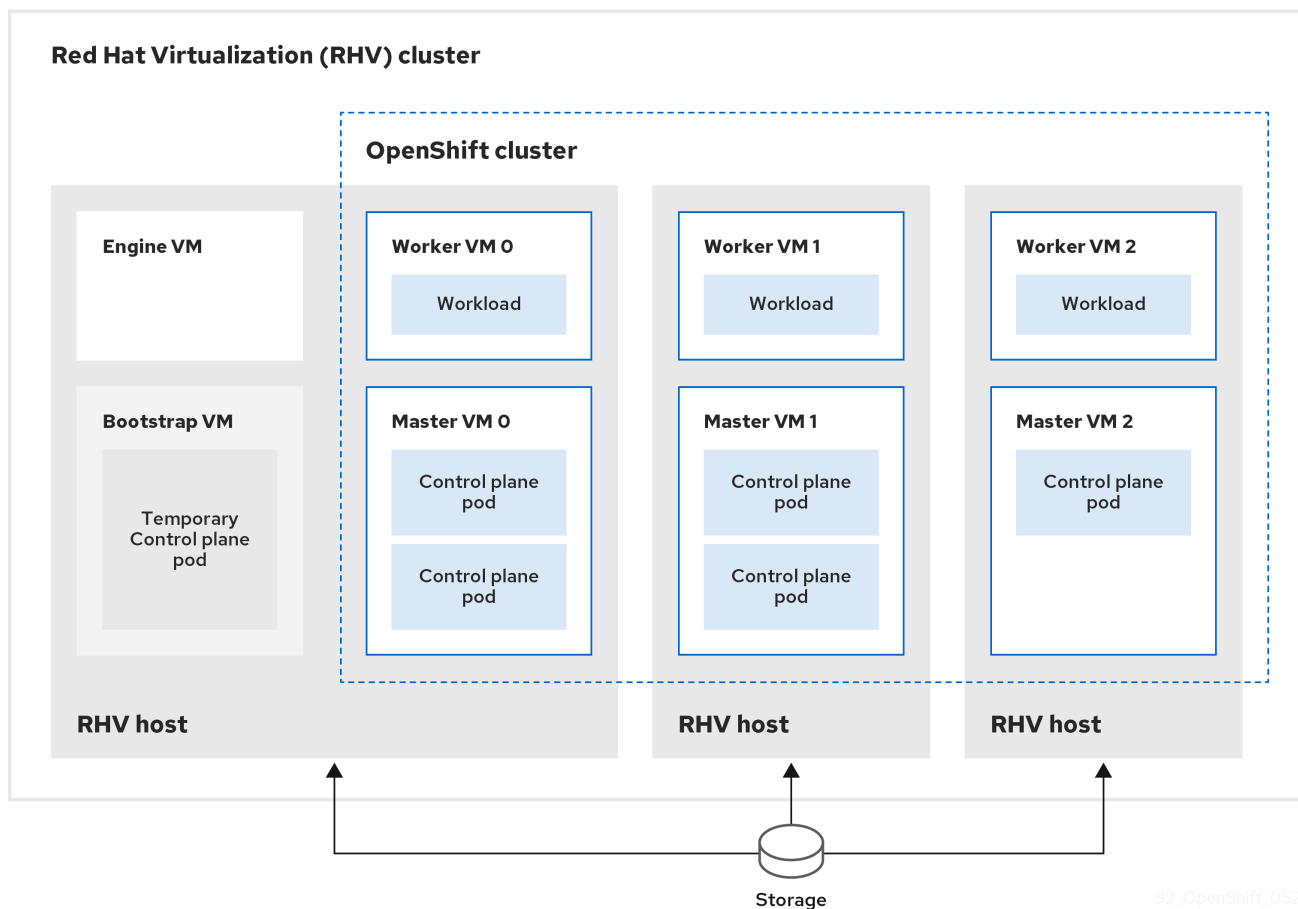
##### 16.1.2.2. Installing a cluster on user-provisioned infrastructure

You can install a cluster on RHV virtual machines that you provision, by using one of the following methods:

- **Installing a cluster on RHV with user-provisioned infrastructure** You can install OpenShift Container Platform on RHV virtual machines that you provision. You can use the provided Ansible playbooks to assist with the installation.
- **Installing a cluster on RHV in a restricted network** You can install OpenShift Container Platform on RHV in a restricted or disconnected network by creating an internal mirror of the installation release content. You can use this method to install a user-provisioned cluster that does not require an active internet connection to obtain the software components. You can also use this installation method to ensure that your clusters only use container images that satisfy your organizational controls on external content.

## 16.2. INSTALLING A CLUSTER QUICKLY ON RHV

You can quickly install a default, non-customized, OpenShift Container Platform cluster on a Red Hat Virtualization (RHV) cluster, similar to the one shown in the following diagram.



The installation program uses installer-provisioned infrastructure to automate creating and deploying the cluster.

To install a default cluster, you prepare the environment, run the installation program and answer its prompts. Then, the installation program creates the OpenShift Container Platform cluster.

For an alternative to installing a default cluster, see [Installing a cluster with customizations](#).



### NOTE

This installation program is available for Linux and macOS only.

### 16.2.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You have a supported combination of versions in the [Support Matrix for OpenShift Container Platform on Red Hat Virtualization \(RHV\)](#).
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).

- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.

## 16.2.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



### IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

## 16.2.3. Requirements for the RHV environment

To install and run an OpenShift Container Platform version 4.9 cluster, the RHV environment must meet the following requirements.

Not meeting these requirements can cause the installation or process to fail. Additionally, not meeting these requirements can cause the OpenShift Container Platform cluster to fail days or weeks after installation.

The following requirements for CPU, memory, and storage resources are based on **default** values multiplied by the default number of virtual machines the installation program creates. These resources must be available **in addition to** what the RHV environment uses for non-OpenShift Container Platform operations.

By default, the installation program creates seven virtual machines during the installation process. First, it creates a bootstrap virtual machine to provide temporary services and a control plane while it creates the rest of the OpenShift Container Platform cluster. When the installation program finishes creating the cluster, deleting the bootstrap machine frees up its resources.

If you increase the number of virtual machines in the RHV environment, you must increase the resources accordingly.

### Requirements

- The RHV version is 4.4.
- The RHV environment has one data center whose state is **Up**.
- The RHV data center contains an RHV cluster.

- The RHV cluster has the following resources exclusively for the OpenShift Container Platform cluster:
  - Minimum 28 vCPUs: four for each of the seven virtual machines created during installation.
  - 112 GiB RAM or more, including:
    - 16 GiB or more for the bootstrap machine, which provides the temporary control plane.
    - 16 GiB or more for each of the three control plane machines which provide the control plane.
    - 16 GiB or more for each of the three compute machines, which run the application workloads.
- The RHV storage domain must meet [these etcd backend performance requirements](#).
- For affinity group support: Three or more hosts in the RHV cluster. If necessary, you can disable affinity groups. For details, see *Example: Removing all affinity groups for a non-production lab setup* in *Installing a cluster on RHV with customizations*
- In production environments, each virtual machine must have 120 GiB or more. Therefore, the storage domain must provide 840 GiB or more for the default OpenShift Container Platform cluster. In resource-constrained or non-production environments, each virtual machine must have 32 GiB or more, so the storage domain must have 230 GiB or more for the default OpenShift Container Platform cluster.
- To download images from the Red Hat Ecosystem Catalog during installation and update procedures, the RHV cluster must have access to an internet connection. The Telemetry service also needs an internet connection to simplify the subscription and entitlement process.
- The RHV cluster must have a virtual network with access to the REST API on the RHV Manager. Ensure that DHCP is enabled on this network, because the VMs that the installer creates obtain their IP address by using DHCP.
- A user account and group with the following least privileges for installing and managing an OpenShift Container Platform cluster on the target RHV cluster:
  - **DiskOperator**
  - **DiskCreator**
  - **UserTemplateBasedVm**
  - **TemplateOwner**
  - **TemplateCreator**
  - **ClusterAdmin** on the target cluster

**WARNING**

Apply the principle of least privilege: Avoid using an administrator account with **SuperUser** privileges on RHV during the installation process. The installation program saves the credentials you provide to a temporary **ovirt-config.yaml** file that might be compromised.

**Additional resources**

- [Example: Removing all affinity groups for a non-production lab setup](#) .

**16.2.4. Verifying the requirements for the RHV environment**

Verify that the RHV environment meets the requirements to install and run an OpenShift Container Platform cluster. Not meeting these requirements can cause failures.

**IMPORTANT**

These requirements are based on the default resources the installation program uses to create control plane and compute machines. These resources include vCPUs, memory, and storage. If you change these resources or increase the number of OpenShift Container Platform machines, adjust these requirements accordingly.

**Procedure**

1. Check that the RHV version supports installation of OpenShift Container Platform version 4.9.
  - a. In the RHV Administration Portal, click the ? help icon in the upper-right corner and select **About**.
  - b. In the window that opens, make a note of the **RHV Software Version**
  - c. Confirm that the RHV version is 4.4. For more information about supported version combinations, see [Support Matrix for OpenShift Container Platform on RHV](#) .
2. Inspect the data center, cluster, and storage.
  - a. In the RHV Administration Portal, click **Compute → Data Centers**.
  - b. Confirm that the data center where you plan to install OpenShift Container Platform is accessible.
  - c. Click the name of that data center.
  - d. In the data center details, on the **Storage** tab, confirm the storage domain where you plan to install OpenShift Container Platform is **Active**.
  - e. Record the **Domain Name** for use later on.
  - f. Confirm **Free Space** has at least 230 GiB.



- g. Confirm that the storage domain meets [these etcd backend performance requirements](#), which you [can measure by using the fio performance benchmarking tool](#).
  - h. In the data center details, click the **Clusters** tab.
  - i. Find the RHV cluster where you plan to install OpenShift Container Platform. Record the cluster name for use later on.
3. Inspect the RHV host resources.
    - a. In the RHV Administration Portal, click **Compute > Clusters**.
    - b. Click the cluster where you plan to install OpenShift Container Platform.
    - c. In the cluster details, click the **Hosts** tab.
    - d. Inspect the hosts and confirm they have a combined total of at least 28 **Logical CPU Cores** available *exclusively* for the OpenShift Container Platform cluster.
    - e. Record the number of available **Logical CPU Cores** for use later on.
    - f. Confirm that these CPU cores are distributed so that each of the seven virtual machines created during installation can have four cores.
    - g. Confirm that, all together, the hosts have 112 GiB of **Max free Memory for scheduling new virtual machines** distributed to meet the requirements for each of the following OpenShift Container Platform machines:
      - 16 GiB required for the bootstrap machine
      - 16 GiB required for each of the three control plane machines
      - 16 GiB for each of the three compute machines
    - h. Record the amount of **Max free Memory for scheduling new virtual machines** for use later on.
  4. Verify that the virtual network for installing OpenShift Container Platform has access to the RHV Manager's REST API. From a virtual machine on this network, use curl to reach the RHV Manager's REST API:

```
$ curl -k -u <username>@<profile>:<password> \ 1
https://<engine-fqdn>/ovirt-engine/api 2
```

- 1 For **<username>**, specify the user name of an RHV account with privileges to create and manage an OpenShift Container Platform cluster on RHV. For **<profile>**, specify the login profile, which you can get by going to the RHV Administration Portal login page and reviewing the **Profile** dropdown list. For **<password>**, specify the password for that user name.

- 2 For **<engine-fqdn>**, specify the fully qualified domain name of the RHV environment.

For example:

```
$ curl -k -u ocpadmin@internal:pw123 \
https://rhv-env.virtlab.example.com/ovirt-engine/api
```

## 16.2.5. Preparing the network environment on RHV

Configure two static IP addresses for the OpenShift Container Platform cluster and create DNS entries using these addresses.

### Procedure

1. Reserve two static IP addresses
  - a. On the network where you plan to install OpenShift Container Platform, identify two static IP addresses that are outside the DHCP lease pool.
  - b. Connect to a host on this network and verify that each of the IP addresses is not in use. For example, use Address Resolution Protocol (ARP) to check that none of the IP addresses have entries:

```
$ arp 10.35.1.19
```

### Example output

```
10.35.1.19 (10.35.1.19) -- no entry
```

- c. Reserve two static IP addresses following the standard practices for your network environment.
  - d. Record these IP addresses for future reference.
2. Create DNS entries for the OpenShift Container Platform REST API and apps domain names using this format:

```
api.<cluster-name>.<base-domain> <ip-address> 1  
*.apps.<cluster-name>.<base-domain> <ip-address> 2
```

- 1 For **<cluster-name>**, **<base-domain>**, and **<ip-address>**, specify the cluster name, base domain, and static IP address of your OpenShift Container Platform API.
- 2 Specify the cluster name, base domain, and static IP address of your OpenShift Container Platform apps for Ingress and the load balancer.

For example:

```
api.my-cluster.virtlab.example.com 10.35.1.19  
*.apps.my-cluster.virtlab.example.com 10.35.1.20
```

## 16.2.6. Installing OpenShift Container Platform on RHV in insecure mode

By default, the installer creates a CA certificate, prompts you for confirmation, and stores the certificate to use during installation. You do not need to create or install one manually.

Although it is not recommended, you can override this functionality and install OpenShift Container Platform without verifying a certificate by installing OpenShift Container Platform on RHV in **insecure** mode.



## WARNING

Installing in **insecure** mode is not recommended, because it enables a potential attacker to perform a Man-in-the-Middle attack and capture sensitive credentials on the network.

### Procedure

1. Create a file named `~/.ovirt/ovirt-config.yaml`.
2. Add the following content to **ovirt-config.yaml**:

```
ovirt_url: https://ovirt.example.com/ovirt-engine/api 1
ovirt_fqdn: ovirt.example.com 2
ovirt_pem_url: ""
ovirt_username: ocpadmin@internal
ovirt_password: super-secret-password 3
ovirt_insecure: true
```

- 1 Specify the hostname or address of your oVirt engine.
- 2 Specify the fully qualified domain name of your oVirt engine.
- 3 Specify the admin password for your oVirt engine.

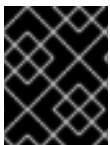
3. Run the installer.

### 16.2.7. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.



## IMPORTANT

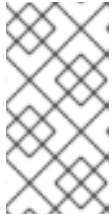
Do not skip this procedure in production environments, where disaster recovery and debugging is required.

### Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.



#### NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

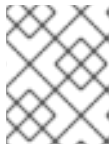
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.



#### NOTE

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

#### Example output

```
Agent pid 31874
```



#### NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1 Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

### Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

### Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

## 16.2.8. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

### Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space

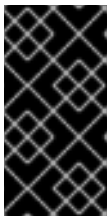
### Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



#### IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



#### IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

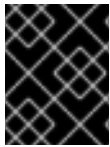
```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#) . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform

components.

## 16.2.9. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



### IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

### Prerequisites

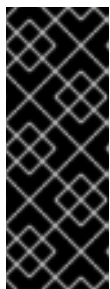
- Open the **ovirt-imageio** port to the Manager from the machine running the installer. By default, the port is **54322**.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

### Procedure

1. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
--log-level=info 2
```

- 1 For **<installation\_directory>**, specify the directory name to store the files that the installation program creates.
- 2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.



### IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

Respond to the installation program prompts.

- a. Optional: For **SSH Public Key**, select a password-less public key, such as `~/.ssh/id_rsa.pub`. This key authenticates connections with the new OpenShift Container Platform cluster.



### NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, select an SSH key that your **ssh-agent** process uses.

- b. For **Platform**, select **ovirt**.
- c. For **Engine FQDN[:PORT]**, enter the fully qualified domain name (FQDN) of the RHV environment.  
For example:

```
rhv-env.virtlab.example.com:443
```

- d. The installer automatically generates a CA certificate. For **Would you like to use the above certificate to connect to the Manager?**, answer **y** or **N**. If you answer **N**, you must install OpenShift Container Platform in insecure mode.
- e. For **Engine username**, enter the user name and profile of the RHV administrator using this format:

```
<username>@<profile> 1
```

- 1 For **<username>**, specify the user name of an RHV administrator. For **<profile>**, specify the login profile, which you can get by going to the RHV Administration Portal login page and reviewing the **Profile** dropdown list. For example: **admin@internal**.

- f. For **Engine password**, enter the RHV admin password.
- g. For **Cluster**, select the RHV cluster for installing OpenShift Container Platform.
- h. For **Storage domain**, select the storage domain for installing OpenShift Container Platform.
- i. For **Network**, select a virtual network that has access to the RHV Manager REST API.
- j. For **Internal API Virtual IP**, enter the static IP address you set aside for the cluster's REST API.
- k. For **Ingress virtual IP**, enter the static IP address you reserved for the wildcard apps domain.
- l. For **Base Domain**, enter the base domain of the OpenShift Container Platform cluster. If this cluster is exposed to the outside world, this must be a valid domain recognized by DNS infrastructure. For example, enter: **virtlab.example.com**
- m. For **Cluster Name**, enter the name of the cluster. For example, **my-cluster**. Use cluster name from the externally registered/resolvable DNS entries you created for the OpenShift Container Platform REST API and apps domain names. The installation program also gives this name to the cluster in the RHV environment.
- n. For **Pull Secret**, copy the pull secret from the **pull-secret.txt** file you downloaded earlier and paste it here. You can also get a copy of the same [pull secret from the Red Hat OpenShift Cluster Manager](#).



## NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

When the cluster deployment completes, directions for accessing your cluster, including a link to its web console and credentials for the **kubeadmin** user, display in your terminal.

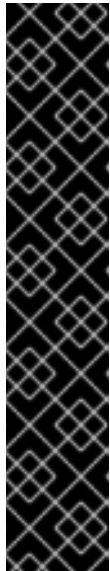
### Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Ee6gm-ymBZj-
Wt5AL"
INFO Time elapsed: 36m22s
```



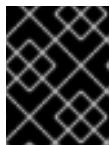
#### NOTE

The cluster access and credential information also outputs to **<installation\_directory>/openshift\_install.log** when an installation succeeds.



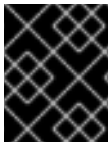
#### IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.



#### IMPORTANT

You must not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.



#### IMPORTANT

You have completed the steps required to install the cluster. The remaining steps show you how to verify the cluster and troubleshoot the installation.

### 16.2.10. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.





## IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

### Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

```
$ tar xvf <file>
```

5. Place the **oc** binary in a directory that is on your **PATH**.  
To check your **PATH**, execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

## Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your **PATH**.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

To learn more, see [Getting started with the OpenShift CLI](#).

## 16.2.11. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

### Example output

```
-
```

```
system:admin
```

### Additional resources

- See [Accessing the web console](#) for more details about accessing and understanding the OpenShift Container Platform web console.

## 16.2.12. Verifying cluster status

You can verify your OpenShift Container Platform cluster's status during or after installation.

### Procedure

1. In the cluster environment, export the administrator's kubeconfig file:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server.

2. View the control plane and compute machines created after a deployment:

```
$ oc get nodes
```

3. View your cluster's version:

```
$ oc get clusterversion
```

4. View your Operators' status:

```
$ oc get clusteroperator
```

5. View all running pods in the cluster:

```
$ oc get pods -A
```

### Troubleshooting

If the installation fails, the installation program times out and displays an error message. To learn more, see [Troubleshooting installation issues](#).

## 16.2.13. Accessing the OpenShift Container Platform web console on RHV

After the OpenShift Container Platform cluster initializes, you can log in to the OpenShift Container Platform web console.

### Procedure

1. Optional: In the Red Hat Virtualization (RHV) Administration Portal, open **Compute → Cluster**.

2. Verify that the installation program creates the virtual machines.
3. Return to the command line where the installation program is running. When the installation program finishes, it displays the user name and temporary password for logging into the OpenShift Container Platform web console.
4. In a browser, open the URL of the OpenShift Container Platform web console. The URL uses this format:

```
console-openshift-console.apps.<clustername>.<basedomain> 1
```

- 1** For **<clustername>.<basedomain>**, specify the cluster name and base domain.

For example:

```
console-openshift-console.apps.my-cluster.virtlab.example.com
```

### 16.2.14. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

#### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

### 16.2.15. Troubleshooting common issues with installing on Red Hat Virtualization (RHV)

Here are some common issues you might encounter, along with proposed causes and solutions.

#### 16.2.15.1. CPU load increases and nodes go into a **Not Ready** state

- **Symptom:** CPU load increases significantly and nodes start going into a **Not Ready** state.
- **Cause:** The storage domain latency might be too high, especially for control plane nodes.
- **Solution:**  
Make the nodes ready again by restarting the kubelet service:

```
$ systemctl restart kubelet
```

Inspect the OpenShift Container Platform metrics service, which automatically gathers and reports on some valuable data such as the etcd disk sync duration. If the cluster is operational, use this data to help determine whether storage latency or throughput is the root issue. If so, consider using a storage resource that has lower latency and higher throughput.

To get raw metrics, enter the following command as kubeadmin or user with cluster-admin privileges:

```
$ oc get --insecure-skip-tls-verify --server=https://localhost:<port> --raw=/metrics
```

To learn more, see [Exploring Application Endpoints for the purposes of Debugging with OpenShift 4.x](#)

### 16.2.15.2. Trouble connecting the OpenShift Container Platform cluster API

- **Symptom:** The installation program completes but the OpenShift Container Platform cluster API is not available. The bootstrap virtual machine remains up after the bootstrap process is complete. When you enter the following command, the response will time out.

```
$ oc login -u kubeadmin -p *** <apiurl>
```

- **Cause:** The bootstrap VM was not deleted by the installation program and has not released the cluster's API IP address.
- **Solution:** Use the **wait-for** subcommand to be notified when the bootstrap process is complete:

```
$ ./openshift-install wait-for bootstrap-complete
```

When the bootstrap process is complete, delete the bootstrap virtual machine:

```
$ ./openshift-install destroy bootstrap
```

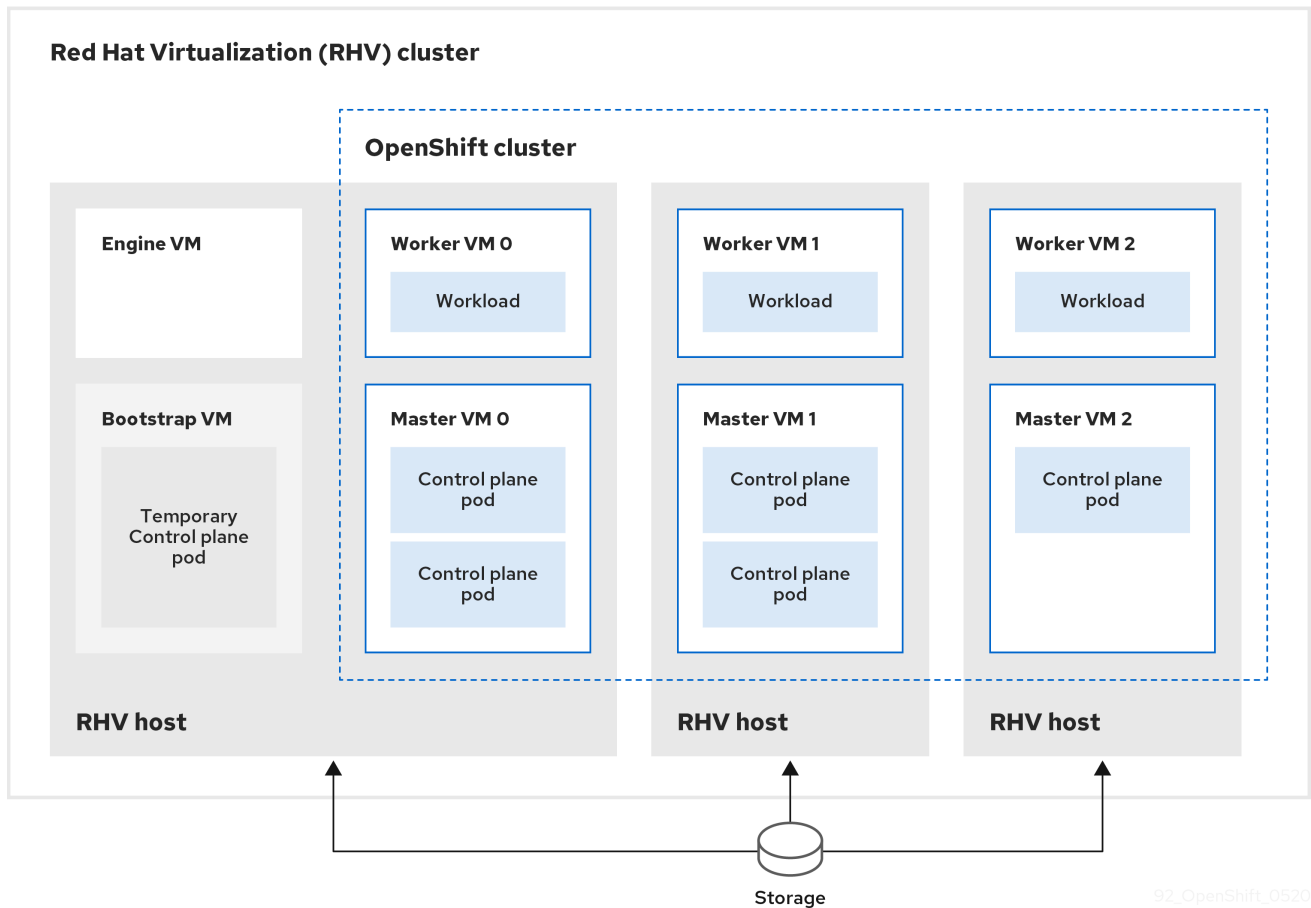
### 16.2.16. Post-installation tasks

After the OpenShift Container Platform cluster initializes, you can perform the following tasks.

- Optional: After deployment, add or replace SSH keys using the Machine Config Operator (MCO) in OpenShift Container Platform.
- Optional: Remove the **kubeadmin** user. Instead, use the authentication provider to create a user with cluster-admin privileges.

## 16.3. INSTALLING A CLUSTER ON RHV WITH CUSTOMIZATIONS

You can customize and install an OpenShift Container Platform cluster on Red Hat Virtualization (RHV), similar to the one shown in the following diagram.



92\_OpenShift\_0520

The installation program uses installer-provisioned infrastructure to automate creating and deploying the cluster.

To install a customized cluster, you prepare the environment and perform the following steps:

1. Create an installation configuration file, the **install-config.yaml** file, by running the installation program and answering its prompts.
2. Inspect and modify parameters in the **install-config.yaml** file.
3. Make a working copy of the **install-config.yaml** file.
4. Run the installation program with a copy of the **install-config.yaml** file.

Then, the installation program creates the OpenShift Container Platform cluster.

For an alternative to installing a customized cluster, see [Installing a default cluster](#).



#### NOTE

This installation program is available for Linux and macOS only.

### 16.3.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update processes](#).

- You have a supported combination of versions in the [Support Matrix for OpenShift Container Platform on Red Hat Virtualization \(RHV\)](#).
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.

### 16.3.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



#### IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

### 16.3.3. Requirements for the RHV environment

To install and run an OpenShift Container Platform version 4.9 cluster, the RHV environment must meet the following requirements.

Not meeting these requirements can cause the installation or process to fail. Additionally, not meeting these requirements can cause the OpenShift Container Platform cluster to fail days or weeks after installation.

The following requirements for CPU, memory, and storage resources are based on **default** values multiplied by the default number of virtual machines the installation program creates. These resources must be available **in addition to** what the RHV environment uses for non-OpenShift Container Platform operations.

By default, the installation program creates seven virtual machines during the installation process. First, it creates a bootstrap virtual machine to provide temporary services and a control plane while it creates the rest of the OpenShift Container Platform cluster. When the installation program finishes creating the cluster, deleting the bootstrap machine frees up its resources.

If you increase the number of virtual machines in the RHV environment, you must increase the resources accordingly.

#### Requirements

- The RHV version is 4.4.

- The RHV environment has one data center whose state is **Up**.
- The RHV data center contains an RHV cluster.
- The RHV cluster has the following resources exclusively for the OpenShift Container Platform cluster:
  - Minimum 28 vCPUs: four for each of the seven virtual machines created during installation.
  - 112 GiB RAM or more, including:
    - 16 GiB or more for the bootstrap machine, which provides the temporary control plane.
    - 16 GiB or more for each of the three control plane machines which provide the control plane.
    - 16 GiB or more for each of the three compute machines, which run the application workloads.
- The RHV storage domain must meet [these etcd backend performance requirements](#).
- For affinity group support:

One physical machine per worker or control plane. Workers and control planes can be on the same physical machine. For example, if you have three workers and three control planes, you need three physical machines. If you have four workers and three control planes, you need four physical machines.

  - For hard anti-affinity (default): A minimum of three physical machines. For more than three worker nodes, one physical machine per worker or control plane. Workers and control planes can be on the same physical machine.
  - For custom affinity groups: Ensure that the resources are appropriate for the affinity group rules that you define.
- In production environments, each virtual machine must have 120 GiB or more. Therefore, the storage domain must provide 840 GiB or more for the default OpenShift Container Platform cluster. In resource-constrained or non-production environments, each virtual machine must have 32 GiB or more, so the storage domain must have 230 GiB or more for the default OpenShift Container Platform cluster.
- To download images from the Red Hat Ecosystem Catalog during installation and update procedures, the RHV cluster must have access to an internet connection. The Telemetry service also needs an internet connection to simplify the subscription and entitlement process.
- The RHV cluster must have a virtual network with access to the REST API on the RHV Manager. Ensure that DHCP is enabled on this network, because the VMs that the installer creates obtain their IP address by using DHCP.
- A user account and group with the following least privileges for installing and managing an OpenShift Container Platform cluster on the target RHV cluster:
  - **DiskOperator**
  - **DiskCreator**
  - **UserTemplateBasedVm**
  - **TemplateOwner**



- **TemplateCreator**
- **ClusterAdmin** on the target cluster



### WARNING

Apply the principle of least privilege: Avoid using an administrator account with **SuperUser** privileges on RHV during the installation process. The installation program saves the credentials you provide to a temporary **ovirt-config.yaml** file that might be compromised.

## 16.3.4. Verifying the requirements for the RHV environment

Verify that the RHV environment meets the requirements to install and run an OpenShift Container Platform cluster. Not meeting these requirements can cause failures.



### IMPORTANT

These requirements are based on the default resources the installation program uses to create control plane and compute machines. These resources include vCPUs, memory, and storage. If you change these resources or increase the number of OpenShift Container Platform machines, adjust these requirements accordingly.

### Procedure

1. Check that the RHV version supports installation of OpenShift Container Platform version 4.9.
  - a. In the RHV Administration Portal, click the ? help icon in the upper-right corner and select **About**.
  - b. In the window that opens, make a note of the **RHV Software Version**
  - c. Confirm that the RHV version is 4.4. For more information about supported version combinations, see [Support Matrix for OpenShift Container Platform on RHV](#).
2. Inspect the data center, cluster, and storage.
  - a. In the RHV Administration Portal, click **Compute → Data Centers**.
  - b. Confirm that the data center where you plan to install OpenShift Container Platform is accessible.
  - c. Click the name of that data center.
  - d. In the data center details, on the **Storage** tab, confirm the storage domain where you plan to install OpenShift Container Platform is **Active**.
  - e. Record the **Domain Name** for use later on.
  - f. Confirm **Free Space** has at least 230 GiB.

- g. Confirm that the storage domain meets [these etcd backend performance requirements](#), which you [can measure by using the fio performance benchmarking tool](#).
  - h. In the data center details, click the **Clusters** tab.
  - i. Find the RHV cluster where you plan to install OpenShift Container Platform. Record the cluster name for use later on.
3. Inspect the RHV host resources.
    - a. In the RHV Administration Portal, click **Compute > Clusters**.
    - b. Click the cluster where you plan to install OpenShift Container Platform.
    - c. In the cluster details, click the **Hosts** tab.
    - d. Inspect the hosts and confirm they have a combined total of at least 28 **Logical CPU Cores** available *exclusively* for the OpenShift Container Platform cluster.
    - e. Record the number of available **Logical CPU Cores** for use later on.
    - f. Confirm that these CPU cores are distributed so that each of the seven virtual machines created during installation can have four cores.
    - g. Confirm that, all together, the hosts have 112 GiB of **Max free Memory for scheduling new virtual machines** distributed to meet the requirements for each of the following OpenShift Container Platform machines:
      - 16 GiB required for the bootstrap machine
      - 16 GiB required for each of the three control plane machines
      - 16 GiB for each of the three compute machines
    - h. Record the amount of **Max free Memory for scheduling new virtual machines** for use later on.
  4. Verify that the virtual network for installing OpenShift Container Platform has access to the RHV Manager's REST API. From a virtual machine on this network, use curl to reach the RHV Manager's REST API:

```
$ curl -k -u <username>@<profile>:<password> \ 1
https://<engine-fqdn>/ovirt-engine/api 2
```

- 1 For **<username>**, specify the user name of an RHV account with privileges to create and manage an OpenShift Container Platform cluster on RHV. For **<profile>**, specify the login profile, which you can get by going to the RHV Administration Portal login page and reviewing the **Profile** dropdown list. For **<password>**, specify the password for that user name.

- 2 For **<engine-fqdn>**, specify the fully qualified domain name of the RHV environment.

For example:

```
$ curl -k -u ocpadmin@internal:pw123 \
https://rhv-env.virtlab.example.com/ovirt-engine/api
```

### 16.3.5. Preparing the network environment on RHV

Configure two static IP addresses for the OpenShift Container Platform cluster and create DNS entries using these addresses.

#### Procedure

1. Reserve two static IP addresses
  - a. On the network where you plan to install OpenShift Container Platform, identify two static IP addresses that are outside the DHCP lease pool.
  - b. Connect to a host on this network and verify that each of the IP addresses is not in use. For example, use Address Resolution Protocol (ARP) to check that none of the IP addresses have entries:

```
$ arp 10.35.1.19
```

#### Example output

```
10.35.1.19 (10.35.1.19) -- no entry
```

- c. Reserve two static IP addresses following the standard practices for your network environment.
  - d. Record these IP addresses for future reference.
2. Create DNS entries for the OpenShift Container Platform REST API and apps domain names using this format:

```
api.<cluster-name>.<base-domain> <ip-address> 1  
*.apps.<cluster-name>.<base-domain> <ip-address> 2
```

- 1 For **<cluster-name>**, **<base-domain>**, and **<ip-address>**, specify the cluster name, base domain, and static IP address of your OpenShift Container Platform API.
- 2 Specify the cluster name, base domain, and static IP address of your OpenShift Container Platform apps for Ingress and the load balancer.

For example:

```
api.my-cluster.virtlab.example.com 10.35.1.19  
*.apps.my-cluster.virtlab.example.com 10.35.1.20
```

### 16.3.6. Installing OpenShift Container Platform on RHV in insecure mode

By default, the installer creates a CA certificate, prompts you for confirmation, and stores the certificate to use during installation. You do not need to create or install one manually.

Although it is not recommended, you can override this functionality and install OpenShift Container Platform without verifying a certificate by installing OpenShift Container Platform on RHV in **insecure** mode.

**WARNING**

Installing in **insecure** mode is not recommended, because it enables a potential attacker to perform a Man-in-the-Middle attack and capture sensitive credentials on the network.

**Procedure**

1. Create a file named `~/.ovirt/ovirt-config.yaml`.
2. Add the following content to **ovirt-config.yaml**:

```
ovirt_url: https://ovirt.example.com/ovirt-engine/api 1
ovirt_fqdn: ovirt.example.com 2
ovirt_pem_url: ""
ovirt_username: ocpadmin@internal
ovirt_password: super-secret-password 3
ovirt_insecure: true
```

- 1 Specify the hostname or address of your oVirt engine.
- 2 Specify the fully qualified domain name of your oVirt engine.
- 3 Specify the admin password for your oVirt engine.

3. Run the installer.

**16.3.7. Generating a key pair for cluster node SSH access**

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.

**IMPORTANT**

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

**Procedure**

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.



#### NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.



#### NOTE

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

#### Example output

```
Agent pid 31874
```



#### NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1 Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

### Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

### Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

## 16.3.8. Obtaining the installation program

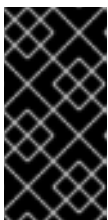
Before you install OpenShift Container Platform, download the installation file on a local computer.

### Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space

### Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



#### IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



#### IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#) . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform

components.

### 16.3.9. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on Red Hat Virtualization (RHV).

#### Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

#### Procedure

1. Create the **install-config.yaml** file.
  - a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

- 1** For **<installation\_directory>**, specify the directory name to store the files that the installation program creates.



#### IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

- b. Respond to the installation program prompts.
  - i. For **SSH Public Key**, select a password-less public key, such as `~/.ssh/id_rsa.pub`. This key authenticates connections with the new OpenShift Container Platform cluster.



#### NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, select an SSH key that your **ssh-agent** process uses.

- ii. For **Platform**, select **ovirt**.
- iii. For **Enter oVirt's API endpoint URL**, enter the URL of the RHV API using this format:

```
https://<engine-fqdn>/ovirt-engine/api 1
```

- 1 For **<engine-fqdn>**, specify the fully qualified domain name of the RHV environment.

For example:

```
$ curl -k -u ocpadmin@internal:pw123 \
https://rhv-env.virtlab.example.com/ovirt-engine/api
```

- iv. For **Is the oVirt CA trusted locally?**, enter **Yes**, because you have already set up a CA certificate. Otherwise, enter **No**.
- v. For **oVirt's CA bundle**, if you entered **Yes** for the preceding question, copy the certificate content from **/etc/pki/ca-trust/source/anchors/ca.pem** and paste it here. Then, press **Enter** twice. Otherwise, if you entered **No** for the preceding question, this question does not appear.
- vi. For **oVirt engine username**, enter the user name and profile of the RHV administrator using this format:

```
<username>@<profile> 1
```

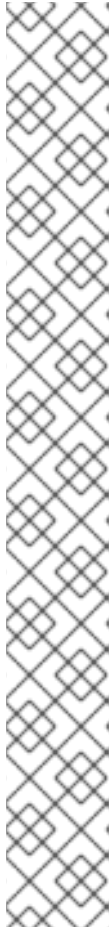
- 1 For **<username>**, specify the user name of an RHV administrator. For **<profile>**, specify the login profile, which you can get by going to the RHV Administration Portal login page and reviewing the **Profile** dropdown list. Together, the user name and profile should look similar to this example:

```
ocpadmin@internal
```

- vii. For **oVirt engine password**, enter the RHV admin password.
- viii. For **oVirt cluster**, select the cluster for installing OpenShift Container Platform.
- ix. For **oVirt storage domain**, select the storage domain for installing OpenShift Container Platform.
- x. For **oVirt network**, select a virtual network that has access to the RHV Manager REST API.
- xi. For **Internal API Virtual IP**, enter the static IP address you set aside for the cluster's REST API.
- xii. For **Ingress virtual IP**, enter the static IP address you reserved for the wildcard apps domain.
- xiii. For **Base Domain**, enter the base domain of the OpenShift Container Platform cluster. If this cluster is exposed to the outside world, this must be a valid domain recognized by DNS infrastructure. For example, enter: **virtlab.example.com**
- xiv. For **Cluster Name**, enter the name of the cluster. For example, **my-cluster**. Use cluster name from the externally registered/resolvable DNS entries you created for the OpenShift Container Platform REST API and apps domain names. The installation program also gives this name to the cluster in the RHV environment.



- xv. For **Pull Secret**, copy the pull secret from the **pull-secret.txt** file you downloaded earlier and paste it here. You can also get a copy of the same [pull secret from the Red Hat OpenShift Cluster Manager](#).
2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.



## NOTE

If you have any intermediate CA certificates on the Manager, verify that the certificates appear in the **ovirt-config.yaml** file and the **install-config.yaml** file. If they do not appear, add them as follows:

1. In the `~/ovirt/ovirt-config.yaml` file:

```
[ovirt_ca_bundle]: |
  -----BEGIN CERTIFICATE-----
  <MY_TRUSTED_CA>
  -----END CERTIFICATE-----
  -----BEGIN CERTIFICATE-----
  <INTERMEDIATE_CA>
  -----END CERTIFICATE-----
```

2. In the **install-config.yaml** file:

```
[additionalTrustBundle]: |
  -----BEGIN CERTIFICATE-----
  <MY_TRUSTED_CA>
  -----END CERTIFICATE-----
  -----BEGIN CERTIFICATE-----
  <INTERMEDIATE_CA>
  -----END CERTIFICATE-----
```

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



## IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

### 16.3.9.1. Example **install-config.yaml** files for Red Hat Virtualization (RHV)

You can customize the OpenShift Container Platform cluster the installation program creates by changing the parameters and parameter values in the **install-config.yaml** file.

The following examples are specific to installing OpenShift Container Platform on RHV.

**install-config.yaml** is located in `<installation_directory>`, which you specified when you ran the following command.

```
$ ./openshift-install create install-config --dir <installation_directory>
```

**NOTE**

- These example files are provided for reference only. You must obtain your **install-config.yaml** file by using the installation program.
- Changing the **install-config.yaml** file can increase the resources your cluster requires. Verify that your RHV environment has those additional resources. Otherwise, the installation or cluster will fail.

**Example default install-config.yaml file**

```

apiVersion: v1
baseDomain: example.com
compute:
- architecture: amd64
  hyperthreading: Enabled
  name: worker
  platform: {}
  replicas: 3
controlPlane:
  architecture: amd64
  hyperthreading: Enabled
  name: master
  platform: {}
  replicas: 3
metadata:
  creationTimestamp: null
  name: my-cluster
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
  ovirt:
    api_vip: 10.46.8.230
    ingress_vip: 192.168.1.5
    ovirt_cluster_id: 68833f9f-e89c-4891-b768-e2ba0815b76b
    ovirt_storage_domain_id: ed7b0f4e-0e96-492a-8fff-279213ee1468
    ovirt_network_name: ovirtmgmt
    vnicProfileID: 3fa86930-0be5-4052-b667-b79f0a729692
publish: External
pullSecret: '{"auths": ...}'
sshKey: ssh-ed12345 AAAA...

```

**Example minimal install-config.yaml file**

```

apiVersion: v1
baseDomain: example.com
metadata:
  name: test-cluster

```

```

platform:
  ovirt:
    api_vip: 10.46.8.230
    ingress_vip: 10.46.8.232
    ovirt_cluster_id: 68833f9f-e89c-4891-b768-e2ba0815b76b
    ovirt_storage_domain_id: ed7b0f4e-0e96-492a-8fff-279213ee1468
    ovirt_network_name: ovirtmgmt
    vnicProfileID: 3fa86930-0be5-4052-b667-b79f0a729692
pullSecret: '{"auths": ...}'
sshKey: ssh-ed12345 AAAA...

```

### Example Custom machine pools in `arinstall-config.yaml` file

```

apiVersion: v1
baseDomain: example.com
controlPlane:
  name: master
  platform:
    ovirt:
      cpu:
        cores: 4
        sockets: 2
      memoryMB: 65536
      osDisk:
        sizeGB: 100
      vmType: server
  replicas: 3
compute:
- name: worker
  platform:
    ovirt:
      cpu:
        cores: 4
        sockets: 4
      memoryMB: 65536
      osDisk:
        sizeGB: 200
      vmType: server
  replicas: 5
metadata:
  name: test-cluster
platform:
  ovirt:
    api_vip: 10.46.8.230
    ingress_vip: 10.46.8.232
    ovirt_cluster_id: 68833f9f-e89c-4891-b768-e2ba0815b76b
    ovirt_storage_domain_id: ed7b0f4e-0e96-492a-8fff-279213ee1468
    ovirt_network_name: ovirtmgmt
    vnicProfileID: 3fa86930-0be5-4052-b667-b79f0a729692
pullSecret: '{"auths": ...}'
sshKey: ssh-ed25519 AAAA...

```

### Example non-enforcing affinity group

It is recommended to add a non-enforcing affinity group to distribute the control plane and workers, if possible, to use as much of the cluster as possible.

■

```

platform:
  ovirt:
    affinityGroups:
      - description: AffinityGroup to place each compute machine on a separate host
        enforcing: true
        name: compute
        priority: 3
      - description: AffinityGroup to place each control plane machine on a separate host
        enforcing: true
        name: controlplane
        priority: 5
      - description: AffinityGroup to place worker nodes and control plane nodes on separate hosts
        enforcing: false
        name: openshift
        priority: 5
  compute:
    - architecture: amd64
      hyperthreading: Enabled
      name: worker
      platform:
        ovirt:
          affinityGroupsNames:
            - compute
            - openshift
      replicas: 3
  controlPlane:
    architecture: amd64
    hyperthreading: Enabled
    name: master
    platform:
      ovirt:
        affinityGroupsNames:
          - controlplane
          - openshift
      replicas: 3

```

### Example removing all affinity groups for a non-production lab setup

For non-production lab setups, you must remove all affinity groups to concentrate the OpenShift Container Platform cluster on the few hosts you have.

```

platform:
  ovirt:
    affinityGroups: []
  compute:
    - architecture: amd64
      hyperthreading: Enabled
      name: worker
      platform:
        ovirt:
          affinityGroupsNames: []
      replicas: 3
  controlPlane:
    architecture: amd64
    hyperthreading: Enabled
    name: master
    platform:

```

```
ovirt:
  affinityGroupsNames: []
  replicas: 3
```

### 16.3.9.2. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.



#### NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.



#### IMPORTANT

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

#### 16.3.9.2.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 16.1. Required parameters

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;</b> . <b>&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .

Parameter	Description	Values
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}</b> . <b>{{.baseDomain}}</b> .	String of lowercase letters, hyphens (-), and periods (.), such as <b>dev</b> .
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws, baremetal, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } }</pre>


### 16.3.9.2.2. Network configuration parameters


You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

**Table 16.2. Network parameters**

Parameter	Description	Values
-----------	-------------	--------

Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	Object  <b>NOTE</b> You cannot modify parameters specified by the <b>networking</b> object after installation.
<b>networking.networkType</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .
<b>networking.clusterNetwork</b>	The IP address blocks for pods.  The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b> .  If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example:  <pre>networking:   clusterNetwork:     - cidr: 10.128.0.0/14       hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	Required if you use <b>networking.clusterNetwork</b> . An IP address block.  An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b> .
<b>networking.clusterNetwork.hostPrefix</b>	The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b> . A <b>hostPrefix</b> value of <b>23</b> provides 510 ( $2^{(32 - 23)} - 2$ ) pod IP addresses.	A subnet prefix.  The default value is <b>23</b> .
<b>networking.serviceNetwork</b>	The IP address block for services. The default value is <b>172.30.0.0/16</b> .  The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.	An array with an IP address block in CIDR format. For example:  <pre>networking:   serviceNetwork:     - 172.30.0.0/16</pre>

Parameter	Description	Values
<b>networking.machineNetwork</b>	The IP address blocks for machines.  If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example:  <pre>networking:   machineNetwork:   - cidr: 10.0.0.0/16</pre>
<b>networking.machineNetwork.cidr</b>	Required if you use <b>networking.machineNetwork</b> . An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b> .	An IP network block in CIDR notation.  For example, <b>10.0.0.0/16</b> .   <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p>


### 16.3.9.2.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

Table 16.3. Optional parameters

Parameter	Description	Values
<b>additionalTrustBundle</b>	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
<b>compute</b>	The configuration for the machines that comprise the compute nodes.	Array of <b>MachinePool</b> objects. For details, see the "Additional RHV parameters for machine pools" table.
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String




Parameter	Description	Values
<b>compute.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b>
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects. For details, see the "Additional RHV parameters for machine pools" table.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String

Parameter	Description	Values
<b>controlPlane.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platform</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>controlPlane.replicas</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.

Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.</p> <div data-bbox="485 510 595 860" style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p><b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators reference content</i>.</p> </div> <div data-bbox="485 909 595 1258" style="border: 1px solid black; padding: 5px;"> <p><b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p> </div>	<b>Mint, Passthrough, Manual</b> or an empty string ("").

Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start;"> <div style="width: 40px; height: 40px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 40px; height: 40px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<b>Internal</b> or <b>External</b> . The default value is <b>External</b> .  Setting this field to <b>Internal</b> is not supported on non-cloud platforms.

Parameter	Description	Values
<b>sshKey</b>	<p>The SSH key or keys to authenticate access your cluster machines.</p>  <p><b>NOTE</b></p> <p>For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.</p>	<p>One or more keys. For example:</p> <pre>sshKey: &lt;key1&gt; &lt;key2&gt; &lt;key3&gt;</pre>

#### 16.3.9.2.4. Additional Red Hat Virtualization (RHV) configuration parameters

Additional RHV configuration parameters are described in the following table:

Table 16.4. Additional Red Hat Virtualization (RHV) parameters for clusters

Parameter	Description	Values
<b>platform.ovirt.ovirt_cluster_id</b>	Required. The Cluster where the VMs will be created.	String. For example: <b>68833f9f-e89c-4891-b768-e2ba0815b76b</b>
<b>platform.ovirt.ovirt_storage_domain_id</b>	Required. The Storage Domain ID where the VM disks will be created.	String. For example: <b>ed7b0f4e-0e96-492a-8fff-279213ee1468</b>
<b>platform.ovirt.ovirt_network_name</b>	Required. The network name where the VM nics will be created.	String. For example: <b>ocpcluster</b>
<b>platform.ovirt.vnicProfileID</b>	Required. The vNIC profile ID of the VM network interfaces. This can be inferred if the cluster network has a single profile.	String. For example: <b>3fa86930-0be5-4052-b667-b79f0a729692</b>
<b>platform.ovirt.api_vip</b>	Required. An IP address on the machine network that will be assigned to the API virtual IP (VIP). You can access the OpenShift API at this endpoint.	String. Example: <b>10.46.8.230</b>
<b>platform.ovirt.ingress_vip</b>	Required. An IP address on the machine network that will be assigned to the Ingress virtual IP (VIP).	String. Example: <b>10.46.8.232</b>


Parameter	Description	Values
<b>platform.ovirt.affinityGroups</b>	Optional. A list of affinity groups to create during the installation process.	List of objects.
<b>platform.ovirt.affinityGroups.description</b>	Required if you include <b>platform.ovirt.affinityGroups</b> . A description of the affinity group.	String. Example: <b>AffinityGroup for spreading each compute machine to a different host</b>
<b>platform.ovirt.affinityGroups.enforcing</b>	Required if you include <b>platform.ovirt.affinityGroups</b> . When set to <b>true</b> , RHV does not provision any machines if not enough hardware nodes are available. When set to <b>false</b> , RHV does provision machines even if not enough hardware nodes are available, resulting in multiple virtual machines being hosted on the same physical machine.	String. Example: <b>true</b>
<b>platform.ovirt.affinityGroups.name</b>	Required if you include <b>platform.ovirt.affinityGroups</b> . The name of the affinity group.	String. Example: <b>compute</b>
<b>platform.ovirt.affinityGroups.priority</b>	Required if you include <b>platform.ovirt.affinityGroups</b> . The priority given to an affinity group when <b>platform.ovirt.affinityGroups.enforcing = false</b> . RHV applies affinity groups in the order of priority, where a greater number takes precedence over a lesser one. If multiple affinity groups have the same priority, the order in which they are applied is not guaranteed.	Integer. Example: <b>3</b>


#### 16.3.9.2.5. Additional RHV parameters for machine pools

Additional RHV configuration parameters for machine pools are described in the following table:

Table 16.5. Additional RHV parameters for machine pools

Parameter	Description	Values
<b>&lt;machine-pool&gt;.platform.ovirt.cpu</b>	Optional. Defines the CPU of the VM.	Object

Parameter	Description	Values
<code>&lt;machine-pool&gt;.platform.ovirt.cpu.cores</code>	Required if you use <code>&lt;machine-pool&gt;.platform.ovirt.cpu</code> . The number of cores. Total virtual CPUs (vCPUs) is cores * sockets.	Integer
<code>&lt;machine-pool&gt;.platform.ovirt.cpu.sockets</code>	Required if you use <code>&lt;machine-pool&gt;.platform.ovirt.cpu</code> . The number of sockets per core. Total virtual CPUs (vCPUs) is cores * sockets.	Integer
<code>&lt;machine-pool&gt;.platform.ovirt.memoryMB</code>	Optional. Memory of the VM in MiB.	Integer
<code>&lt;machine-pool&gt;.platform.ovirt.instanceTypeID</code>	Optional. An instance type UUID, such as <code>00000009-0009-0009-0009-0000000000f1</code> , which you can get from the <a href="https://&lt;engine-fqdn&gt;/ovirt-engine/api/instancetype">https://&lt;engine-fqdn&gt;/ovirt-engine/api/instancetype</a> endpoint.	String of UUID
	<div style="background-color: #fff9c4; padding: 10px; border: 1px solid #ccc;">  <p><b>WARNING</b></p> <p>The <code>instance_type_id</code> field is deprecated and will be removed in a future release.</p> </div>	
<code>&lt;machine-pool&gt;.platform.ovirt.osDisk</code>	Optional. Defines the first and bootable disk of the VM.	String
<code>&lt;machine-pool&gt;.platform.ovirt.osDisk.sizeGB</code>	Required if you use <code>&lt;machine-pool&gt;.platform.ovirt.osDisk</code> . Size of the disk in GiB.	Number

Parameter	Description	Values
<code>&lt;machine-pool&gt;.platform.ovirt.vmType</code>	<p>Optional. The VM workload type, such as <b>high-performance</b>, <b>server</b>, or <b>desktop</b>. By default, control plane nodes use <b>high-performance</b>, and worker nodes use <b>server</b>. For details, see <a href="#">Explanation of Settings in the New Virtual Machine and Edit Virtual Machine Windows</a> and <a href="#">Configuring High Performance Virtual Machines, Templates, and Pools</a> in the <i>Virtual Machine Management Guide</i>.</p>  <p><b>NOTE</b></p> <p><b>high_performance</b> improves performance on the VM, but there are limitations. For example, you cannot access the VM with a graphical console. For more information, see <a href="#">Configuring High Performance Virtual Machines, Templates, and Pools</a> in the <i>Virtual Machine Management Guide</i>.</p>	String



Parameter	Description	Values
<code>&lt;machine-pool&gt;.platform.ovirt.affinityGroupNames</code>	<p>Optional. A list of affinity group names that should be applied to the virtual machines. The affinity groups must exist in RHV, or be created during installation as described in <i>Additional RHV parameters for clusters</i> in this topic. This entry can be empty.</p> <p><b>Example with two affinity groups</b></p> <p>This example defines two affinity groups, named <b>compute</b> and <b>clusterWideNonEnforcing</b>:</p> <pre>&lt;machine-pool&gt;: platform: ovirt:   affinityGroupNames:     - compute     - clusterWideNonEnforcing</pre> <p>This example defines no affinity groups:</p> <pre>&lt;machine-pool&gt;: platform: ovirt:   affinityGroupNames: []</pre>	String
<code>&lt;machine-pool&gt;.platform.ovirt.AutoPinningPolicy</code>	<p>Optional. <code>AutoPinningPolicy</code> defines the policy to automatically set the CPU and NUMA settings, including pinning to the host for the instance. When the field is omitted, the default is <b>none</b>. Supported values: <b>none</b>, <b>resize_and_pin</b>. For more information, see <a href="#">Setting NUMA Nodes</a> in the <i>Virtual Machine Management Guide</i>.</p>	String
<code>&lt;machine-pool&gt;.platform.ovirt.hugepages</code>	<p>Optional. <code>Hugepages</code> is the size in KiB for defining hugepages in a VM. Supported values: <b>2048</b> or <b>1048576</b>. For more information, see <a href="#">Configuring Huge Pages</a> in the <i>Virtual Machine Management Guide</i>.</p>	Integer

**NOTE**

You can replace `<machine-pool>` with **controlPlane** or **compute**.

## 16.3.10. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



### IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

### Prerequisites

- Open the **ovirt-imageio** port to the Manager from the machine running the installer. By default, the port is **54322**.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

### Procedure

1. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
--log-level=info 2
```

- 1 For **<installation\_directory>**, specify the location of your customized **./install-config.yaml** file.
- 2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.



### NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

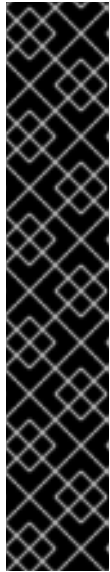
When the cluster deployment completes, directions for accessing your cluster, including a link to its web console and credentials for the **kubeadmin** user, display in your terminal.

### Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Ee6gm-ymBZj-
Wt5AL"
INFO Time elapsed: 36m22s
```

**NOTE**

The cluster access and credential information also outputs to `<installation_directory>/openshift_install.log` when an installation succeeds.

**IMPORTANT**

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

**IMPORTANT**

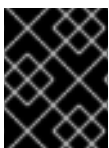
You must not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

**IMPORTANT**

You have completed the steps required to install the cluster. The remaining steps show you how to verify the cluster and troubleshoot the installation.

### 16.3.11. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

**IMPORTANT**

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

#### Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.

4. Unpack the archive:

```
$ tar xvf <file>
```

5. Place the **oc** binary in a directory that is on your **PATH**.  
To check your **PATH**, execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

### Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your **PATH**.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### 16.3.12. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

#### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

#### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

#### Example output

```
system:admin
```

To learn more, see [Getting started with the OpenShift CLI](#).

### 16.3.13. Verifying cluster status

You can verify your OpenShift Container Platform cluster's status during or after installation.

#### Procedure

1. In the cluster environment, export the administrator's kubeconfig file:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server.

2. View the control plane and compute machines created after a deployment:

```
$ oc get nodes
```

3. View your cluster's version:

```
$ oc get clusterversion
```

4. View your Operators' status:

```
$ oc get clusteroperator
```

5. View all running pods in the cluster:

```
$ oc get pods -A
```

## Troubleshooting

If the installation fails, the installation program times out and displays an error message. To learn more, see [Troubleshooting installation issues](#).

### 16.3.14. Accessing the OpenShift Container Platform web console on RHV

After the OpenShift Container Platform cluster initializes, you can log in to the OpenShift Container Platform web console.

#### Procedure

1. Optional: In the Red Hat Virtualization (RHV) Administration Portal, open **Compute** → **Cluster**.
2. Verify that the installation program creates the virtual machines.
3. Return to the command line where the installation program is running. When the installation program finishes, it displays the user name and temporary password for logging into the OpenShift Container Platform web console.
4. In a browser, open the URL of the OpenShift Container Platform web console. The URL uses this format:

```
console-openshift-console.apps.<clustername>.<basedomain> 1
```

**1** For **<clustername>.<basedomain>**, specify the cluster name and base domain.

For example:

```
console-openshift-console.apps.my-cluster.virtlab.example.com
```

### 16.3.15. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

## 16.3.16. Troubleshooting common issues with installing on Red Hat Virtualization (RHV)

Here are some common issues you might encounter, along with proposed causes and solutions.

### 16.3.16.1. CPU load increases and nodes go into a **Not Ready** state

- **Symptom:** CPU load increases significantly and nodes start going into a **Not Ready** state.
- **Cause:** The storage domain latency might be too high, especially for control plane nodes.

- **Solution:**

Make the nodes ready again by restarting the kubelet service:

```
$ systemctl restart kubelet
```

Inspect the OpenShift Container Platform metrics service, which automatically gathers and reports on some valuable data such as the etcd disk sync duration. If the cluster is operational, use this data to help determine whether storage latency or throughput is the root issue. If so, consider using a storage resource that has lower latency and higher throughput.

To get raw metrics, enter the following command as kubeadmin or user with cluster-admin privileges:

```
$ oc get --insecure-skip-tls-verify --server=https://localhost:<port> --raw=/metrics
```

To learn more, see [Exploring Application Endpoints for the purposes of Debugging with OpenShift 4.x](#)

### 16.3.16.2. Trouble connecting the OpenShift Container Platform cluster API

- **Symptom:** The installation program completes but the OpenShift Container Platform cluster API is not available. The bootstrap virtual machine remains up after the bootstrap process is complete. When you enter the following command, the response will time out.

```
$ oc login -u kubeadmin -p *** <apiurl>
```

- **Cause:** The bootstrap VM was not deleted by the installation program and has not released the cluster's API IP address.
- **Solution:** Use the **wait-for** subcommand to be notified when the bootstrap process is complete:

```
┆ $ ./openshift-install wait-for bootstrap-complete
```

When the bootstrap process is complete, delete the bootstrap virtual machine:

```
┆ $ ./openshift-install destroy bootstrap
```

### 16.3.17. Post-installation tasks

After the OpenShift Container Platform cluster initializes, you can perform the following tasks.

- Optional: After deployment, add or replace SSH keys using the Machine Config Operator (MCO) in OpenShift Container Platform.
- Optional: Remove the **kubeadmin** user. Instead, use the authentication provider to create a user with cluster-admin privileges.

### 16.3.18. Next steps

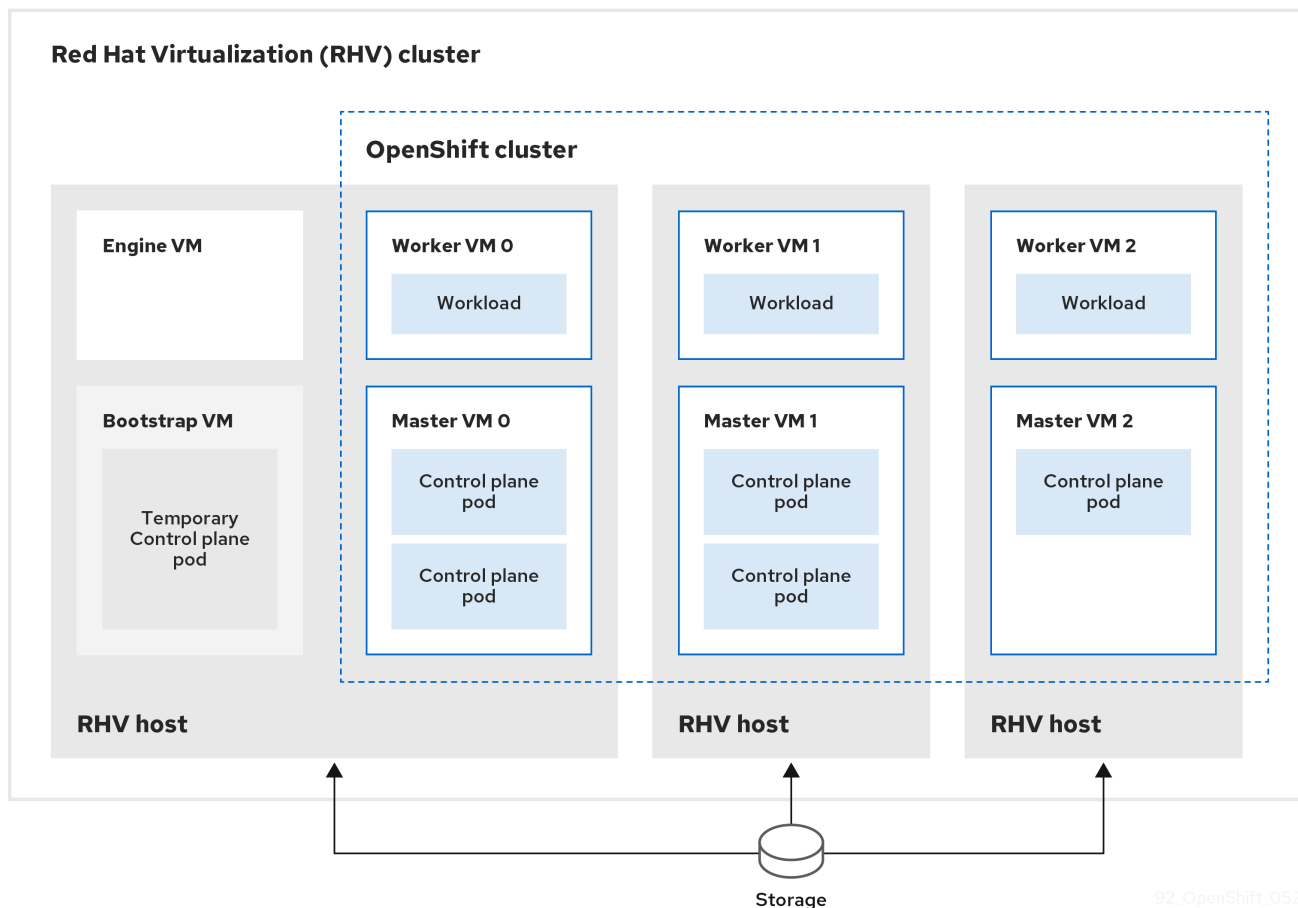
- [Customize your cluster](#).
- If necessary, you can [opt out of remote health reporting](#).

## 16.4. INSTALLING A CLUSTER ON RHV WITH USER-PROVISIONED INFRASTRUCTURE

In OpenShift Container Platform version 4.9, you can install a customized OpenShift Container Platform cluster on Red Hat Virtualization (RHV) and other infrastructure that you provide. The OpenShift Container Platform documentation uses the term *user-provisioned infrastructure* to refer to this infrastructure type.

The following diagram shows an example of a potential OpenShift Container Platform cluster running on a RHV cluster.





92\_OpenShift\_0520

The RHV hosts run virtual machines that contain both control plane and compute pods. One of the hosts also runs a Manager virtual machine and a bootstrap virtual machine that contains a temporary control plane pod.]

### 16.4.1. Prerequisites

The following items are required to install an OpenShift Container Platform cluster on a RHV environment.

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You have a supported combination of versions in the [Support Matrix for OpenShift Container Platform on Red Hat Virtualization \(RHV\)](#).

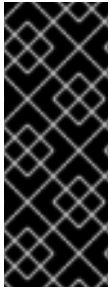
### 16.4.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.

- Access [Quay.io](https://quay.io) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



### IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

### 16.4.3. Requirements for the RHV environment

To install and run an OpenShift Container Platform version 4.9 cluster, the RHV environment must meet the following requirements.

Not meeting these requirements can cause the installation or process to fail. Additionally, not meeting these requirements can cause the OpenShift Container Platform cluster to fail days or weeks after installation.

The following requirements for CPU, memory, and storage resources are based on **default** values multiplied by the default number of virtual machines the installation program creates. These resources must be available **in addition to** what the RHV environment uses for non-OpenShift Container Platform operations.

By default, the installation program creates seven virtual machines during the installation process. First, it creates a bootstrap virtual machine to provide temporary services and a control plane while it creates the rest of the OpenShift Container Platform cluster. When the installation program finishes creating the cluster, deleting the bootstrap machine frees up its resources.

If you increase the number of virtual machines in the RHV environment, you must increase the resources accordingly.

#### Requirements

- The RHV version is 4.4.
- The RHV environment has one data center whose state is **Up**.
- The RHV data center contains an RHV cluster.
- The RHV cluster has the following resources exclusively for the OpenShift Container Platform cluster:
  - Minimum 28 vCPUs: four for each of the seven virtual machines created during installation.
  - 112 GiB RAM or more, including:
    - 16 GiB or more for the bootstrap machine, which provides the temporary control plane.
    - 16 GiB or more for each of the three control plane machines which provide the control plane.

- 16 GiB or more for each of the three compute machines, which run the application workloads.
- The RHV storage domain must meet [these etcd backend performance requirements](#).
- In production environments, each virtual machine must have 120 GiB or more. Therefore, the storage domain must provide 840 GiB or more for the default OpenShift Container Platform cluster. In resource-constrained or non-production environments, each virtual machine must have 32 GiB or more, so the storage domain must have 230 GiB or more for the default OpenShift Container Platform cluster.
- To download images from the Red Hat Ecosystem Catalog during installation and update procedures, the RHV cluster must have access to an internet connection. The Telemetry service also needs an internet connection to simplify the subscription and entitlement process.
- The RHV cluster must have a virtual network with access to the REST API on the RHV Manager. Ensure that DHCP is enabled on this network, because the VMs that the installer creates obtain their IP address by using DHCP.
- A user account and group with the following least privileges for installing and managing an OpenShift Container Platform cluster on the target RHV cluster:
  - **DiskOperator**
  - **DiskCreator**
  - **UserTemplateBasedVm**
  - **TemplateOwner**
  - **TemplateCreator**
  - **ClusterAdmin** on the target cluster



#### WARNING

Apply the principle of least privilege: Avoid using an administrator account with **SuperUser** privileges on RHV during the installation process. The installation program saves the credentials you provide to a temporary **ovirt-config.yaml** file that might be compromised.

#### 16.4.4. Verifying the requirements for the RHV environment

Verify that the RHV environment meets the requirements to install and run an OpenShift Container Platform cluster. Not meeting these requirements can cause failures.



#### IMPORTANT

These requirements are based on the default resources the installation program uses to create control plane and compute machines. These resources include vCPUs, memory, and storage. If you change these resources or increase the number of OpenShift Container Platform machines, adjust these requirements accordingly.

## Procedure

1. Check that the RHV version supports installation of OpenShift Container Platform version 4.9.
  - a. In the RHV Administration Portal, click the ? help icon in the upper-right corner and select **About**.
  - b. In the window that opens, make a note of the **RHV Software Version**
  - c. Confirm that the RHV version is 4.4. For more information about supported version combinations, see [Support Matrix for OpenShift Container Platform on RHV](#) .
2. Inspect the data center, cluster, and storage.
  - a. In the RHV Administration Portal, click **Compute → Data Centers**.
  - b. Confirm that the data center where you plan to install OpenShift Container Platform is accessible.
  - c. Click the name of that data center.
  - d. In the data center details, on the **Storage** tab, confirm the storage domain where you plan to install OpenShift Container Platform is **Active**.
  - e. Record the **Domain Name** for use later on.
  - f. Confirm **Free Space** has at least 230 GiB.
  - g. Confirm that the storage domain meets [these etcd backend performance requirements](#), which you [can measure by using the fio performance benchmarking tool](#) .
  - h. In the data center details, click the **Clusters** tab.
  - i. Find the RHV cluster where you plan to install OpenShift Container Platform. Record the cluster name for use later on.
3. Inspect the RHV host resources.
  - a. In the RHV Administration Portal, click **Compute > Clusters**
  - b. Click the cluster where you plan to install OpenShift Container Platform.
  - c. In the cluster details, click the **Hosts** tab.
  - d. Inspect the hosts and confirm they have a combined total of at least 28 **Logical CPU Cores** available *exclusively* for the OpenShift Container Platform cluster.
  - e. Record the number of available **Logical CPU Cores** for use later on.
  - f. Confirm that these CPU cores are distributed so that each of the seven virtual machines created during installation can have four cores.
  - g. Confirm that, all together, the hosts have 112 GiB of **Max free Memory for scheduling new virtual machines** distributed to meet the requirements for each of the following OpenShift Container Platform machines:
    - 16 GiB required for the bootstrap machine
    - 16 GiB required for each of the three control plane machines

- 16 GiB for each of the three compute machines
- h. Record the amount of **Max free Memory for scheduling new virtual machines** for use later on.
4. Verify that the virtual network for installing OpenShift Container Platform has access to the RHV Manager's REST API. From a virtual machine on this network, use curl to reach the RHV Manager's REST API:

```
$ curl -k -u <username>@<profile>:<password> \ 1
https://<engine-fqdn>/ovirt-engine/api 2
```

**1** For **<username>**, specify the user name of an RHV account with privileges to create and manage an OpenShift Container Platform cluster on RHV. For **<profile>**, specify the login profile, which you can get by going to the RHV Administration Portal login page and reviewing the **Profile** dropdown list. For **<password>**, specify the password for that user name.

**2** For **<engine-fqdn>**, specify the fully qualified domain name of the RHV environment.

For example:

```
$ curl -k -u ocpadmin@internal:pw123 \
https://rhv-env.virtlab.example.com/ovirt-engine/api
```

### 16.4.5. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.

It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.



#### NOTE

If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow the API server to resolve the node names. Another supported approach is to always refer to hosts by

their fully-qualified domain names in both the node objects and all DNS requests.

## Firewall

Configure your firewall so your cluster has access to required sites.

See also:

- [Red Hat Virtualization Manager firewall requirements](#)
- [Host firewall requirements](#)

## Load balancers

Configure one or preferably two layer-4 load balancers:

- Provide load balancing for ports **6443** and **22623** on the control plane and bootstrap machines. Port **6443** provides access to the Kubernetes API server and must be reachable both internally and externally. Port **22623** must be accessible to nodes within the cluster.
- Provide load balancing for port **443** and **80** for machines that run the Ingress router, which are usually compute nodes in the default configuration. Both ports must be accessible from within and outside the cluster.

## DNS

Configure infrastructure-provided DNS to allow the correct resolution of the main components and services. If you use only one load balancer, these DNS records can point to the same IP address.

- Create DNS records for **api.<cluster\_name>.<base\_domain>** (internal and external resolution) and **api-int.<cluster\_name>.<base\_domain>** (internal resolution) that point to the load balancer for the control plane machines.
- Create a DNS record for **\*.apps.<cluster\_name>.<base\_domain>** that points to the load balancer for the Ingress router. For example, ports **443** and **80** of the compute machines.

### 16.4.5.1. Setting the cluster node hostnames through DHCP

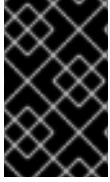
On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

### 16.4.5.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.



## IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

**Table 16.6. Ports used for all-machine to all-machine communications**

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	<b>1936</b>	Metrics
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> and the Cluster Version Operator on port <b>9099</b> .
	<b>10250-10259</b>	The default ports that Kubernetes reserves
	<b>10256</b>	openshift-sdn
UDP	<b>4789</b>	VXLAN and Geneve
	<b>6081</b>	VXLAN and Geneve
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> .
	<b>500</b>	IPsec IKE packets
	<b>4500</b>	IPsec NAT-T packets
TCP/UDP	<b>30000-32767</b>	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

**Table 16.7. Ports used for all-machine to control plane communications**

Protocol	Port	Description
TCP	<b>6443</b>	Kubernetes API

**Table 16.8. Ports used for control plane machine to control plane machine communications**

Protocol	Port	Description
TCP	<b>2379-2380</b>	etcd server and peer ports

### NTP configuration for user-provisioned infrastructure

OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service*.

If a DHCP server provides NTP server information, the chrony time service on the Red Hat Enterprise Linux CoreOS (RHCOS) machines read the information and can sync the clock with the NTP servers.

## 16.4.6. Setting up the installation machine

To run the binary **openshift-install** installation program and Ansible scripts, set up the RHV Manager or an Red Hat Enterprise Linux (RHEL) computer with network access to the RHV environment and the REST API on the Manager.

### Procedure

1. Update or install Python3 and Ansible. For example:

```
# dnf update python3 ansible
```

2. Install the **python3-ovirt-engine-sdk4** package to get the Python Software Development Kit.
3. Install the **ovirt.image-template** Ansible role. On the RHV Manager and other Red Hat Enterprise Linux (RHEL) machines, this role is distributed as the **ovirt-ansible-image-template** package. For example, enter:

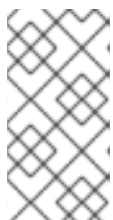
```
# dnf install ovirt-ansible-image-template
```

4. Install the **ovirt.vm-infra** Ansible role. On the RHV Manager and other RHEL machines, this role is distributed as the **ovirt-ansible-vm-infra** package.

```
# dnf install ovirt-ansible-vm-infra
```

5. Create an environment variable and assign an absolute or relative path to it. For example, enter:

```
$ export ASSETS_DIR=./wrk
```



### NOTE

The installation program uses this variable to create a directory where it saves important installation-related files. Later, the installation process reuses this variable to locate those asset files. Avoid deleting this assets directory; it is required for uninstalling the cluster.

## 16.4.7. Installing OpenShift Container Platform on RHV in insecure mode

By default, the installer creates a CA certificate, prompts you for confirmation, and stores the certificate to use during installation. You do not need to create or install one manually.

Although it is not recommended, you can override this functionality and install OpenShift Container Platform without verifying a certificate by installing OpenShift Container Platform on RHV in **insecure** mode.



**WARNING**

Installing in **insecure** mode is not recommended, because it enables a potential attacker to perform a Man-in-the-Middle attack and capture sensitive credentials on the network.

**Procedure**

1. Create a file named `~/.ovirt/ovirt-config.yaml`.
2. Add the following content to **ovirt-config.yaml**:

```
ovirt_url: https://ovirt.example.com/ovirt-engine/api 1
ovirt_fqdn: ovirt.example.com 2
ovirt_pem_url: ""
ovirt_username: ocpadmin@internal
ovirt_password: super-secret-password 3
ovirt_insecure: true
```

- 1 Specify the hostname or address of your oVirt engine.
- 2 Specify the fully qualified domain name of your oVirt engine.
- 3 Specify the admin password for your oVirt engine.

3. Run the installer.

**16.4.8. Generating a key pair for cluster node SSH access**

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.

**IMPORTANT**

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

**NOTE**

You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

**Procedure**

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.

**NOTE**

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.

**NOTE**

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

**Example output**

```
Agent pid 31874
```

**NOTE**

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1** Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

**Example output**

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

**Next steps**

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

**16.4.9. Obtaining the installation program**

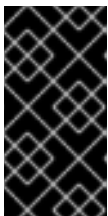
Before you install OpenShift Container Platform, download the installation file on a local computer.

**Prerequisites**

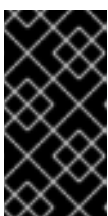
- You have a computer that runs Linux or macOS, with 500 MB of local disk space

**Procedure**

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.

**IMPORTANT**

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.

**IMPORTANT**

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#) . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

### 16.4.10. Downloading the Ansible playbooks

Download the Ansible playbooks for installing OpenShift Container Platform version 4.9 on RHV.

#### Procedure

- On your installation machine, run the following commands:

```
$ mkdir playbooks
```

```
$ cd playbooks
```

```
$ curl -s -L -X GET https://api.github.com/repos/openshift/installer/contents/upi/ovirt?ref=release-4.9 |  
grep 'download_url.*\.yml' |  
awk '{ print $2 }' | sed -r 's/(\"|\",)//g' |  
xargs -n 1 curl -O
```

#### Next steps

- After you download these Ansible playbooks, you must also create the environment variable for the assets directory and customize the **inventory.yml** file before you create an installation configuration file by running the installation program.

### 16.4.11. The inventory.yml file

You use the **inventory.yml** file to define and create elements of the OpenShift Container Platform cluster you are installing. This includes elements such as the Red Hat Enterprise Linux CoreOS (RHCOS) image, virtual machine templates, bootstrap machine, control plane nodes, and worker nodes. You also use **inventory.yml** to destroy the cluster.

The following **inventory.yml** example shows you the parameters and their default values. The quantities and numbers in these default values meet the requirements for running a production OpenShift Container Platform cluster in a RHV environment.

#### Example inventory.yml file

```
---  
all:  
  vars:  
  
  ovirt_cluster: "Default"  
  ocp:
```

```

assets_dir: "{{ lookup('env', 'ASSETS_DIR') }}"
ovirt_config_path: "{{ lookup('env', 'HOME') }}/.ovirt/ovirt-config.yaml"

# ---
# {op-system} section
# ---
rhcos:
  image_url: "https://mirror.openshift.com/pub/openshift-v4/dependencies/rhcos/4.9/latest/rhcos-
openstack.x86_64.qcow2.gz"
  local_cmp_image_path: "/tmp/rhcos.qcow2.gz"
  local_image_path: "/tmp/rhcos.qcow2"

# ---
# Profiles section
# ---
control_plane:
  cluster: "{{ ovirt_cluster }}"
  memory: 16GiB
  sockets: 4
  cores: 1
  template: rhcos_tpl
  operating_system: "rhcos_x64"
  type: high_performance
  graphical_console:
    headless_mode: false
  protocol:
    - spice
    - vnc
  disks:
    - size: 120GiB
      name: os
      interface: virtio_scsi
      storage_domain: depot_nvme
  nics:
    - name: nic1
      network: lab
      profile: lab

compute:
  cluster: "{{ ovirt_cluster }}"
  memory: 16GiB
  sockets: 4
  cores: 1
  template: worker_rhcos_tpl
  operating_system: "rhcos_x64"
  type: high_performance
  graphical_console:
    headless_mode: false
  protocol:
    - spice
    - vnc
  disks:
    - size: 120GiB
      name: os
      interface: virtio_scsi
      storage_domain: depot_nvme

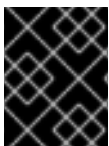
```

```

    nics:
    - name: nic1
      network: lab
      profile: lab

    # ---
    # Virtual machines section
    # ---
    vms:
    - name: "{{ metadata.infraID }}-bootstrap"
      ocp_type: bootstrap
      profile: "{{ control_plane }}"
      type: server
    - name: "{{ metadata.infraID }}-master0"
      ocp_type: master
      profile: "{{ control_plane }}"
    - name: "{{ metadata.infraID }}-master1"
      ocp_type: master
      profile: "{{ control_plane }}"
    - name: "{{ metadata.infraID }}-master2"
      ocp_type: master
      profile: "{{ control_plane }}"
    - name: "{{ metadata.infraID }}-worker0"
      ocp_type: worker
      profile: "{{ compute }}"
    - name: "{{ metadata.infraID }}-worker1"
      ocp_type: worker
      profile: "{{ compute }}"
    - name: "{{ metadata.infraID }}-worker2"
      ocp_type: worker
      profile: "{{ compute }}"

```



## IMPORTANT

Enter values for parameters whose descriptions begin with "Enter." Otherwise, you can use the default value or replace it with a new value.

### General section

- **ovirt\_cluster**: Enter the name of an existing RHV cluster in which to install the OpenShift Container Platform cluster.
- **ocp.assets\_dir**: The path of a directory the **openshift-install** installation program creates to store the files that it generates.
- **ocp.ovirt\_config\_path**: The path of the **ovirt-config.yaml** file the installation program generates, for example, **./wrk/install-config.yaml**. This file contains the credentials required to interact with the REST API of the Manager.

### Red Hat Enterprise Linux CoreOS (RHCOS) section

- **image\_url**: Enter the URL of the RHCOS image you specified for download.
- **local\_cmp\_image\_path**: The path of a local download directory for the compressed RHCOS image.

- **local\_image\_path**: The path of a local directory for the extracted RHCOS image.

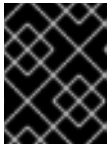
## Profiles section

This section consists of two profiles:

- **control\_plane**: The profile of the bootstrap and control plane nodes.
- **compute**: The profile of workers nodes in the compute plane.

These profiles have the following parameters. The default values of the parameters meet the minimum requirements for running a production cluster. You can increase or customize these values to meet your workload requirements.

- **cluster**: The value gets the cluster name from **ovirt\_cluster** in the General Section.
- **memory**: The amount of memory, in GB, for the virtual machine.
- **sockets**: The number of sockets for the virtual machine.
- **cores**: The number of cores for the virtual machine.
- **template**: The name of the virtual machine template. If plan to install multiple clusters, and these clusters use templates that contain different specifications, prepend the template name with the ID of the cluster.
- **operating\_system**: The type of guest operating system in the virtual machine. With oVirt/RHV version 4.4, this value must be **rhcos\_x64** so the value of **Ignition script** can be passed to the VM.
- **type**: Enter **server** as the type of the virtual machine.



### IMPORTANT

You must change the value of the **type** parameter from **high\_performance** to **server**.

- **disks**: The disk specifications. The **control\_plane** and **compute** nodes can have different storage domains.
- **size**: The minimum disk size.
- **name**: Enter the name of a disk connected to the target cluster in RHV.
- **interface**: Enter the interface type of the disk you specified.
- **storage\_domain**: Enter the storage domain of the disk you specified.
- **nics**: Enter the **name** and **network** the virtual machines use. You can also specify the virtual network interface profile. By default, NICs obtain their MAC addresses from the oVirt/RHV MAC pool.

## Virtual machines section

This final section, **vms**, defines the virtual machines you plan to create and deploy in the cluster. By default, it provides the minimum number of control plane and worker nodes for a production environment.

**vms** contains three required elements:

- **name**: The name of the virtual machine. In this case, **metadata.infraID** prepends the virtual machine name with the infrastructure ID from the **metadata.yml** file.
- **ocp\_type**: The role of the virtual machine in the OpenShift Container Platform cluster. Possible values are **bootstrap**, **master**, **worker**.
- **profile**: The name of the profile from which each virtual machine inherits specifications. Possible values in this example are **control\_plane** or **compute**.

You can override the value a virtual machine inherits from its profile. To do this, you add the name of the profile attribute to the virtual machine in **inventory.yml** and assign it an overriding value. To see an example of this, examine the **name: "{{ metadata.infraID }}-bootstrap"** virtual machine in the preceding **inventory.yml** example: It has a **type** attribute whose value, **server**, overrides the value of the **type** attribute this virtual machine would otherwise inherit from the **control\_plane** profile.

## Metadata variables

For virtual machines, **metadata.infraID** prepends the name of the virtual machine with the infrastructure ID from the **metadata.json** file you create when you build the Ignition files.

The playbooks use the following code to read **infraID** from the specific file located in the **ocp.assets\_dir**.

```
---
- name: include metadata.json vars
  include_vars:
    file: "{{ ocp.assets_dir }}/metadata.json"
    name: metadata
...
```

## 16.4.12. Specifying the RHCOS image settings

Update the Red Hat Enterprise Linux CoreOS (RHCOS) image settings of the **inventory.yml** file. Later, when you run this file one of the playbooks, it downloads a compressed Red Hat Enterprise Linux CoreOS (RHCOS) image from the **image\_url** URL to the **local\_cmp\_image\_path** directory. The playbook then uncompresses the image to the **local\_image\_path** directory and uses it to create oVirt/RHV templates.

### Procedure

1. Locate the RHCOS image download page for the version of OpenShift Container Platform you are installing, such as [Index of /pub/openshift-v4/dependencies/rhcos/latest/latest](#).
2. From that download page, copy the URL of an OpenStack **qcow2** image, such as **https://mirror.openshift.com/pub/openshift-v4/dependencies/rhcos/4.9/latest/rhcos-openstack.x86\_64.qcow2.gz**.
3. Edit the **inventory.yml** playbook you downloaded earlier. In it, paste the URL as the value for **image\_url**. For example:

```
rhcos:
  "https://mirror.openshift.com/pub/openshift-v4/dependencies/rhcos/4.9/latest/rhcos-
  openstack.x86_64.qcow2.gz"
```



### 16.4.13. Creating the install config file

You create an installation configuration file by running the installation program, **openshift-install**, and responding to its prompts with information you specified or gathered earlier.

When you finish responding to the prompts, the installation program creates an initial version of the **install-config.yaml** file in the assets directory you specified earlier, for example, **./wrk/install-config.yaml**

The installation program also creates a file, **\$HOME/.ovirt/ovirt-config.yaml**, that contains all the connection parameters that are required to reach the Manager and use its REST API.

**NOTE:** The installation process does not use values you supply for some parameters, such as **Internal API virtual IP** and **Ingress virtual IP**, because you have already configured them in your infrastructure DNS.

It also uses the values you supply for parameters in **inventory.yml**, like the ones for **oVirt cluster**, **oVirt storage**, and **oVirt network**. And uses a script to remove or replace these same values from **install-config.yaml** with the previously mentioned **virtual IPs**.

#### Procedure

1. Run the installation program:

```
$ openshift-install create install-config --dir $ASSETS_DIR
```

2. Respond to the installation program's prompts with information about your system.

#### Example output

```
? SSH Public Key /home/user/.ssh/id_dsa.pub
? Platform <ovirt>
? Engine FQDN[:PORT] [? for help] <engine.fqdn>
? Enter ovirt-engine username <ocpadmin@internal>
? Enter password <*****>
? oVirt cluster <cluster>
? oVirt storage <storage>
? oVirt network <net>
? Internal API virtual IP <172.16.0.252>
? Ingress virtual IP <172.16.0.251>
? Base Domain <example.org>
? Cluster Name <ocp4>
? Pull Secret [? for help] <*****>
```

```
? SSH Public Key /home/user/.ssh/id_dsa.pub
? Platform <ovirt>
? Engine FQDN[:PORT] [? for help] <engine.fqdn>
? Enter ovirt-engine username <ocpadmin@internal>
? Enter password <*****>
? oVirt cluster <cluster>
? oVirt storage <storage>
? oVirt network <net>
? Internal API virtual IP <172.16.0.252>
```

```
? Ingress virtual IP <172.16.0.251>
? Base Domain <example.org>
? Cluster Name <ocp4>
? Pull Secret [? for help] <*****>
```

For **Internal API virtual IP** and **Ingress virtual IP**, supply the IP addresses you specified when you configured the DNS service.

Together, the values you enter for the **oVirt cluster** and **Base Domain** prompts form the FQDN portion of URLs for the REST API and any applications you create, such as **https://api.ocp4.example.org:6443/** and **https://console-openshift-console.apps.ocp4.example.org**.

You can get the [pull secret from the Red Hat OpenShift Cluster Manager](#) .

## 16.4.14. Customizing install-config.yaml

Here, you use three Python scripts to override some of the installation program's default behaviors:

- By default, the installation program uses the machine API to create nodes. To override this default behavior, you set the number of compute nodes to zero replicas. Later, you use Ansible playbooks to create the compute nodes.
- By default, the installation program sets the IP range of the machine network for nodes. To override this default behavior, you set the IP range to match your infrastructure.
- By default, the installation program sets the platform to **ovirt**. However, installing a cluster on user-provisioned infrastructure is more similar to installing a cluster on bare metal. Therefore, you delete the **ovirt** platform section from **install-config.yaml** and change the platform to **none**. Instead, you use **inventory.yml** to specify all of the required settings.



### NOTE

These snippets work with Python 3 and Python 2.

### Procedure

1. Set the number of compute nodes to zero replicas:

```
$ python3 -c 'import os, yaml
path = "%s/install-config.yaml" % os.environ["ASSETS_DIR"]
conf = yaml.safe_load(open(path))
conf["compute"][0]["replicas"] = 0
open(path, "w").write(yaml.dump(conf, default_flow_style=False))'
```

2. Set the IP range of the machine network. For example, to set the range to **172.16.0.0/16**, enter:

```
$ python3 -c 'import os, yaml
path = "%s/install-config.yaml" % os.environ["ASSETS_DIR"]
conf = yaml.safe_load(open(path))
conf["networking"]["machineNetwork"][0]["cidr"] = "172.16.0.0/16"
open(path, "w").write(yaml.dump(conf, default_flow_style=False))'
```

3. Remove the **ovirt** section and change the platform to **none**:

```
$ python3 -c 'import os, yaml
path = "%s/install-config.yaml" % os.environ["ASSETS_DIR"]
conf = yaml.safe_load(open(path))
platform = conf["platform"]
del platform["ovirt"]
platform["none"] = {}
open(path, "w").write(yaml.dump(conf, default_flow_style=False))'
```



### WARNING

Red Hat Virtualization does not currently support installation with user-provisioned infrastructure on the oVirt platform. Therefore, you must set the platform to **none**, allowing OpenShift Container Platform to identify each node as a bare-metal node and the cluster as a bare-metal cluster. This is the same as [installing a cluster on any platform](#), and has the following limitations:

1. There will be no cluster provider so you must manually add each machine and there will be no node scaling capabilities.
2. The oVirt CSI driver will not be installed and there will be no CSI capabilities.

### 16.4.15. Generate manifest files

Use the installation program to generate a set of manifest files in the assets directory.

The command to generate the manifest files displays a warning message before it consumes the **install-config.yaml** file.

If you plan to reuse the **install-config.yaml** file, create a backup copy of it before you back it up before you generate the manifest files.

#### Procedure

1. Optional: Create a backup copy of the **install-config.yaml** file:

```
$ cp install-config.yaml install-config.yaml.backup
```

2. Generate a set of manifests in your assets directory:

```
$ openshift-install create manifests --dir $ASSETS_DIR
```

This command displays the following messages.

#### Example output

INFO Consuming Install Config from target directory  
 WARNING Making control-plane schedulable by setting MastersSchedulable to true for Scheduler cluster settings

The command generates the following manifest files:

### Example output

```
$ tree
.
├── wrk
│   ├── manifests
│   │   ├── 04-openshift-machine-config-operator.yaml
│   │   ├── cluster-config.yaml
│   │   ├── cluster-dns-02-config.yml
│   │   ├── cluster-infrastructure-02-config.yml
│   │   ├── cluster-ingress-02-config.yml
│   │   ├── cluster-network-01-crd.yml
│   │   ├── cluster-network-02-config.yml
│   │   ├── cluster-proxy-01-config.yaml
│   │   ├── cluster-scheduler-02-config.yml
│   │   ├── cvo-overrides.yaml
│   │   ├── etcd-ca-bundle-configmap.yaml
│   │   ├── etcd-client-secret.yaml
│   │   ├── etcd-host-service-endpoints.yaml
│   │   ├── etcd-host-service.yaml
│   │   ├── etcd-metric-client-secret.yaml
│   │   ├── etcd-metric-serving-ca-configmap.yaml
│   │   ├── etcd-metric-signer-secret.yaml
│   │   ├── etcd-namespace.yaml
│   │   ├── etcd-service.yaml
│   │   ├── etcd-serving-ca-configmap.yaml
│   │   ├── etcd-signer-secret.yaml
│   │   ├── kube-cloud-config.yaml
│   │   ├── kube-system-configmap-root-ca.yaml
│   │   ├── machine-config-server-tls-secret.yaml
│   │   └── openshift-config-secret-pull-secret.yaml
│   └── openshift
│       ├── 99_kubeadmin-password-secret.yaml
│       ├── 99_openshift-cluster-api_master-user-data-secret.yaml
│       ├── 99_openshift-cluster-api_worker-user-data-secret.yaml
│       ├── 99_openshift-machineconfig_99-master-ssh.yaml
│       ├── 99_openshift-machineconfig_99-worker-ssh.yaml
│       └── openshift-install-manifests.yaml
```

### Next steps

- Make control plane nodes non-schedulable.

## 16.4.16. Making control-plane nodes non-schedulable

Because you are manually creating and deploying the control plane machines, you must configure a manifest file to make the control plane nodes non-schedulable.

### Procedure

## Procedure

1. To make the control plane nodes non-schedulable, enter:

```
$ python3 -c 'import os, yaml
path = "%s/manifests/cluster-scheduler-02-config.yml" % os.environ["ASSETS_DIR"]
data = yaml.safe_load(open(path))
data["spec"]["mastersSchedulable"] = False
open(path, "w").write(yaml.dump(data, default_flow_style=False))'
```

### 16.4.17. Building the Ignition files

To build the Ignition files from the manifest files you just generated and modified, you run the installation program. This action creates a Red Hat Enterprise Linux CoreOS (RHCOS) machine, **initramfs**, which fetches the Ignition files and performs the configurations needed to create a node.

In addition to the Ignition files, the installation program generates the following:

- An **auth** directory that contains the admin credentials for connecting to the cluster with the **oc** and **kubectl** utilities.
- A **metadata.json** file that contains information such as the OpenShift Container Platform cluster name, cluster ID, and infrastructure ID for the current installation.

The Ansible playbooks for this installation process use the value of **infralD** as a prefix for the virtual machines they create. This prevents naming conflicts when there are multiple installations in the same oVirt/RHV cluster.



#### NOTE

Certificates in Ignition configuration files expire after 24 hours. Complete the cluster installation and keep the cluster running in a non-degraded state for 24 hours so that the first certificate rotation can finish.

## Procedure

1. To build the Ignition files, enter:

```
$ openshift-install create ignition-configs --dir $ASSETS_DIR
```

### Example output

```
$ tree
.
├── wrk
│   ├── auth
│   │   ├── kubeadmin-password
│   │   └── kubeconfig
│   ├── bootstrap.ign
│   ├── master.ign
│   ├── metadata.json
│   └── worker.ign
```

### 16.4.18. Creating templates and virtual machines

After confirming the variables in the **inventory.yml**, you run the first Ansible provisioning playbook, **create-templates-and-vms.yml**.

This playbook uses the connection parameters for the RHV Manager from **\$HOME/.ovirt/ovirt-config.yml** and reads **metadata.json** in the assets directory.

If a local Red Hat Enterprise Linux CoreOS (RHCOS) image is not already present, the playbook downloads one from the URL you specified for **image\_url** in **inventory.yml**. It extracts the image and uploads it to RHV to create templates.

The playbook creates a template based on the **control\_plane** and **compute** profiles in the **inventory.yml** file. If these profiles have different names, it creates two templates.

When the playbook finishes, the virtual machines it creates are stopped. You can get information from them to help configure other infrastructure elements. For example, you can get the virtual machines' MAC addresses to configure DHCP to assign permanent IP addresses to the virtual machines.

### Procedure

1. In **inventory.yml**, under the **control\_plane** and **compute** variables, change both instances of **type: high\_performance** to **type: server**.
2. Optional: If you plan to perform multiple installations to the same cluster, create different templates for each OpenShift Container Platform installation. In the **inventory.yml** file, prepend the value of **template** with **infraID**. For example:

```
control_plane:
  cluster: "{{ ovirt_cluster }}"
  memory: 16GiB
  sockets: 4
  cores: 1
  template: "{{ metadata.infraID }}-rhcos_tpl"
  operating_system: "rhcos_x64"
  ...
```

3. Create the templates and virtual machines:

```
$ ansible-playbook -i inventory.yml create-templates-and-vms.yml
```

### 16.4.19. Creating the bootstrap machine

You create a bootstrap machine by running the **bootstrap.yml** playbook. This playbook starts the bootstrap virtual machine, and passes it the **bootstrap.ign** Ignition file from the assets directory. The bootstrap node configures itself so it can serve Ignition files to the control plane nodes.

To monitor the bootstrap process, you use the console in the RHV Administration Portal or connect to the virtual machine by using SSH.

### Procedure

1. Create the bootstrap machine:

```
$ ansible-playbook -i inventory.yml bootstrap.yml
```

2. Connect to the bootstrap machine using a console in the Administration Portal or SSH. Replace **<bootstrap\_ip>** with the bootstrap node IP address. To use SSH, enter:

```
$ ssh core@<bootstrap.ip>
```

3. Collect **bootkube.service** journald unit logs for the release image service from the bootstrap node:

```
[core@ocp4-1k6b4-bootstrap ~]$ journalctl -b -f -u release-image.service -u bootkube.service
```



#### NOTE

The **bootkube.service** log on the bootstrap node outputs etcd **connection refused** errors, indicating that the bootstrap server is unable to connect to etcd on control plane nodes. After etcd has started on each control plane node and the nodes have joined the cluster, the errors should stop.

### 16.4.20. Creating the control plane nodes

You create the control plane nodes by running the **masters.yml** playbook. This playbook passes the **master.ign** Ignition file to each of the virtual machines. The Ignition file contains a directive for the control plane node to get the Ignition from a URL such as <https://api-int.ocp4.example.org:22623/config/master>. The port number in this URL is managed by the load balancer, and is accessible only inside the cluster.

#### Procedure

1. Create the control plane nodes:

```
$ ansible-playbook -i inventory.yml masters.yml
```

2. While the playbook creates your control plane, monitor the bootstrapping process:

```
$ openshift-install wait-for bootstrap-complete --dir $ASSETS_DIR
```

#### Example output

```
INFO API v1.22.1 up
INFO Waiting up to 40m0s for bootstrapping to complete...
```

3. When all the pods on the control plane nodes and etcd are up and running, the installation program displays the following output.

#### Example output

```
INFO It is now safe to remove the bootstrap resources
```

### 16.4.21. Verifying cluster status

You can verify your OpenShift Container Platform cluster's status during or after installation.

## Procedure

1. In the cluster environment, export the administrator's kubeconfig file:

```
$ export KUBECONFIG=$ASSETS_DIR/auth/kubeconfig
```

The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server.

2. View the control plane and compute machines created after a deployment:

```
$ oc get nodes
```

3. View your cluster's version:

```
$ oc get clusterversion
```

4. View your Operators' status:

```
$ oc get clusteroperator
```

5. View all running pods in the cluster:

```
$ oc get pods -A
```

### 16.4.22. Removing the bootstrap machine

After the **wait-for** command shows that the bootstrap process is complete, you must remove the bootstrap virtual machine to free up compute, memory, and storage resources. Also, remove settings for the bootstrap machine from the load balancer directives.

## Procedure

1. To remove the bootstrap machine from the cluster, enter:

```
$ ansible-playbook -i inventory.yml retire-bootstrap.yml
```

2. Remove settings for the bootstrap machine from the load balancer directives.

### 16.4.23. Creating the worker nodes and completing the installation

Creating worker nodes is similar to creating control plane nodes. However, worker nodes workers do not automatically join the cluster. To add them to the cluster, you review and approve the workers' pending CSRs (Certificate Signing Requests).

After approving the first requests, you continue approving CSR until all of the worker nodes are approved. When you complete this process, the worker nodes become **Ready** and can have pods scheduled to run on them.

Finally, monitor the command line to see when the installation process completes.

## Procedure



1. Create the worker nodes:

```
$ ansible-playbook -i inventory.yml workers.yml
```

2. To list all of the CSRs, enter:

```
$ oc get csr -A
```

Eventually, this command displays one CSR per node. For example:

### Example output

```
NAME      AGE  SIGNERNAME                                REQUESTOR
CONDITION
csr-2lnxd 63m  kubernetes.io/kubelet-serving             system:node:ocp4-lk6b4-
master0.ocp4.example.org                 Approved,Issued
csr-hff4q 64m  kubernetes.io/kube-apiserver-client-kubelet
system:serviceaccount:openshift-machine-config-operator:node-bootstrapper
Approved,Issued
csr-hsn96 60m  kubernetes.io/kubelet-serving             system:node:ocp4-lk6b4-
master2.ocp4.example.org                 Approved,Issued
csr-m724n 6m2s kubernetes.io/kube-apiserver-client-kubelet
system:serviceaccount:openshift-machine-config-operator:node-bootstrapper Pending
csr-p4dz2 60m  kubernetes.io/kube-apiserver-client-kubelet
system:serviceaccount:openshift-machine-config-operator:node-bootstrapper
Approved,Issued
csr-t9vfj 60m  kubernetes.io/kubelet-serving             system:node:ocp4-lk6b4-
master1.ocp4.example.org                 Approved,Issued
csr-tggtr 61m  kubernetes.io/kube-apiserver-client-kubelet
system:serviceaccount:openshift-machine-config-operator:node-bootstrapper
Approved,Issued
csr-wcbrf 7m6s kubernetes.io/kube-apiserver-client-kubelet
system:serviceaccount:openshift-machine-config-operator:node-bootstrapper Pending
```

3. To filter the list and see only pending CSRs, enter:

```
$ watch "oc get csr -A | grep pending -i"
```

This command refreshes the output every two seconds and displays only pending CSRs. For example:

### Example output

```
Every 2.0s: oc get csr -A | grep pending -i

csr-m724n 10m kubernetes.io/kube-apiserver-client-kubelet
system:serviceaccount:openshift-machine-config-operator:node-bootstrapper Pending
csr-wcbrf 11m kubernetes.io/kube-apiserver-client-kubelet
system:serviceaccount:openshift-machine-config-operator:node-bootstrapper Pending
```

4. Inspect each pending request. For example:

### Example output

```
$ oc describe csr csr-m724n
```

### Example output

```
Name:          csr-m724n
Labels:        <none>
Annotations:   <none>
CreationTimestamp: Sun, 19 Jul 2020 15:59:37 +0200
Requesting User: system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper
Signer:        kubernetes.io/kube-apiserver-client-kubelet
Status:        Pending
Subject:
  Common Name:  system:node:ocp4-1k6b4-worker1.ocp4.example.org
  Serial Number:
  Organization: system:nodes
Events: <none>
```

5. If the CSR information is correct, approve the request:

```
$ oc adm certificate approve csr-m724n
```

6. Wait for the installation process to finish:

```
$ openshift-install wait-for install-complete --dir $ASSETS_DIR --log-level debug
```

When the installation completes, the command line displays the URL of the OpenShift Container Platform web console and the administrator user name and password.

## 16.4.24. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

## 16.5. INSTALLING A CLUSTER ON RHV IN A RESTRICTED NETWORK

In OpenShift Container Platform version 4.9, you can install a customized OpenShift Container Platform cluster on Red Hat Virtualization (RHV) in a restricted network by creating an internal mirror of the installation release content.

### 16.5.1. Prerequisites

The following items are required to install an OpenShift Container Platform cluster on a RHV environment.

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You have a supported combination of versions in the [Support Matrix for OpenShift Container Platform on RHV](#).
- You [created a registry on your mirror host](#) and obtained the **imageContentSources** data for your version of OpenShift Container Platform.



### IMPORTANT

Because the installation media is on the mirror host, you can use that computer to complete all installation steps.

- You provisioned [persistent storage](#) for your cluster. To deploy a private image registry, your storage must provide ReadWriteMany access modes.
- If you use a firewall and plan to use the Telemetry service, you [configured the firewall to allow the sites](#) that your cluster requires access to.



### NOTE

Be sure to also review this site list if you are configuring a proxy.

## 16.5.2. About installations in restricted networks

In OpenShift Container Platform 4.9, you can perform an installation that does not require an active connection to the internet to obtain software components. Restricted network installations can be completed using installer-provisioned infrastructure or user-provisioned infrastructure, depending on the cloud platform to which you are installing the cluster.

If you choose to perform a restricted network installation on a cloud platform, you still require access to its cloud APIs. Some cloud functions, like Amazon Web Service's Route 53 DNS and IAM services, require internet access. Depending on your network, you might require less internet access for an installation on bare metal hardware or on VMware vSphere.

To complete a restricted network installation, you must create a registry that mirrors the contents of the OpenShift Container Platform registry and contains the installation media. You can create this registry on a mirror host, which can access both the internet and your closed network, or by using other methods that meet your restrictions.

### 16.5.2.1. Additional limits

Clusters in restricted networks have the following additional limitations and restrictions:

- The **ClusterVersion** status includes an **Unable to retrieve available updates** error.
- By default, you cannot use the contents of the Developer Catalog because you cannot access the required image stream tags.

## 16.5.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to obtain the images that are necessary to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



### IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

#### 16.5.4. Requirements for the RHV environment

To install and run an OpenShift Container Platform version 4.9 cluster, the RHV environment must meet the following requirements.

Not meeting these requirements can cause the installation or process to fail. Additionally, not meeting these requirements can cause the OpenShift Container Platform cluster to fail days or weeks after installation.

The following requirements for CPU, memory, and storage resources are based on **default** values multiplied by the default number of virtual machines the installation program creates. These resources must be available **in addition to** what the RHV environment uses for non-OpenShift Container Platform operations.

By default, the installation program creates seven virtual machines during the installation process. First, it creates a bootstrap virtual machine to provide temporary services and a control plane while it creates the rest of the OpenShift Container Platform cluster. When the installation program finishes creating the cluster, deleting the bootstrap machine frees up its resources.

If you increase the number of virtual machines in the RHV environment, you must increase the resources accordingly.

#### Requirements

- The RHV version is 4.4.
- The RHV environment has one data center whose state is **Up**.
- The RHV data center contains an RHV cluster.
- The RHV cluster has the following resources exclusively for the OpenShift Container Platform cluster:
  - Minimum 28 vCPUs: four for each of the seven virtual machines created during installation.

- 112 GiB RAM or more, including:
  - 16 GiB or more for the bootstrap machine, which provides the temporary control plane.
  - 16 GiB or more for each of the three control plane machines which provide the control plane.
  - 16 GiB or more for each of the three compute machines, which run the application workloads.
- The RHV storage domain must meet [these etcd backend performance requirements](#).
- In production environments, each virtual machine must have 120 GiB or more. Therefore, the storage domain must provide 840 GiB or more for the default OpenShift Container Platform cluster. In resource-constrained or non-production environments, each virtual machine must have 32 GiB or more, so the storage domain must have 230 GiB or more for the default OpenShift Container Platform cluster.
- To download images from the Red Hat Ecosystem Catalog during installation and update procedures, the RHV cluster must have access to an internet connection. The Telemetry service also needs an internet connection to simplify the subscription and entitlement process.
- The RHV cluster must have a virtual network with access to the REST API on the RHV Manager. Ensure that DHCP is enabled on this network, because the VMs that the installer creates obtain their IP address by using DHCP.
- A user account and group with the following least privileges for installing and managing an OpenShift Container Platform cluster on the target RHV cluster:
  - **DiskOperator**
  - **DiskCreator**
  - **UserTemplateBasedVm**
  - **TemplateOwner**
  - **TemplateCreator**
  - **ClusterAdmin** on the target cluster

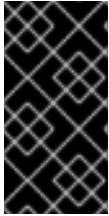


#### WARNING

Apply the principle of least privilege: Avoid using an administrator account with **SuperUser** privileges on RHV during the installation process. The installation program saves the credentials you provide to a temporary **ovirt-config.yaml** file that might be compromised.

### 16.5.5. Verifying the requirements for the RHV environment

Verify that the RHV environment meets the requirements to install and run an OpenShift Container Platform cluster. Not meeting these requirements can cause failures.



## IMPORTANT

These requirements are based on the default resources the installation program uses to create control plane and compute machines. These resources include vCPUs, memory, and storage. If you change these resources or increase the number of OpenShift Container Platform machines, adjust these requirements accordingly.

### Procedure

1. Check that the RHV version supports installation of OpenShift Container Platform version 4.9.
  - a. In the RHV Administration Portal, click the ? help icon in the upper-right corner and select **About**.
  - b. In the window that opens, make a note of the **RHV Software Version**
  - c. Confirm that the RHV version is 4.4. For more information about supported version combinations, see [Support Matrix for OpenShift Container Platform on RHV](#).
2. Inspect the data center, cluster, and storage.
  - a. In the RHV Administration Portal, click **Compute → Data Centers**.
  - b. Confirm that the data center where you plan to install OpenShift Container Platform is accessible.
  - c. Click the name of that data center.
  - d. In the data center details, on the **Storage** tab, confirm the storage domain where you plan to install OpenShift Container Platform is **Active**.
  - e. Record the **Domain Name** for use later on.
  - f. Confirm **Free Space** has at least 230 GiB.
  - g. Confirm that the storage domain meets [these etcd backend performance requirements](#), which you [can measure by using the fio performance benchmarking tool](#).
  - h. In the data center details, click the **Clusters** tab.
  - i. Find the RHV cluster where you plan to install OpenShift Container Platform. Record the cluster name for use later on.
3. Inspect the RHV host resources.
  - a. In the RHV Administration Portal, click **Compute > Clusters**.
  - b. Click the cluster where you plan to install OpenShift Container Platform.
  - c. In the cluster details, click the **Hosts** tab.
  - d. Inspect the hosts and confirm they have a combined total of at least 28 **Logical CPU Cores** available *exclusively* for the OpenShift Container Platform cluster.
  - e. Record the number of available **Logical CPU Cores** for use later on.
  - f. Confirm that these CPU cores are distributed so that each of the seven virtual machines created during installation can have four cores.

- g. Confirm that, all together, the hosts have 112 GiB of **Max free Memory for scheduling new virtual machines** distributed to meet the requirements for each of the following OpenShift Container Platform machines:
- 16 GiB required for the bootstrap machine
  - 16 GiB required for each of the three control plane machines
  - 16 GiB for each of the three compute machines
- h. Record the amount of **Max free Memory for scheduling new virtual machines** for use later on.
4. Verify that the virtual network for installing OpenShift Container Platform has access to the RHV Manager's REST API. From a virtual machine on this network, use curl to reach the RHV Manager's REST API:

```
$ curl -k -u <username>@<profile>:<password> \ 1
https://<engine-fqdn>/ovirt-engine/api 2
```

1 For **<username>**, specify the user name of an RHV account with privileges to create and manage an OpenShift Container Platform cluster on RHV. For **<profile>**, specify the login profile, which you can get by going to the RHV Administration Portal login page and reviewing the **Profile** dropdown list. For **<password>**, specify the password for that user name.

2 For **<engine-fqdn>**, specify the fully qualified domain name of the RHV environment.

For example:

```
$ curl -k -u ocpadmin@internal:pw123 \
https://rhv-env.virtlab.example.com/ovirt-engine/api
```

### 16.5.6. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.

It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.



## NOTE

If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

## Firewall

Configure your firewall so your cluster has access to required sites.

See also:

- [Red Hat Virtualization Manager firewall requirements](#)
- [Host firewall requirements](#)

## DNS

Configure infrastructure-provided DNS to allow the correct resolution of the main components and services. If you use only one load balancer, these DNS records can point to the same IP address.

- Create DNS records for **api.<cluster\_name>.<base\_domain>** (internal and external resolution) and **api-int.<cluster\_name>.<base\_domain>** (internal resolution) that point to the load balancer for the control plane machines.
- Create a DNS record for **\*.apps.<cluster\_name>.<base\_domain>** that points to the load balancer for the Ingress router. For example, ports **443** and **80** of the compute machines.

### 16.5.6.1. Setting the cluster node hostnames through DHCP

On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

### 16.5.6.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.





## IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

**Table 16.9. Ports used for all-machine to all-machine communications**

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	<b>1936</b>	Metrics
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> and the Cluster Version Operator on port <b>9099</b> .
	<b>10250-10259</b>	The default ports that Kubernetes reserves
	<b>10256</b>	openshift-sdn
UDP	<b>4789</b>	VXLAN and Geneve
	<b>6081</b>	VXLAN and Geneve
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> .
	<b>500</b>	IPsec IKE packets
	<b>4500</b>	IPsec NAT-T packets
TCP/UDP	<b>30000-32767</b>	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

**Table 16.10. Ports used for all-machine to control plane communications**

Protocol	Port	Description
TCP	<b>6443</b>	Kubernetes API

**Table 16.11. Ports used for control plane machine to control plane machine communications**

Protocol	Port	Description
TCP	<b>2379-2380</b>	etcd server and peer ports

### NTP configuration for user-provisioned infrastructure

OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service*.

If a DHCP server provides NTP server information, the chrony time service on the Red Hat Enterprise Linux CoreOS (RHCOS) machines read the information and can sync the clock with the NTP servers.

### 16.5.7. User-provisioned DNS requirements

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API
- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines

Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.




#### NOTE

It is recommended to use a DHCP server to provide the hostnames to each cluster node. See the *DHCP recommendations for user-provisioned infrastructure* section for more information.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, **<cluster\_name>** is the cluster name and **<base\_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster\_name>.<base\_domain>..**

**Table 16.12. Required DNS records**

Component	Record	Description
Kubernetes API	<b>api.&lt;cluster_name&gt;.&lt;base_domain&gt;..</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.

Component	Record	Description
	<b>api-int.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	<p>A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>IMPORTANT</b></p> <p>The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.</p> </div> </div>
Routes	<b>*.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	<p>A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.</p> <p>For example, <b>console-openshift-console.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;</b> is used as a wildcard route to the OpenShift Container Platform console.</p>
Bootstrap machine	<b>bootstrap.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.
Control plane machines	<b>&lt;master&gt;&lt;n&gt;.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.
Compute machines	<b>&lt;worker&gt;&lt;n&gt;.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.

**NOTE**

In OpenShift Container Platform 4.4 and later, you do not need to specify etcd host and SRV records in your DNS configuration.

**TIP**

You can use the **dig** command to verify name and reverse name resolution. See the section on *Validating DNS resolution for user-provisioned infrastructure* for detailed validation steps.

### 16.5.7.1. Example DNS configuration for user-provisioned clusters

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is **ocp4** and the base domain is **example.com**.

#### Example DNS A record configuration for a user-provisioned cluster

The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

##### Example 16.1. Sample DNS zone database

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H ; refresh (3 hours)
  30M ; retry (30 minutes)
  2W ; expiry (2 weeks)
  1W ) ; minimum (1 week)
IN NS ns1.example.com.
IN MX 10 smtp.example.com.
;
;
ns1.example.com. IN A 192.168.1.5
smtp.example.com. IN A 192.168.1.5
;
helper.example.com. IN A 192.168.1.5
helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com. IN A 192.168.1.5 1
api-int.ocp4.example.com. IN A 192.168.1.5 2
;
*.apps.ocp4.example.com. IN A 192.168.1.5 3
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 4
;
master0.ocp4.example.com. IN A 192.168.1.97 5
master1.ocp4.example.com. IN A 192.168.1.98 6
master2.ocp4.example.com. IN A 192.168.1.99 7
;
worker0.ocp4.example.com. IN A 192.168.1.11 8
worker1.ocp4.example.com. IN A 192.168.1.7 9
;
;EOF
```

- 1 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.
- 2 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.
- 3 Provides name resolution for the wildcard routes. The record refers to the IP address of the application ingress load balancer. The application ingress load balancer targets the machines

application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



## NOTE

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

- 4 Provides name resolution for the bootstrap machine.
- 5 6 7 Provides name resolution for the control plane machines.
- 8 9 Provides name resolution for the compute machines.

## Example DNS PTR record configuration for a user-provisioned cluster

The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

### Example 16.2. Sample DNS zone database for reverse records

```
$TTL 1W
@ IN SOA ns1.example.com. root (
    2019070700 ; serial
    3H ; refresh (3 hours)
    30M ; retry (30 minutes)
    2W ; expiry (2 weeks)
    1W ) ; minimum (1 week)
IN NS ns1.example.com.
;
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. 2
;
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. 3
;
97.1.168.192.in-addr.arpa. IN PTR master0.ocp4.example.com. 4
98.1.168.192.in-addr.arpa. IN PTR master1.ocp4.example.com. 5
99.1.168.192.in-addr.arpa. IN PTR master2.ocp4.example.com. 6
;
11.1.168.192.in-addr.arpa. IN PTR worker0.ocp4.example.com. 7
7.1.168.192.in-addr.arpa. IN PTR worker1.ocp4.example.com. 8
;
;EOF
```

- 1 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.
- 2 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.

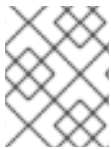
- 3 Provides reverse DNS resolution for the bootstrap machine.
- 4 5 6 Provides reverse DNS resolution for the control plane machines.
- 7 8 Provides reverse DNS resolution for the compute machines.

**NOTE**

A PTR record is not required for the OpenShift Container Platform application wildcard.

### 16.5.7.2. Load balancing requirements for user-provisioned infrastructure

Before you install OpenShift Container Platform, you must provision the API and application ingress load balancing infrastructure. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

**NOTE**

If you want to deploy the API and application ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer.** Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:
  - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the API routes.
  - A stateless load balancing algorithm. The options vary based on the load balancer implementation.

**NOTE**

Session persistence is not required for the API load balancer to function properly.

Configure the following ports on both the front and back of the load balancers:

**Table 16.13. API load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
<b>6443</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the <b>/readyz</b> endpoint for the API server health check probe.	X	X	Kubernetes API server

Port	Back-end machines (pool members)	Internal	External	Description
<b>22623</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server



## NOTE

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the **/readyz** endpoint to the removal of the API server instance from the pool. Within the time frame after **/readyz** returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application ingress load balancer:** Provides an ingress point for application traffic flowing in from outside the cluster. Configure the following conditions:
  - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the ingress routes.
  - A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

## TIP

If the true IP address of the client can be seen by the application ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

Configure the following ports on both the front and back of the load balancers:

**Table 16.14. Application ingress load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
<b>443</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic
<b>80</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic

Port	Back-end machines (pool members)	Internal	External	Description
1936	The worker nodes that run the Ingress Controller pods, by default. You must configure the <b>/healthz/ready</b> endpoint for the ingress health check probe.	X	X	HTTP traffic

**NOTE**

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

**NOTE**

A working configuration for the Ingress router is required for an OpenShift Container Platform cluster. You must configure the Ingress router after the control plane initializes.

#### 16.5.7.2.1. Example load balancer configuration for user-provisioned clusters

This section provides an example API and application ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an **/etc/haproxy/haproxy.cfg** configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing one load balancing solution over another.

**NOTE**

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

#### Example 16.3. Sample API and application ingress load balancer configuration

```
global
  log 127.0.0.1 local2
  pidfile /var/run/haproxy.pid
  maxconn 4000
  daemon
defaults
  mode http
  log global
  option dontlognull
  option http-server-close
  option redispatch
  retries 3
  timeout http-request 10s
  timeout queue 1m
  timeout connect 10s
```



```

timeout client      1m
timeout server     1m
timeout http-keep-alive 10s
timeout check      10s
maxconn            3000
frontend stats
bind *:1936
mode              http
log               global
maxconn 10
stats enable
stats hide-version
stats refresh 30s
stats show-node
stats show-desc Stats for ocp4 cluster 1
stats auth admin:ocp4
stats uri /stats
listen api-server-6443 2
bind *:6443
mode tcp
server bootstrap bootstrap.ocp4.example.com:6443 check inter 1s backup 3
server master0 master0.ocp4.example.com:6443 check inter 1s
server master1 master1.ocp4.example.com:6443 check inter 1s
server master2 master2.ocp4.example.com:6443 check inter 1s
listen machine-config-server-22623 4
bind *:22623
mode tcp
server bootstrap bootstrap.ocp4.example.com:22623 check inter 1s backup 5
server master0 master0.ocp4.example.com:22623 check inter 1s
server master1 master1.ocp4.example.com:22623 check inter 1s
server master2 master2.ocp4.example.com:22623 check inter 1s
listen ingress-router-443 6
bind *:443
mode tcp
balance source
server worker0 worker0.ocp4.example.com:443 check inter 1s
server worker1 worker1.ocp4.example.com:443 check inter 1s
listen ingress-router-80 7
bind *:80
mode tcp
balance source
server worker0 worker0.ocp4.example.com:80 check inter 1s
server worker1 worker1.ocp4.example.com:80 check inter 1s

```

- 1** In the example, the cluster name is **ocp4**.
- 2** Port **6443** handles the Kubernetes API traffic and points to the control plane machines.
- 3** **5** The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.
- 4** Port **22623** handles the machine config server traffic and points to the control plane machines.
- 6** Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

- 7 Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



#### NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

#### TIP

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltp** on the HAProxy node.



#### NOTE

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running **setsebool -P haproxy\_connect\_any=1**.

### 16.5.8. Setting up the installation machine

To run the binary **openshift-install** installation program and Ansible scripts, set up the RHV Manager or an Red Hat Enterprise Linux (RHEL) computer with network access to the RHV environment and the REST API on the Manager.

#### Procedure

1. Update or install Python3 and Ansible. For example:

```
# dnf update python3 ansible
```

2. Install the [python3-ovirt-engine-sdk4](#) package to get the Python Software Development Kit.
3. Install the **ovirt.image-template** Ansible role. On the RHV Manager and other Red Hat Enterprise Linux (RHEL) machines, this role is distributed as the **ovirt-ansible-image-template** package. For example, enter:

```
# dnf install ovirt-ansible-image-template
```

4. Install the **ovirt.vm-infra** Ansible role. On the RHV Manager and other RHEL machines, this role is distributed as the **ovirt-ansible-vm-infra** package.

```
# dnf install ovirt-ansible-vm-infra
```

5. Create an environment variable and assign an absolute or relative path to it. For example, enter:

```
$ export ASSETS_DIR=./wrk
```

**NOTE**

The installation program uses this variable to create a directory where it saves important installation-related files. Later, the installation process reuses this variable to locate those asset files. Avoid deleting this assets directory; it is required for uninstalling the cluster.

### 16.5.9. Setting up the CA certificate for RHV

Download the CA certificate from the Red Hat Virtualization (RHV) Manager and set it up on the installation machine.

You can download the certificate from a webpage on the RHV Manager or by using a **curl** command.

Later, you provide the certificate to the installation program.

**Procedure**

1. Use either of these two methods to download the CA certificate:

- Go to the Manager's webpage, **<https://<engine-fqdn>/ovirt-engine/>**. Then, under **Downloads**, click the **CA Certificate** link.
- Run the following command:

```
$ curl -k 'https://<engine-fqdn>/ovirt-engine/services/pki-resource?resource=ca-certificate&format=X509-PEM-CA' -o /tmp/ca.pem 1
```

- 1** For **<engine-fqdn>**, specify the fully qualified domain name of the RHV Manager, such as **rhv-env.virtlab.example.com**.

2. Configure the CA file to grant rootless user access to the Manager. Set the CA file permissions to have an octal value of **0644** (symbolic value: **-rw-r--r--**):

```
$ sudo chmod 0644 /tmp/ca.pem
```

3. For Linux, copy the CA certificate to the directory for server certificates. Use **-p** to preserve the permissions:

```
$ sudo cp -p /tmp/ca.pem /etc/pki/ca-trust/source/anchors/ca.pem
```

4. Add the certificate to the certificate manager for your operating system:

- For macOS, double-click the certificate file and use the **Keychain Access** utility to add the file to the **System** keychain.
- For Linux, update the CA trust:

```
$ sudo update-ca-trust
```

**NOTE**

If you use your own certificate authority, make sure the system trusts it.

## Additional resources

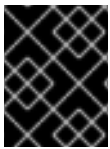
- To learn more, see [Authentication and Security](#) in the RHV documentation.

### 16.5.10. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.



#### IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



#### NOTE

You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

## Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.



#### NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

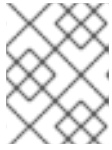
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.



#### NOTE

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the `ssh-agent` process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

#### Example output

```
Agent pid 31874
```



#### NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the `ssh-agent`:

```
$ ssh-add <path>/<file_name> 1
```

- 1** Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

#### Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

#### Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

### 16.5.11. Downloading the Ansible playbooks

Download the Ansible playbooks for installing OpenShift Container Platform version 4.9 on RHV.

#### Procedure

- On your installation machine, run the following commands:

```
$ mkdir playbooks
```

```
■
```

```
$ cd playbooks
```

```
$ curl -s -L -X GET https://api.github.com/repos/openshift/installer/contents/upi/ovirt?
ref=release-4.9 |
grep 'download_url.*\.yml' |
awk '{ print $2 }' | sed -r 's/(\"|\",)//g' |
xargs -n 1 curl -O
```

## Next steps

- After you download these Ansible playbooks, you must also create the environment variable for the assets directory and customize the **inventory.yml** file before you create an installation configuration file by running the installation program.

### 16.5.12. The inventory.yml file

You use the **inventory.yml** file to define and create elements of the OpenShift Container Platform cluster you are installing. This includes elements such as the Red Hat Enterprise Linux CoreOS (RHCOS) image, virtual machine templates, bootstrap machine, control plane nodes, and worker nodes. You also use **inventory.yml** to destroy the cluster.

The following **inventory.yml** example shows you the parameters and their default values. The quantities and numbers in these default values meet the requirements for running a production OpenShift Container Platform cluster in a RHV environment.

#### Example inventory.yml file

```
---
all:
  vars:

    ovirt_cluster: "Default"
    ocp:
      assets_dir: "{{ lookup('env', 'ASSETS_DIR') }}"
      ovirt_config_path: "{{ lookup('env', 'HOME') }}/.ovirt/ovirt-config.yaml"

    # ---
    # {op-system} section
    # ---
    rhcos:
      image_url: "https://mirror.openshift.com/pub/openshift-v4/dependencies/rhcos/4.9/latest/rhcos-
openstack.x86_64.qcow2.gz"
      local_cmp_image_path: "/tmp/rhcos.qcow2.gz"
      local_image_path: "/tmp/rhcos.qcow2"

    # ---
    # Profiles section
    # ---
    control_plane:
      cluster: "{{ ovirt_cluster }}"
      memory: 16GiB
      sockets: 4
      cores: 1
      template: rhcos_tpl
```

```

operating_system: "rhcos_x64"
type: high_performance
graphical_console:
  headless_mode: false
protocol:
  - spice
  - vnc
disks:
- size: 120GiB
  name: os
  interface: virtio_scsi
  storage_domain: depot_nvme
nics:
- name: nic1
  network: lab
  profile: lab

```

```

compute:
  cluster: "{{ ovirt_cluster }}"
  memory: 16GiB
  sockets: 4
  cores: 1
  template: worker_rhcos_tpl
  operating_system: "rhcos_x64"
  type: high_performance
  graphical_console:
    headless_mode: false
  protocol:
    - spice
    - vnc
  disks:
- size: 120GiB
  name: os
  interface: virtio_scsi
  storage_domain: depot_nvme
  nics:
- name: nic1
  network: lab
  profile: lab

```

```
# ---
```

```
# Virtual machines section
```

```
# ---
```

```

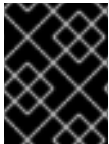
vms:
- name: "{{ metadata.infraID }}-bootstrap"
  ocp_type: bootstrap
  profile: "{{ control_plane }}"
  type: server
- name: "{{ metadata.infraID }}-master0"
  ocp_type: master
  profile: "{{ control_plane }}"
- name: "{{ metadata.infraID }}-master1"
  ocp_type: master
  profile: "{{ control_plane }}"
- name: "{{ metadata.infraID }}-master2"
  ocp_type: master

```

```

profile: "{{ control_plane }}"
- name: "{{ metadata.infraID }}-worker0"
  ocp_type: worker
  profile: "{{ compute }}"
- name: "{{ metadata.infraID }}-worker1"
  ocp_type: worker
  profile: "{{ compute }}"
- name: "{{ metadata.infraID }}-worker2"
  ocp_type: worker
  profile: "{{ compute }}"

```



## IMPORTANT

Enter values for parameters whose descriptions begin with "Enter." Otherwise, you can use the default value or replace it with a new value.

### General section

- **ovirt\_cluster**: Enter the name of an existing RHV cluster in which to install the OpenShift Container Platform cluster.
- **ocp.assets\_dir**: The path of a directory the **openshift-install** installation program creates to store the files that it generates.
- **ocp.ovirt\_config\_path**: The path of the **ovirt-config.yaml** file the installation program generates, for example, **./wrk/install-config.yaml**. This file contains the credentials required to interact with the REST API of the Manager.

### Red Hat Enterprise Linux CoreOS (RHCOS) section

- **image\_url**: Enter the URL of the RHCOS image you specified for download.
- **local\_cmp\_image\_path**: The path of a local download directory for the compressed RHCOS image.
- **local\_image\_path**: The path of a local directory for the extracted RHCOS image.

### Profiles section

This section consists of two profiles:

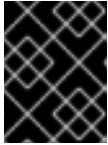
- **control\_plane**: The profile of the bootstrap and control plane nodes.
- **compute**: The profile of workers nodes in the compute plane.

These profiles have the following parameters. The default values of the parameters meet the minimum requirements for running a production cluster. You can increase or customize these values to meet your workload requirements.

- **cluster**: The value gets the cluster name from **ovirt\_cluster** in the General Section.
- **memory**: The amount of memory, in GB, for the virtual machine.
- **sockets**: The number of sockets for the virtual machine.
- **cores**: The number of cores for the virtual machine.



- **template:** The name of the virtual machine template. If plan to install multiple clusters, and these clusters use templates that contain different specifications, prepend the template name with the ID of the cluster.
- **operating\_system:** The type of guest operating system in the virtual machine. With oVirt/RHV version 4.4, this value must be **rhcos\_x64** so the value of **Ignition script** can be passed to the VM.
- **type:** Enter **server** as the type of the virtual machine.



### IMPORTANT

You must change the value of the **type** parameter from **high\_performance** to **server**.

- **disks:** The disk specifications. The **control\_plane** and **compute** nodes can have different storage domains.
- **size:** The minimum disk size.
- **name:** Enter the name of a disk connected to the target cluster in RHV.
- **interface:** Enter the interface type of the disk you specified.
- **storage\_domain:** Enter the storage domain of the disk you specified.
- **nics:** Enter the **name** and **network** the virtual machines use. You can also specify the virtual network interface profile. By default, NICs obtain their MAC addresses from the oVirt/RHV MAC pool.

## Virtual machines section

This final section, **vms**, defines the virtual machines you plan to create and deploy in the cluster. By default, it provides the minimum number of control plane and worker nodes for a production environment.

**vms** contains three required elements:

- **name:** The name of the virtual machine. In this case, **metadata.infraID** prepends the virtual machine name with the infrastructure ID from the **metadata.yml** file.
- **ocp\_type:** The role of the virtual machine in the OpenShift Container Platform cluster. Possible values are **bootstrap**, **master**, **worker**.
- **profile:** The name of the profile from which each virtual machine inherits specifications. Possible values in this example are **control\_plane** or **compute**.  
You can override the value a virtual machine inherits from its profile. To do this, you add the name of the profile attribute to the virtual machine in **inventory.yml** and assign it an overriding value. To see an example of this, examine the **name: "{{ metadata.infraID }}-bootstrap"** virtual machine in the preceding **inventory.yml** example: It has a **type** attribute whose value, **server**, overrides the value of the **type** attribute this virtual machine would otherwise inherit from the **control\_plane** profile.

## Metadata variables

For virtual machines, **metadata.infraID** prepends the name of the virtual machine with the infrastructure ID from the **metadata.json** file you create when you build the Ignition files.

The playbooks use the following code to read **infraID** from the specific file located in the **ocp.assets\_dir**.

```
---
- name: include metadata.json vars
  include_vars:
    file: "{{ ocp.assets_dir }}/metadata.json"
    name: metadata
...
```

### 16.5.13. Specifying the RHCOS image settings

Update the Red Hat Enterprise Linux CoreOS (RHCOS) image settings of the **inventory.yml** file. Later, when you run this file one of the playbooks, it downloads a compressed Red Hat Enterprise Linux CoreOS (RHCOS) image from the **image\_url** URL to the **local\_cmp\_image\_path** directory. The playbook then uncompresses the image to the **local\_image\_path** directory and uses it to create oVirt/RHV templates.

#### Procedure

1. Locate the RHCOS image download page for the version of OpenShift Container Platform you are installing, such as [Index of /pub/openshift-v4/dependencies/rhcos/latest/latest](#).
2. From that download page, copy the URL of an OpenStack **qcow2** image, such as **[https://mirror.openshift.com/pub/openshift-v4/dependencies/rhcos/4.9/latest/rhcos-openstack.x86\\_64.qcow2.gz](https://mirror.openshift.com/pub/openshift-v4/dependencies/rhcos/4.9/latest/rhcos-openstack.x86_64.qcow2.gz)**.
3. Edit the **inventory.yml** playbook you downloaded earlier. In it, paste the URL as the value for **image\_url**. For example:

```
rhcos:
  "https://mirror.openshift.com/pub/openshift-v4/dependencies/rhcos/4.9/latest/rhcos-
  openstack.x86_64.qcow2.gz"
```

### 16.5.14. Creating the install config file

You create an installation configuration file by running the installation program, **openshift-install**, and responding to its prompts with information you specified or gathered earlier.

When you finish responding to the prompts, the installation program creates an initial version of the **install-config.yaml** file in the assets directory you specified earlier, for example, **./wrk/install-config.yaml**

The installation program also creates a file, **\$HOME/.ovirt/ovirt-config.yaml**, that contains all the connection parameters that are required to reach the Manager and use its REST API.

**NOTE:** The installation process does not use values you supply for some parameters, such as **Internal API virtual IP** and **Ingress virtual IP**, because you have already configured them in your infrastructure DNS.

It also uses the values you supply for parameters in **inventory.yml**, like the ones for **oVirt cluster**, **oVirt storage**, and **oVirt network**. And uses a script to remove or replace these same values from **install-config.yaml** with the previously mentioned **virtual IPs**.

## Procedure

1. Run the installation program:

```
$ openshift-install create install-config --dir $ASSETS_DIR
```

2. Respond to the installation program's prompts with information about your system.

### Example output

```
? SSH Public Key /home/user/.ssh/id_dsa.pub
? Platform <ovirt>
? Engine FQDN[:PORT] [? for help] <engine.fqdn>
? Enter ovirt-engine username <ocpadmin@internal>
? Enter password <*****>
? oVirt cluster <cluster>
? oVirt storage <storage>
? oVirt network <net>
? Internal API virtual IP <172.16.0.252>
? Ingress virtual IP <172.16.0.251>
? Base Domain <example.org>
? Cluster Name <ocp4>
? Pull Secret [? for help] <*****>
```

```
? SSH Public Key /home/user/.ssh/id_dsa.pub
? Platform <ovirt>
? Engine FQDN[:PORT] [? for help] <engine.fqdn>
? Enter ovirt-engine username <ocpadmin@internal>
? Enter password <*****>
? oVirt cluster <cluster>
? oVirt storage <storage>
? oVirt network <net>
? Internal API virtual IP <172.16.0.252>
? Ingress virtual IP <172.16.0.251>
? Base Domain <example.org>
? Cluster Name <ocp4>
? Pull Secret [? for help] <*****>
```

For **Internal API virtual IP** and **Ingress virtual IP**, supply the IP addresses you specified when you configured the DNS service.

Together, the values you enter for the **oVirt cluster** and **Base Domain** prompts form the FQDN portion of URLs for the REST API and any applications you create, such as **https://api.ocp4.example.org:6443/** and **https://console-openshift-console.apps.ocp4.example.org**.

You can get the [pull secret from the Red Hat OpenShift Cluster Manager](#) .

### 16.5.15. Sample install-config.yaml file for RHV

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```
apiVersion: v1
baseDomain: example.com 1
```

```

compute: 2
- hyperthreading: Enabled 3
  name: worker
  replicas: 0 4
controlPlane: 5
  hyperthreading: Enabled 6
  name: master
  replicas: 3 7
metadata:
  name: test 8
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14 9
    hostPrefix: 23 10
  networkType: OpenShiftSDN
  serviceNetwork: 11
  - 172.30.0.0/16
platform:
  none: {} 12
fips: false 13
pullSecret: '{"auths": ...}' 14
sshKey: 'ssh-ed25519 AAAA...' 15

```

- 1 The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.
- 2 5 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. Only one control plane pool is used.
- 3 6 Specifies whether to enable or disable simultaneous multithreading (SMT), or hyperthreading. By default, SMT is enabled to increase the performance of the cores in your machines. You can disable it by setting the parameter value to **Disabled**. If you disable SMT, you must disable it in all cluster machines; this includes both control plane and compute machines.



#### NOTE

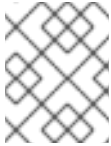
Simultaneous multithreading (SMT) is enabled by default. If SMT is not enabled in your BIOS settings, the **hyperthreading** parameter has no effect.



#### IMPORTANT

If you disable **hyperthreading**, whether in the BIOS or in the **install-config.yaml** file, ensure that your capacity planning accounts for the dramatically decreased machine performance.

- 4 You must set this value to **0** when you install OpenShift Container Platform on user-provisioned infrastructure. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. In user-provisioned installations, you must manually deploy the compute machines before you finish installing the cluster.

**NOTE**

If you are installing a three-node cluster, do not deploy any compute machines when you install the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

- 7 The number of control plane machines that you add to the cluster. Because the cluster uses these values as the number of etcd endpoints in the cluster, the value must match the number of control plane machines that you deploy.
- 8 The cluster name that you specified in your DNS records.
- 9 A block of IP addresses from which pod IP addresses are allocated. This block must not overlap with existing physical networks. These IP addresses are used for the pod network. If you need to access the pods from an external network, you must configure load balancers and routers to manage the traffic.

**NOTE**

Class E CIDR range is reserved for a future use. To use the Class E CIDR range, you must ensure your networking environment accepts the IP addresses within the Class E CIDR range.

- 10 The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23**, then each node is assigned a **/23** subnet out of the given **cidr**, which allows for 510 ( $2^{(32 - 23)} - 2$ ) pod IP addresses. If you are required to provide access to nodes from an external network, configure load balancers and routers to manage the traffic.
- 11 The IP address pool to use for service IP addresses. You can enter only one IP address pool. This block must not overlap with existing physical networks. If you need to access the services from an external network, configure load balancers and routers to manage the traffic.
- 12 You must set the platform to **none**. You cannot provide additional platform configuration variables for RHV infrastructure.

**IMPORTANT**

Clusters that are installed with the platform type **none** are unable to use some features, such as managing compute machines with the Machine API. This limitation applies even if the compute machines that are attached to the cluster are installed on a platform that would normally support the feature. This parameter cannot be changed after installation.

- 13 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

**IMPORTANT**

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

- 14 The [pull secret from the Red Hat OpenShift Cluster Manager](#) . This pull secret allows you to

authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

- 15 The SSH public key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).



#### NOTE

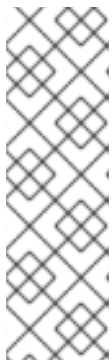
For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

### 16.5.15.1. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

#### Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



#### NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

#### Procedure

- Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
  additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
  ...
```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations.
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

**NOTE**

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

**NOTE**

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

### 16.5.16. Customizing install-config.yaml

Here, you use three Python scripts to override some of the installation program's default behaviors:

- By default, the installation program uses the machine API to create nodes. To override this default behavior, you set the number of compute nodes to zero replicas. Later, you use Ansible playbooks to create the compute nodes.
- By default, the installation program sets the IP range of the machine network for nodes. To override this default behavior, you set the IP range to match your infrastructure.
- By default, the installation program sets the platform to **ovirt**. However, installing a cluster on user-provisioned infrastructure is more similar to installing a cluster on bare metal. Therefore, you delete the **ovirt** platform section from **install-config.yaml** and change the platform to **none**. Instead, you use **inventory.yml** to specify all of the required settings.

**NOTE**

These snippets work with Python 3 and Python 2.

## Procedure

1. Set the number of compute nodes to zero replicas:

```
$ python3 -c 'import os, yaml
path = "%s/install-config.yaml" % os.environ["ASSETS_DIR"]
conf = yaml.safe_load(open(path))
conf["compute"][0]["replicas"] = 0
open(path, "w").write(yaml.dump(conf, default_flow_style=False))'
```

2. Set the IP range of the machine network. For example, to set the range to **172.16.0.0/16**, enter:

```
$ python3 -c 'import os, yaml
path = "%s/install-config.yaml" % os.environ["ASSETS_DIR"]
conf = yaml.safe_load(open(path))
conf["networking"]["machineNetwork"][0]["cidr"] = "172.16.0.0/16"
open(path, "w").write(yaml.dump(conf, default_flow_style=False))'
```

3. Remove the **ovirt** section and change the platform to **none**:

```
$ python3 -c 'import os, yaml
path = "%s/install-config.yaml" % os.environ["ASSETS_DIR"]
conf = yaml.safe_load(open(path))
platform = conf["platform"]
del platform["ovirt"]
platform["none"] = {}
open(path, "w").write(yaml.dump(conf, default_flow_style=False))'
```



### WARNING

Red Hat Virtualization does not currently support installation with user-provisioned infrastructure on the oVirt platform. Therefore, you must set the platform to **none**, allowing OpenShift Container Platform to identify each node as a bare-metal node and the cluster as a bare-metal cluster. This is the same as [installing a cluster on any platform](#), and has the following limitations:

1. There will be no cluster provider so you must manually add each machine and there will be no node scaling capabilities.
2. The oVirt CSI driver will not be installed and there will be no CSI capabilities.

## 16.5.17. Generate manifest files

Use the installation program to generate a set of manifest files in the assets directory.

The command to generate the manifest files displays a warning message before it consumes the **install-config.yaml** file.



If you plan to reuse the **install-config.yaml** file, create a backup copy of it before you back it up before you generate the manifest files.

## Procedure

1. Optional: Create a backup copy of the **install-config.yaml** file:

```
$ cp install-config.yaml install-config.yaml.backup
```

2. Generate a set of manifests in your assets directory:

```
$ openshift-install create manifests --dir $ASSETS_DIR
```

This command displays the following messages.

## Example output

```
INFO Consuming Install Config from target directory
WARNING Making control-plane schedulable by setting MastersSchedulable to true for
Scheduler cluster settings
```

The command generates the following manifest files:

## Example output

```
$ tree
.
├── wrk
│   └── manifests
│       ├── 04-openshift-machine-config-operator.yaml
│       ├── cluster-config.yaml
│       ├── cluster-dns-02-config.yml
│       ├── cluster-infrastructure-02-config.yml
│       ├── cluster-ingress-02-config.yml
│       ├── cluster-network-01-crd.yml
│       ├── cluster-network-02-config.yml
│       ├── cluster-proxy-01-config.yaml
│       ├── cluster-scheduler-02-config.yml
│       ├── cvo-overrides.yaml
│       ├── etcd-ca-bundle-configmap.yaml
│       ├── etcd-client-secret.yaml
│       ├── etcd-host-service-endpoints.yaml
│       ├── etcd-host-service.yaml
│       ├── etcd-metric-client-secret.yaml
│       ├── etcd-metric-serving-ca-configmap.yaml
│       ├── etcd-metric-signer-secret.yaml
│       ├── etcd-namespace.yaml
│       ├── etcd-service.yaml
│       ├── etcd-serving-ca-configmap.yaml
│       ├── etcd-signer-secret.yaml
│       ├── kube-cloud-config.yaml
│       ├── kube-system-configmap-root-ca.yaml
│       ├── machine-config-server-tls-secret.yaml
│       └── openshift-config-secret-pull-secret.yaml
```

```

├── openshift
│   ├── 99_kubeadmin-password-secret.yaml
│   ├── 99_openshift-cluster-api_master-user-data-secret.yaml
│   ├── 99_openshift-cluster-api_worker-user-data-secret.yaml
│   ├── 99_openshift-machineconfig_99-master-ssh.yaml
│   ├── 99_openshift-machineconfig_99-worker-ssh.yaml
│   └── openshift-install-manifests.yaml

```

### Next steps

- Make control plane nodes non-schedulable.

## 16.5.18. Making control-plane nodes non-schedulable

Because you are manually creating and deploying the control plane machines, you must configure a manifest file to make the control plane nodes non-schedulable.

### Procedure

1. To make the control plane nodes non-schedulable, enter:

```

$ python3 -c 'import os, yaml
path = "%s/manifests/cluster-scheduler-02-config.yml" % os.environ["ASSETS_DIR"]
data = yaml.safe_load(open(path))
data["spec"]["mastersSchedulable"] = False
open(path, "w").write(yaml.dump(data, default_flow_style=False))'

```

## 16.5.19. Building the Ignition files

To build the Ignition files from the manifest files you just generated and modified, you run the installation program. This action creates a Red Hat Enterprise Linux CoreOS (RHCOS) machine, **iniramfs**, which fetches the Ignition files and performs the configurations needed to create a node.

In addition to the Ignition files, the installation program generates the following:

- An **auth** directory that contains the admin credentials for connecting to the cluster with the **oc** and **kubectl** utilities.
- A **metadata.json** file that contains information such as the OpenShift Container Platform cluster name, cluster ID, and infrastructure ID for the current installation.

The Ansible playbooks for this installation process use the value of **infralD** as a prefix for the virtual machines they create. This prevents naming conflicts when there are multiple installations in the same oVirt/RHV cluster.



### NOTE

Certificates in Ignition configuration files expire after 24 hours. Complete the cluster installation and keep the cluster running in a non-degraded state for 24 hours so that the first certificate rotation can finish.

### Procedure

1. To build the Ignition files, enter:

```
$ openshift-install create ignition-configs --dir $ASSETS_DIR
```

### Example output

```
$ tree
.
├── wrk
│   ├── auth
│   │   ├── kubeadmin-password
│   │   └── kubeconfig
│   ├── bootstrap.ign
│   ├── master.ign
│   ├── metadata.json
│   └── worker.ign
```

## 16.5.20. Creating templates and virtual machines

After confirming the variables in the **inventory.yml**, you run the first Ansible provisioning playbook, **create-templates-and-vms.yml**.

This playbook uses the connection parameters for the RHV Manager from **\$HOME/.ovirt/ovirt-config.yaml** and reads **metadata.json** in the assets directory.

If a local Red Hat Enterprise Linux CoreOS (RHCOS) image is not already present, the playbook downloads one from the URL you specified for **image\_url** in **inventory.yml**. It extracts the image and uploads it to RHV to create templates.

The playbook creates a template based on the **control\_plane** and **compute** profiles in the **inventory.yml** file. If these profiles have different names, it creates two templates.

When the playbook finishes, the virtual machines it creates are stopped. You can get information from them to help configure other infrastructure elements. For example, you can get the virtual machines' MAC addresses to configure DHCP to assign permanent IP addresses to the virtual machines.

### Procedure

1. In **inventory.yml**, under the **control\_plane** and **compute** variables, change both instances of **type: high\_performance** to **type: server**.
2. Optional: If you plan to perform multiple installations to the same cluster, create different templates for each OpenShift Container Platform installation. In the **inventory.yml** file, prepend the value of **template** with **infraID**. For example:

```
control_plane:
  cluster: "{{ ovirt_cluster }}"
  memory: 16GiB
  sockets: 4
  cores: 1
  template: "{{ metadata.infraID }}-rhcos_tpl"
  operating_system: "rhcos_x64"
  ...
```

3. Create the templates and virtual machines:

```
$ ansible-playbook -i inventory.yml create-templates-and-vms.yml
```

### 16.5.21. Creating the bootstrap machine

You create a bootstrap machine by running the **bootstrap.yml** playbook. This playbook starts the bootstrap virtual machine, and passes it the **bootstrap.ign** Ignition file from the assets directory. The bootstrap node configures itself so it can serve Ignition files to the control plane nodes.

To monitor the bootstrap process, you use the console in the RHV Administration Portal or connect to the virtual machine by using SSH.

#### Procedure

1. Create the bootstrap machine:

```
$ ansible-playbook -i inventory.yml bootstrap.yml
```

2. Connect to the bootstrap machine using a console in the Administration Portal or SSH. Replace **<bootstrap\_ip>** with the bootstrap node IP address. To use SSH, enter:

```
$ ssh core@<bootstrap.ip>
```

3. Collect **bootkube.service** journald unit logs for the release image service from the bootstrap node:

```
[core@ocp4-1k6b4-bootstrap ~]$ journalctl -b -f -u release-image.service -u bootkube.service
```



#### NOTE

The **bootkube.service** log on the bootstrap node outputs etcd **connection refused** errors, indicating that the bootstrap server is unable to connect to etcd on control plane nodes. After etcd has started on each control plane node and the nodes have joined the cluster, the errors should stop.

### 16.5.22. Creating the control plane nodes

You create the control plane nodes by running the **masters.yml** playbook. This playbook passes the **master.ign** Ignition file to each of the virtual machines. The Ignition file contains a directive for the control plane node to get the Ignition from a URL such as <https://api-int.ocp4.example.org:22623/config/master>. The port number in this URL is managed by the load balancer, and is accessible only inside the cluster.

#### Procedure

1. Create the control plane nodes:

```
$ ansible-playbook -i inventory.yml masters.yml
```

2. While the playbook creates your control plane, monitor the bootstrapping process:

```
$ openshift-install wait-for bootstrap-complete --dir $ASSETS_DIR
```

### Example output

```
INFO API v1.22.1 up
INFO Waiting up to 40m0s for bootstrapping to complete...
```

- When all the pods on the control plane nodes and etcd are up and running, the installation program displays the following output.

### Example output

```
INFO It is now safe to remove the bootstrap resources
```

## 16.5.23. Verifying cluster status

You can verify your OpenShift Container Platform cluster's status during or after installation.

### Procedure

- In the cluster environment, export the administrator's kubeconfig file:

```
$ export KUBECONFIG=$ASSETS_DIR/auth/kubeconfig
```

The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server.

- View the control plane and compute machines created after a deployment:

```
$ oc get nodes
```

- View your cluster's version:

```
$ oc get clusterversion
```

- View your Operators' status:

```
$ oc get clusteroperator
```

- View all running pods in the cluster:

```
$ oc get pods -A
```

## 16.5.24. Removing the bootstrap machine

After the **wait-for** command shows that the bootstrap process is complete, you must remove the bootstrap virtual machine to free up compute, memory, and storage resources. Also, remove settings for the bootstrap machine from the load balancer directives.

### Procedure

- To remove the bootstrap machine from the cluster, enter:

```
$ ansible-playbook -i inventory.yml retire-bootstrap.yml
```

- 2. Remove settings for the bootstrap machine from the load balancer directives.

### 16.5.25. Creating the worker nodes and completing the installation

Creating worker nodes is similar to creating control plane nodes. However, worker nodes workers do not automatically join the cluster. To add them to the cluster, you review and approve the workers' pending CSRs (Certificate Signing Requests).

After approving the first requests, you continue approving CSR until all of the worker nodes are approved. When you complete this process, the worker nodes become **Ready** and can have pods scheduled to run on them.

Finally, monitor the command line to see when the installation process completes.

#### Procedure

1. Create the worker nodes:

```
$ ansible-playbook -i inventory.yml workers.yml
```

2. To list all of the CSRs, enter:

```
$ oc get csr -A
```

Eventually, this command displays one CSR per node. For example:

#### Example output

```
NAME      AGE  SIGNERNAME                                REQUESTOR
CONDITION
csr-2lnxd 63m  kubernetes.io/kubelet-serving            system:node:ocp4-lk6b4-
master0.ocp4.example.org                Approved,Issued
csr-hff4q 64m  kubernetes.io/kube-apiserver-client-kubelet
system:serviceaccount:openshift-machine-config-operator:node-bootstrapper
Approved,Issued
csr-hsn96 60m  kubernetes.io/kubelet-serving            system:node:ocp4-lk6b4-
master2.ocp4.example.org                Approved,Issued
csr-m724n 6m2s kubernetes.io/kube-apiserver-client-kubelet
system:serviceaccount:openshift-machine-config-operator:node-bootstrapper Pending
csr-p4dz2 60m  kubernetes.io/kube-apiserver-client-kubelet
system:serviceaccount:openshift-machine-config-operator:node-bootstrapper
Approved,Issued
csr-t9vfj 60m  kubernetes.io/kubelet-serving            system:node:ocp4-lk6b4-
master1.ocp4.example.org                Approved,Issued
csr-tggr 61m  kubernetes.io/kube-apiserver-client-kubelet
system:serviceaccount:openshift-machine-config-operator:node-bootstrapper
Approved,Issued
csr-wcbrf 7m6s kubernetes.io/kube-apiserver-client-kubelet
system:serviceaccount:openshift-machine-config-operator:node-bootstrapper Pending
```

3. To filter the list and see only pending CSRs, enter:

```
$ watch "oc get csr -A | grep pending -i"
```

This command refreshes the output every two seconds and displays only pending CSRs. For example:

### Example output

```
Every 2.0s: oc get csr -A | grep pending -i

csr-m724n 10m kubernetes.io/kube-apiserver-client-kubelet
system:serviceaccount:openshift-machine-config-operator:node-bootstrapper Pending
csr-wcbrf 11m kubernetes.io/kube-apiserver-client-kubelet
system:serviceaccount:openshift-machine-config-operator:node-bootstrapper Pending
```

4. Inspect each pending request. For example:

### Example output

```
$ oc describe csr csr-m724n
```

### Example output

```
Name:          csr-m724n
Labels:        <none>
Annotations:   <none>
CreationTimestamp: Sun, 19 Jul 2020 15:59:37 +0200
Requesting User: system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper
Signer:        kubernetes.io/kube-apiserver-client-kubelet
Status:        Pending
Subject:
  Common Name:  system:node:ocp4-lk6b4-worker1.ocp4.example.org
  Serial Number:
  Organization: system:nodes
Events: <none>
```

5. If the CSR information is correct, approve the request:

```
$ oc adm certificate approve csr-m724n
```

6. Wait for the installation process to finish:

```
$ openshift-install wait-for install-complete --dir $ASSETS_DIR --log-level debug
```

When the installation completes, the command line displays the URL of the OpenShift Container Platform web console and the administrator user name and password.

## 16.5.26. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

## 16.5.27. Disabling the default OperatorHub sources

Operator catalogs that source content provided by Red Hat and community projects are configured for OperatorHub by default during an OpenShift Container Platform installation. In a restricted network environment, you must disable the default catalogs as a cluster administrator.

### Procedure

- Disable the sources for the default catalogs by adding **disableAllDefaultSources: true** to the **OperatorHub** object:

```
$ oc patch OperatorHub cluster --type json \
  -p '[{"op": "add", "path": "/spec/disableAllDefaultSources", "value": true}]'
```

### TIP

Alternatively, you can use the web console to manage catalog sources. From the **Administration** → **Cluster Settings** → **Configuration** → **OperatorHub** page, click the **Sources** tab, where you can create, delete, disable, and enable individual sources.

## 16.6. UNINSTALLING A CLUSTER ON RHV

You can remove an OpenShift Container Platform cluster from Red Hat Virtualization (RHV).

### 16.6.1. Removing a cluster that uses installer-provisioned infrastructure

You can remove a cluster that uses installer-provisioned infrastructure from your cloud.



#### NOTE

After uninstallation, check your cloud provider for any resources not removed properly, especially with User Provisioned Infrastructure (UPI) clusters. There might be resources that the installer did not create or that the installer is unable to access.

### Prerequisites

- Have a copy of the installation program that you used to deploy the cluster.
- Have the files that the installation program generated when you created your cluster.

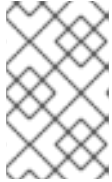
### Procedure

1. From the directory that contains the installation program on the computer that you used to install the cluster, run the following command:



```
$ ./openshift-install destroy cluster \
--dir <installation_directory> --log-level info 1 2
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.
- 2** To view different details, specify **warn**, **debug**, or **error** instead of **info**.



#### NOTE

You must specify the directory that contains the cluster definition files for your cluster. The installation program requires the **metadata.json** file in this directory to delete the cluster.

2. Optional: Delete the **<installation\_directory>** directory and the OpenShift Container Platform installation program.

### 16.6.2. Removing a cluster that uses user-provisioned infrastructure

When you are finished using the cluster, you can remove a cluster that uses user-provisioned infrastructure from your cloud.

#### Prerequisites

- Have the original playbook files, assets directory and files, and **\$ASSETS\_DIR** environment variable that you used to you install the cluster. Typically, you can achieve this by using the same computer you used when you installed the cluster.

#### Procedure

1. To remove the cluster, enter:

```
$ ansible-playbook -i inventory.yml \
  retire-bootstrap.yml \
  retire-masters.yml \
  retire-workers.yml
```

2. Remove any configurations you added to DNS, load balancers, and any other infrastructure for this cluster.

## CHAPTER 17. INSTALLING ON VSPHERE

### 17.1. PREPARING TO INSTALL ON VSPHERE

#### 17.1.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- If you use a firewall and plan to use Telemetry, you [configured the firewall to allow the sites](#) required by your cluster.
- You reviewed your VMware platform licenses. Red Hat does not place any restrictions on your VMware licenses, but some VMware infrastructure components require licensing.

#### 17.1.2. Choosing a method to install OpenShift Container Platform on vSphere

You can install OpenShift Container Platform on vSphere by using installer-provisioned or user-provisioned infrastructure. The default installation type uses installer-provisioned infrastructure, where the installation program provisions the underlying infrastructure for the cluster. You can also install OpenShift Container Platform on infrastructure that you provide. If you do not use infrastructure that the installation program provisions, you must manage and maintain the cluster resources yourself.

See the [Installation process](#) for more information about installer-provisioned and user-provisioned installation processes.



#### IMPORTANT

The steps for performing a user-provisioned infrastructure installation are provided as an example only. Installing a cluster with infrastructure you provide requires knowledge of the vSphere platform and the installation process of OpenShift Container Platform. Use the user-provisioned infrastructure installation instructions as a guide; you are free to create the required resources through other methods.

##### 17.1.2.1. Installer-provisioned infrastructure installation of OpenShift Container Platform on vSphere

Installer-provisioned infrastructure allows the installation program to pre-configure and automate the provisioning of resources required by OpenShift Container Platform.

- [Installing a cluster on vSphere](#) You can install OpenShift Container Platform on vSphere by using installer-provisioned infrastructure installation with no customization.
- [Installing a cluster on vSphere with customizations](#) You can install OpenShift Container Platform on vSphere by using installer-provisioned infrastructure installation with the default customization options.
- [Installing a cluster on vSphere with network customizations](#) You can install OpenShift Container Platform on installer-provisioned vSphere infrastructure, with network customizations. You can customize your OpenShift Container Platform network configuration

during installation, so that your cluster can coexist with your existing IP address allocations and adhere to your network requirements.

- **Installing a cluster on vSphere in a restricted network** You can install a cluster on VMware vSphere infrastructure in a restricted network by creating an internal mirror of the installation release content. You can use this method to deploy OpenShift Container Platform on an internal network that is not visible to the internet.

### 17.1.2.2. User-provisioned infrastructure installation of OpenShift Container Platform on vSphere

User-provisioned infrastructure requires the user to provision all resources required by OpenShift Container Platform.

- **Installing a cluster on vSphere with user-provisioned infrastructure** You can install OpenShift Container Platform on VMware vSphere infrastructure that you provision.
- **Installing a cluster on vSphere with network customizations with user-provisioned infrastructure:** You can install OpenShift Container Platform on VMware vSphere infrastructure that you provision with customized network configuration options.
- **Installing a cluster on vSphere in a restricted network with user-provisioned infrastructure** OpenShift Container Platform can be installed on VMware vSphere infrastructure that you provision in a restricted network.

### 17.1.3. VMware vSphere infrastructure requirements

You must install the OpenShift Container Platform cluster on a VMware vSphere version 6 or 7 instance that meets the requirements for the components that you use.

**Table 17.1. Version requirements for vSphere virtual environments**

Virtual environment product	Required version
VM hardware version	13 or later
vSphere ESXi hosts	6.5 or later
vCenter host	6.5 or later



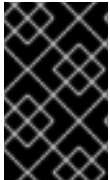
#### IMPORTANT

Installing a cluster on VMware vSphere version 6.7U2 or earlier and virtual hardware version 13 is now deprecated. These versions are still fully supported, but support will be removed in a future version of OpenShift Container Platform. Hardware version 15 is now the default for vSphere virtual machines in OpenShift Container Platform. To update the hardware version for your vSphere nodes, see the "Updating hardware on nodes running in vSphere" article.

**Table 17.2. Minimum supported vSphere version for VMware components**

Component	Minimum supported versions	Description
Hypervisor	vSphere 6.5 and later with HW version 13	This version is the minimum version that Red Hat Enterprise Linux CoreOS (RHCOS) supports. See the <a href="#">Red Hat Enterprise Linux 8 supported hypervisors list</a> .
Storage with in-tree drivers	vSphere 6.5 and later	This plugin creates vSphere storage by using the in-tree storage drivers for vSphere included in OpenShift Container Platform.
Optional: Networking (NSX-T)	vSphere 6.5U3 or vSphere 6.7U2 and later	vSphere 6.5U3 or vSphere 6.7U2+ are required for OpenShift Container Platform. For more information about the compatibility of NSX and OpenShift Container Platform, see the Release Notes section of VMware's <a href="#">NSX container plugin documentation</a> .

If you use a vSphere version 6.5 instance, consider upgrading to 6.7U3 or 7.0 before you install OpenShift Container Platform.



### IMPORTANT

You must ensure that the time on your ESXi hosts is synchronized before you install OpenShift Container Platform. See [Edit Time Configuration for a Host](#) in the VMware documentation.

#### 17.1.4. Uninstalling an installer-provisioned infrastructure installation of OpenShift Container Platform on vSphere

- **Uninstalling a cluster on vSphere that uses installer-provisioned infrastructure** You can remove a cluster that you deployed on VMware vSphere infrastructure that used installer-provisioned infrastructure.

## 17.2. INSTALLING A CLUSTER ON VSPHERE

In OpenShift Container Platform version 4.9, you can install a cluster on your VMware vSphere instance by using installer-provisioned infrastructure.



### NOTE

OpenShift Container Platform supports deploying a cluster to a single VMware vCenter only. Deploying a cluster with machines/machine sets on multiple vCenters is not supported.

### 17.2.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You provisioned [persistent storage](#) for your cluster. To deploy a private image registry, your storage must provide **ReadWriteMany** access modes.
- The OpenShift Container Platform installer requires access to port 443 on the vCenter and ESXi hosts. You verified that port 443 is accessible.
- If you use a firewall, you confirmed with the administrator that port 443 is accessible. Control plane nodes must be able to reach vCenter and ESXi hosts on port 443 for the installation to succeed.
- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.



#### NOTE

Be sure to also review this site list if you are configuring a proxy.

### 17.2.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



#### IMPORTANT

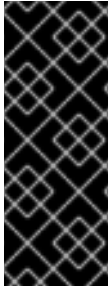
If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

### 17.2.3. VMware vSphere infrastructure requirements

You must install the OpenShift Container Platform cluster on a VMware vSphere version 6 or 7 instance that meets the requirements for the components that you use.

**Table 17.3. Version requirements for vSphere virtual environments**

Virtual environment product	Required version
VM hardware version	13 or later
vSphere ESXi hosts	6.5 or later
vCenter host	6.5 or later



### IMPORTANT

Installing a cluster on VMware vSphere version 6.7U2 or earlier and virtual hardware version 13 is now deprecated. These versions are still fully supported, but support will be removed in a future version of OpenShift Container Platform. Hardware version 15 is now the default for vSphere virtual machines in OpenShift Container Platform. To update the hardware version for your vSphere nodes, see the "Updating hardware on nodes running in vSphere" article.

**Table 17.4. Minimum supported vSphere version for VMware components**

Component	Minimum supported versions	Description
Hypervisor	vSphere 6.5 and later with HW version 13	This version is the minimum version that Red Hat Enterprise Linux CoreOS (RHCOS) supports. See the <a href="#">Red Hat Enterprise Linux 8 supported hypervisors list</a> .
Storage with in-tree drivers	vSphere 6.5 and later	This plugin creates vSphere storage by using the in-tree storage drivers for vSphere included in OpenShift Container Platform.
Optional: Networking (NSX-T)	vSphere 6.5U3 or vSphere 6.7U2 and later	vSphere 6.5U3 or vSphere 6.7U2+ are required for OpenShift Container Platform. For more information about the compatibility of NSX and OpenShift Container Platform, see the Release Notes section of VMware's <a href="#">NSX container plugin documentation</a> .

If you use a vSphere version 6.5 instance, consider upgrading to 6.7U3 or 7.0 before you install OpenShift Container Platform.



## IMPORTANT

You must ensure that the time on your ESXi hosts is synchronized before you install OpenShift Container Platform. See [Edit Time Configuration for a Host](#) in the VMware documentation.

### 17.2.4. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate.

Review the following details about the required network ports.

**Table 17.5. Ports used for all-machine to all-machine communications**

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	<b>1936</b>	Metrics
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> and the Cluster Version Operator on port <b>9099</b> .
	<b>10250-10259</b>	The default ports that Kubernetes reserves
	<b>10256</b>	openshift-sdn
UDP	<b>4789</b>	virtual extensible LAN (VXLAN)
	<b>6081</b>	Geneve
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> .
	<b>500</b>	IPsec IKE packets
	<b>4500</b>	IPsec NAT-T packets
TCP/UDP	<b>30000-32767</b>	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

**Table 17.6. Ports used for all-machine to control plane communications**

Protocol	Port	Description
TCP	<b>6443</b>	Kubernetes API

Table 17.7. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	<b>2379-2380</b>	etcd server and peer ports

#### Additional resources

- To update the hardware version for your vSphere nodes, see [Updating hardware on nodes running in vSphere](#).

### 17.2.5. vCenter requirements

Before you install an OpenShift Container Platform cluster on your vCenter that uses infrastructure that the installer provisions, you must prepare your environment.

#### Required vCenter account privileges

To install an OpenShift Container Platform cluster in a vCenter, the installation program requires access to an account with privileges to read and create the required resources. Using an account that has global administrative privileges is the simplest way to access all of the necessary permissions.

If you cannot use an account with global administrative privileges, you must create roles to grant the privileges necessary for OpenShift Container Platform cluster installation. While most of the privileges are always required, some are required only if you plan for the installation program to provision a folder to contain the OpenShift Container Platform cluster on your vCenter instance, which is the default behavior. You must create or amend vSphere roles for the specified objects to grant the required privileges.

An additional role is required if the installation program is to create a vSphere virtual machine folder.

Example 17.1. Roles and privileges required for installation in vSphere API

vSphere object for role	When required	Required privileges in vSphere API
vSphere vCenter	Always	<b>Cns.Searchable</b> <b>InventoryService.Tagging.AttachTag</b> <b>InventoryService.Tagging.CreateCategory</b> <b>InventoryService.Tagging.CreateTag</b> <b>InventoryService.Tagging.DeleteCategory</b> <b>InventoryService.Tagging.DeleteTag</b> <b>InventoryService.Tagging.EditCategory</b> <b>InventoryService.Tagging.EditTag</b> <b>Sessions.ValidateSession</b> <b>StorageProfile.Update</b> <b>StorageProfile.View</b>



vSphere object for role	When required	Required privileges in vSphere API
vSphere vCenter Cluster	Always	<b>Host.Config.Storage</b> <b>Resource.AssignVMToPool</b> <b>VApp.AssignResourcePool</b> <b>VApp.Import</b> <b>VirtualMachine.Config.AddNewDisk</b>
vSphere Datastore	Always	<b>Datastore.AllocateSpace</b> <b>Datastore.Browse</b> <b>Datastore.FileManagement</b> <b>InventoryService.Tagging.ObjectAttachable</b>
vSphere Port Group	Always	<b>Network.Assign</b>
Virtual Machine Folder	Always	<b>InventoryService.Tagging.ObjectAttachable</b> <b>Resource.AssignVMToPool</b> <b>VApp.Import</b> <b>VirtualMachine.Config.AddExistingDisk</b> <b>VirtualMachine.Config.AddNewDisk</b> <b>VirtualMachine.Config.AddRemoveDevice</b> <b>VirtualMachine.Config.AdvancedConfig</b> <b>VirtualMachine.Config.Annotation</b> <b>VirtualMachine.Config.CPUCount</b> <b>VirtualMachine.Config.DiskExtend</b> <b>VirtualMachine.Config.DiskLease</b> <b>VirtualMachine.Config.EditDevice</b> <b>VirtualMachine.Config.Memory</b> <b>VirtualMachine.Config.RemoveDisk</b> <b>VirtualMachine.Config.Rename</b> <b>VirtualMachine.Config.ResetGuestInfo</b> <b>VirtualMachine.Config.Resource</b> <b>VirtualMachine.Config.Settings</b> <b>VirtualMachine.Config.UpgradeVirtualHardware</b>

vSphere object for role	When required	VirtualMachine.Interact.GuestControl Required privileges in vSphere API VirtualMachine.Interact.PowerOff
		VirtualMachine.Interact.PowerOn VirtualMachine.Interact.Reset VirtualMachine.Inventory.Create VirtualMachine.Inventory.CreateFromExisting VirtualMachine.Inventory.Delete VirtualMachine.Provisioning.Clone VirtualMachine.Provisioning.MarkAsTemplate VirtualMachine.Provisioning.DeployTemplate
vSphere vCenter Datacenter	If the installation program creates the virtual machine folder	InventoryService.Tagging.ObjectAttachable Resource.AssignVMToPool VApp.Import VirtualMachine.Config.AddExistingDisk VirtualMachine.Config.AddNewDisk VirtualMachine.Config.AddRemoveDevice VirtualMachine.Config.AdvancedConfig VirtualMachine.Config.Annotation VirtualMachine.Config.CPUCount VirtualMachine.Config.DiskExtend VirtualMachine.Config.DiskLease VirtualMachine.Config.EditDevice VirtualMachine.Config.Memory VirtualMachine.Config.RemoveDisk VirtualMachine.Config.Rename VirtualMachine.Config.ResetGuestInfo VirtualMachine.Config.Resource VirtualMachine.Config.Settings VirtualMachine.Config.Upgr

vSphere object for role	When required	Required privileges in vSphere API
		VirtualMachine.Interact.QueueControl VirtualMachine.Interact.PowerOff VirtualMachine.Interact.PowerOn VirtualMachine.Interact.Reset VirtualMachine.Inventory.Create VirtualMachine.Inventory.CreateFromExisting VirtualMachine.Inventory.Delete VirtualMachine.Provisioning.Clone VirtualMachine.Provisioning.DeployTemplate VirtualMachine.Provisioning.MarkAsTemplate Folder.Create Folder.Delete

Example 17.2. Roles and privileges required for installation in vCenter graphical user interface (GUI)

vSphere object for role	When required	Required privileges in vCenter GUI

vSphere object for role	When required	Required privileges in vCenter GUI
vSphere vCenter	Always	<b>Cns.Searchable</b> <b>"vSphere Tagging"."Assign or Unassign vSphere Tag"</b> <b>"vSphere Tagging"."Create vSphere Tag Category"</b> <b>"vSphere Tagging"."Create vSphere Tag"</b> <b>vSphere Tagging"."Delete vSphere Tag Category"</b> <b>"vSphere Tagging"."Delete vSphere Tag"</b> <b>"vSphere Tagging"."Edit vSphere Tag Category"</b> <b>"vSphere Tagging"."Edit vSphere Tag"</b> <b>Sessions."Validate session"</b> <b>"Profile-driven storage"."Profile-driven storage update"</b> <b>"Profile-driven storage"."Profile-driven storage view"</b>
vSphere vCenter Cluster	If VMs will be created in the cluster root	<b>Host.Configuration."Storage partition configuration"</b> <b>Resource."Assign virtual machine to resource pool"</b> <b>VApp."Assign resource pool"</b> <b>VApp.Import</b> <b>"Virtual machine"."Change Configuration"."Add new disk"</b>
vSphere vCenter Resource Pool	If an existing resource pool is provided	<b>Host.Configuration."Storage partition configuration"</b> <b>Resource."Assign virtual machine to resource pool"</b> <b>VApp."Assign resource pool"</b> <b>VApp.Import</b> <b>"Virtual machine"."Change Configuration"."Add new disk"</b>

vSphere object for role	When required	Required privileges in vCenter GUI
vSphere Datastore	Always	<b>Datastore."Allocate space"</b> <b>Datastore."Browse datastore"</b> <b>Datastore."Low level file operations"</b> <b>"vSphere Tagging"."Assign or Unassign vSphere Tag on Object"</b>
vSphere Port Group	Always	<b>Network."Assign network"</b>
Virtual Machine Folder	Always	<b>"vSphere Tagging"."Assign or Unassign vSphere Tag on Object"</b> <b>Resource."Assign virtual machine to resource pool"</b> <b>VApp.Import</b> <b>"Virtual machine"."Change Configuration"."Add existing disk"</b> <b>"Virtual machine"."Change Configuration"."Add new disk"</b> <b>"Virtual machine"."Change Configuration"."Add or remove device"</b> <b>"Virtual machine"."Change Configuration"."Advanced configuration"</b> <b>"Virtual machine"."Change Configuration"."Set annotation"</b> <b>"Virtual machine"."Change Configuration"."Change CPU count"</b> <b>"Virtual machine"."Change Configuration"."Extend virtual disk"</b> <b>"Virtual machine"."Change Configuration"."Acquire disk lease"</b> <b>"Virtual machine"."Change Configuration"."Modify device settings"</b> <b>"Virtual machine"."Change Configuration"."Change Memory"</b> <b>"Virtual machine"."Change Configuration"."Remove disk"</b> <b>"Virtual machine"."Change</b>

vSphere object for role	When required	Configuration".Rename Virtual machine".Change GUI Configuration".Reset guest information"
		"Virtual machine".Change Configuration".Change resource" "Virtual machine".Change Configuration".Change Settings" "Virtual machine".Change Configuration".Upgrade virtual machine compatibility" "Virtual machine".Interaction."Gues t operating system management by VIX API" "Virtual machine".Interaction."Powe r off" "Virtual machine".Interaction."Powe r on" "Virtual machine".Interaction.Reset "Virtual machine".Edit Inventory".Create new" "Virtual machine".Edit Inventory".Create from existing" "Virtual machine".Edit Inventory".Remove" "Virtual machine".Provisioning."Clo ne virtual machine" "Virtual machine".Provisioning."Mar k as template" "Virtual machine".Provisioning."De ploy template"
vSphere vCenter Datacenter	If the installation program creates the virtual machine folder	"vSphere Tagging".Assign or Unassign vSphere Tag on Object" Resource."Assign virtual machine to resource pool" VApp.Import "Virtual machine".Change Configuration".Add existing disk" "Virtual machine".Change Configuration".Add new disk" "Virtual machine".Change

vSphere object for role	When required	Configuration". "Add or Remove device" GUI "Virtual machine". "Change Configuration". "Advanced configuration" "Virtual machine". "Change Configuration". "Set annotation" "Virtual machine". "Change Configuration". "Change CPU count" "Virtual machine". "Change Configuration". "Extend virtual disk" "Virtual machine". "Change Configuration". "Acquire disk lease" "Virtual machine". "Change Configuration". "Modify device settings" "Virtual machine". "Change Configuration". "Change Memory" "Virtual machine". "Change Configuration". "Remove disk" "Virtual machine". "Change Configuration". Rename "Virtual machine". "Change Configuration". "Reset guest information" "Virtual machine". "Change Configuration". "Change resource" "Virtual machine". "Change Configuration". "Change Settings" "Virtual machine". "Change Configuration". "Upgrade virtual machine compatibility" "Virtual machine". Interaction. "Guest operating system management by VIX API" "Virtual machine". Interaction. "Power off" "Virtual machine". Interaction. "Power on" "Virtual machine". Interaction. Reset "Virtual machine". "Edit Inventory". "Create new" "Virtual machine". "Edit

vSphere object for role	When required	Inventory". "Create from existing virtual machine". "Edit virtual machine". "Remove virtual machine". "Clone virtual machine". "Deploy template". "Mark as template". "Create folder". "Delete folder"

Additionally, the user requires some **ReadOnly** permissions, and some of the roles require permission to propagate the permissions to child objects. These settings vary depending on whether or not you install the cluster into an existing folder.

**Example 17.3. Required permissions and propagation settings**

vSphere object	Folder type	Propagate to children	Permissions required
vSphere vCenter	Always	False	Listed required privileges
vSphere vCenter Datacenter	Existing folder	False	<b>ReadOnly</b> permission
	Installation program creates the folder	True	Listed required privileges
vSphere vCenter Cluster	Always	True	Listed required privileges
vSphere vCenter Datastore	Always	False	Listed required privileges
vSphere Switch	Always	False	<b>ReadOnly</b> permission
vSphere Port Group	Always	False	Listed required privileges
vSphere vCenter Virtual Machine Folder	Existing folder	True	Listed required privileges

For more information about creating an account with only the required privileges, see [vSphere Permissions and User Management Tasks](#) in the vSphere documentation.



## Using OpenShift Container Platform with vMotion

If you intend on using vMotion in your vSphere environment, consider the following before installing a OpenShift Container Platform cluster.

- OpenShift Container Platform generally supports compute-only vMotion. Using Storage vMotion can cause issues and is not supported.  
To help ensure the uptime of your compute and control plane nodes, it is recommended that you follow the VMware best practices for vMotion. It is also recommended to use VMware anti-affinity rules to improve the availability of OpenShift Container Platform during maintenance or hardware issues.

For more information about vMotion and anti-affinity rules, see the VMware vSphere documentation for [vMotion networking requirements](#) and [VM anti-affinity rules](#).

- If you are using vSphere volumes in your pods, migrating a VM across datastores either manually or through Storage vMotion causes, invalid references within OpenShift Container Platform persistent volume (PV) objects. These references prevent affected pods from starting up and can result in data loss.
- Similarly, OpenShift Container Platform does not support selective migration of VMDKs across datastores, using datastore clusters for VM provisioning or for dynamic or static provisioning of PVs, or using a datastore that is part of a datastore cluster for dynamic or static provisioning of PVs.

### Cluster resources

When you deploy an OpenShift Container Platform cluster that uses installer-provisioned infrastructure, the installation program must be able to create several resources in your vCenter instance.

A standard OpenShift Container Platform installation creates the following vCenter resources:

- 1 Folder
- 1 Tag category
- 1 Tag
- Virtual machines:
  - 1 template
  - 1 temporary bootstrap node
  - 3 control plane nodes
  - 3 compute machines

Although these resources use 856 GB of storage, the bootstrap node is destroyed during the cluster installation process. A minimum of 800 GB of storage is required to use a standard cluster.

If you deploy more compute machines, the OpenShift Container Platform cluster will use more storage.

### Cluster limits

Available resources vary between clusters. The number of possible clusters within a vCenter is limited primarily by available storage space and any limitations on the number of required resources. Be sure to consider both limitations to the vCenter resources that the cluster creates and the resources that you require to deploy a cluster, such as IP addresses and networks.

## Networking requirements

You must use DHCP for the network and ensure that the DHCP server is configured to provide persistent IP addresses to the cluster machines. You must configure the default gateway to use the DHCP server. All nodes must be in the same VLAN. You cannot scale the cluster using a second VLAN as a Day 2 operation. Additionally, you must create the following networking resources before you install the OpenShift Container Platform cluster:



### NOTE

It is recommended that each OpenShift Container Platform node in the cluster must have access to a Network Time Protocol (NTP) server that is discoverable via DHCP. Installation is possible without an NTP server. However, asynchronous server clocks will cause errors, which NTP server prevents.

## Required IP Addresses

An installer-provisioned vSphere installation requires two static IP addresses:

- The **API** address is used to access the cluster API.
- The **Ingress** address is used for cluster ingress traffic.

You must provide these IP addresses to the installation program when you install the OpenShift Container Platform cluster.

## DNS records

You must create DNS records for two static IP addresses in the appropriate DNS server for the vCenter instance that hosts your OpenShift Container Platform cluster. In each record, **<cluster\_name>** is the cluster name and **<base\_domain>** is the cluster base domain that you specify when you install the cluster. A complete DNS record takes the form: **<component>.<cluster\_name>.<base\_domain>.**

Table 17.8. Required DNS records

Component	Record	Description
API VIP	<b>api.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	This DNS A/AAAA or CNAME record must point to the load balancer for the control plane machines. This record must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
Ingress VIP	<b>*.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A wildcard DNS A/AAAA or CNAME record that points to the load balancer that targets the machines that run the Ingress router pods, which are the worker nodes by default. This record must be resolvable by both clients external to the cluster and from all the nodes within the cluster.

## 17.2.6. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.



### IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



### NOTE

You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

### Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.



### NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

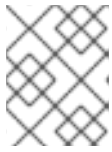
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.

**NOTE**

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the `ssh-agent` process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

**Example output**

```
Agent pid 31874
```

**NOTE**

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the `ssh-agent`:

```
$ ssh-add <path>/<file_name> 1
```

- 1** Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

**Example output**

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

**Next steps**

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

**17.2.7. Obtaining the installation program**

Before you install OpenShift Container Platform, download the installation file on a local computer.

**Prerequisites**

- You have a computer that runs Linux or macOS, with 500 MB of local disk space

**Procedure**

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.

2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



### IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



### IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#). This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

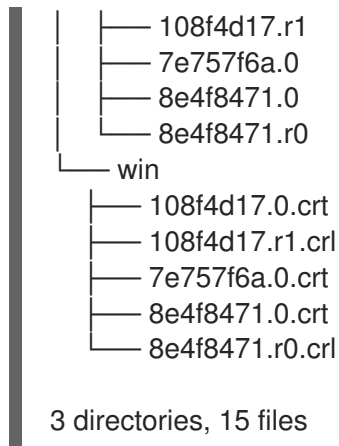
## 17.2.8. Adding vCenter root CA certificates to your system trust

Because the installation program requires access to your vCenter's API, you must add your vCenter's trusted root CA certificates to your system trust before you install an OpenShift Container Platform cluster.

### Procedure

1. From the vCenter home page, download the vCenter's root CA certificates. Click **Download trusted root CA certificates** in the vSphere Web Services SDK section. The **<vCenter>/certs/download.zip** file downloads.
2. Extract the compressed file that contains the vCenter root CA certificates. The contents of the compressed file resemble the following file structure:

```
certs
├── lin
│   ├── 108f4d17.0
│   ├── 108f4d17.r1
│   ├── 7e757f6a.0
│   ├── 8e4f8471.0
│   └── 8e4f8471.r0
└── mac
    └── 108f4d17.0
```



3. Add the files for your operating system to the system trust. For example, on a Fedora operating system, run the following command:

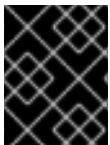
```
# cp certs/lin/* /etc/pki/ca-trust/source/anchors
```

4. Update your system trust. For example, on a Fedora operating system, run the following command:

```
# update-ca-trust extract
```

### 17.2.9. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



#### IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

#### Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

#### Procedure

1. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
--log-level=info 2
```

- 1 For **<installation\_directory>**, specify the directory name to store the files that the installation program creates.

- 2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.



## IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

Provide values at the prompts:

- a. Optional: Select an SSH key to use to access your cluster machines.



## NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

- b. Select **vsphere** as the platform to target.
- c. Specify the name of your vCenter instance.
- d. Specify the user name and password for the vCenter account that has the required permissions to create the cluster.  
The installation program connects to your vCenter instance.
- e. Select the datacenter in your vCenter instance to connect to.
- f. Select the default vCenter datastore to use.



## NOTE

Datastore and cluster names cannot exceed 60 characters; therefore, ensure the combined string length does not exceed the 60 character limit.

- g. Select the vCenter cluster to install the OpenShift Container Platform cluster in. The installation program uses the root resource pool of the vSphere cluster as the default resource pool.
- h. Select the network in the vCenter instance that contains the virtual IP addresses and DNS records that you configured.
- i. Enter the virtual IP address that you configured for control plane API access.
- j. Enter the virtual IP address that you configured for cluster ingress.
- k. Enter the base domain. This base domain must be the same one that you used in the DNS records that you configured.
- l. Enter a descriptive name for your cluster. The cluster name must be the same one that you used in the DNS records that you configured.

**NOTE**

Datastore and cluster names cannot exceed 60 characters; therefore, ensure the combined string length does not exceed the 60 character limit.

m. Paste the [pull secret from the Red Hat OpenShift Cluster Manager](#) .

+ When the cluster deployment completes, directions for accessing your cluster, including a link to its web console and credentials for the **kubeadmin** user, display in your terminal.

+ .Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Ee6gm-ymBZj-Wt5AL"
INFO Time elapsed: 36m22s
```

+

**NOTE**

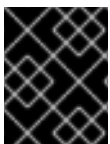
The cluster access and credential information also outputs to **<installation\_directory>/openshift\_install.log** when an installation succeeds.

+

**IMPORTANT**

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

+

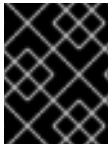
**IMPORTANT**

You must not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.



## 17.2.10. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



### IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

### Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

```
$ tar xvf <file>
```

5. Place the **oc** binary in a directory that is on your **PATH**.  
To check your **PATH**, execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

### Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### 17.2.11. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

#### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

#### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

## Example output

```
system:admin
```

### 17.2.12. Creating registry storage

After you install the cluster, you must create storage for the registry Operator.

#### 17.2.12.1. Image registry removed during installation

On platforms that do not provide shareable object storage, the OpenShift Image Registry Operator bootstraps itself as **Removed**. This allows **openshift-installer** to complete installations on these platform types.

After installation, you must edit the Image Registry Operator configuration to switch the **managementState** from **Removed** to **Managed**.



#### NOTE

The Prometheus console provides an **ImageRegistryRemoved** alert, for example:

"Image Registry has been removed. **ImageStreamTags**, **BuildConfigs** and **DeploymentConfigs** which reference **ImageStreamTags** may not work as expected. Please configure storage and update the config to **Managed** state by editing `configs.imageregistry.operator.openshift.io`."

#### 17.2.12.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

##### 17.2.12.2.1. Configuring registry storage for VMware vSphere

As a cluster administrator, following installation you must configure your registry to use storage.

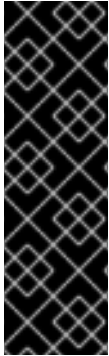
#### Prerequisites

- Cluster administrator permissions.
- A cluster on VMware vSphere.
- Persistent storage provisioned for your cluster, such as Red Hat OpenShift Container Storage.

**IMPORTANT**

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have "100Gi" capacity.

**IMPORTANT**

Testing shows issues with using the NFS server on RHEL as storage backend for core services. This includes the OpenShift Container Registry and Quay, Prometheus for monitoring storage, and Elasticsearch for logging storage. Therefore, using RHEL NFS to back PVs used by core services is not recommended.

Other NFS implementations on the marketplace might not have these issues. Contact the individual NFS implementation vendor for more information on any testing that was possibly completed against these OpenShift Container Platform core components.

**Procedure**

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.

**NOTE**

When using shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

**Example output**

```
No resources found in openshift-image-registry namespace
```

**NOTE**

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

**Example output**

```
storage:
  pvc:
    claim: 1
```

- 1 Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** persistent volume claim (PVC). The PVC is generated based on the default storage class. However, be aware that the default storage class might provide ReadWriteOnce (RWO) volumes, such as a RADOS Block Device (RBD), which can cause issues when replicating to more than one replica.

4. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

#### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED
image-registry	4.7	True	False	6h50m

#### 17.2.12.2.2. Configuring block registry storage for VMware vSphere

To allow the image registry to use block storage types such as vSphere Virtual Machine Disk (VMDK) during upgrades as a cluster administrator, you can use the **Recreate** rollout strategy.



#### IMPORTANT

Block storage volumes are supported but not recommended for use with image registry on production clusters. An installation where the registry is configured on block storage is not highly available because the registry cannot have more than one replica.

#### Procedure

1. To set the image registry storage as a block storage type, patch the registry so that it uses the **Recreate** rollout strategy and runs with only **1** replica:

```
$ oc patch config.imageregistry.operator.openshift.io/cluster --type=merge -p '{"spec": {"rolloutStrategy": "Recreate", "replicas": 1}}'
```

2. Provision the PV for the block storage device, and create a PVC for that volume. The requested block volume uses the ReadWriteOnce (RWO) access mode.
  - a. Create a **pvc.yaml** file with the following contents to define a VMware vSphere **PersistentVolumeClaim** object:

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: image-registry-storage 1
  namespace: openshift-image-registry 2
spec:
  accessModes:
```

```
- ReadWriteOnce 3
resources:
  requests:
    storage: 100Gi 4
```

- 1** A unique name that represents the **PersistentVolumeClaim** object.
- 2** The namespace for the **PersistentVolumeClaim** object, which is **openshift-image-registry**.
- 3** The access mode of the persistent volume claim. With **ReadWriteOnce**, the volume can be mounted with read and write permissions by a single node.
- 4** The size of the persistent volume claim.

b. Create the **PersistentVolumeClaim** object from the file:

```
$ oc create -f pvc.yaml -n openshift-image-registry
```

3. Edit the registry configuration so that it references the correct PVC:

```
$ oc edit config.imageregistry.operator.openshift.io -o yaml
```

### Example output

```
storage:
  pvc:
    claim: 1
```

- 1** Creating a custom PVC allows you to leave the **claim** field blank for the default automatic creation of an **image-registry-storage** PVC.

For instructions about configuring registry storage so that it references the correct PVC, see [Configuring the registry for vSphere](#).

## 17.2.13. Backing up VMware vSphere volumes

OpenShift Container Platform provisions new volumes as independent persistent disks to freely attach and detach the volume on any node in the cluster. As a consequence, it is not possible to back up volumes that use snapshots, or to restore volumes from snapshots. See [Snapshot Limitations](#) for more information.

### Procedure

To create a backup of persistent volumes:

1. Stop the application that is using the persistent volume.
2. Clone the persistent volume.
3. Restart the application.
4. Create a backup of the cloned volume.

5. Delete the cloned volume.

### 17.2.14. Steal clock accounting

By default, the installation program provisions the cluster's virtual machines without enabling the steal clock accounting parameter (**stealclock.enabled**). Enabling steal clock accounting can help with troubleshooting cluster issues. After the cluster is deployed, use the vSphere Client to enable this parameter on each of the virtual machines.

For more information, see this [Red Hat knowledge base article](#).

### 17.2.15. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

#### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

### 17.2.16. Next steps

- [Customize your cluster](#).
- If necessary, you can [opt out of remote health reporting](#).
- [Set up your registry and configure registry storage](#).
- Optional: [View the events from the vSphere Problem Detector Operator](#) to determine if the cluster has permission or storage configuration issues.

## 17.3. INSTALLING A CLUSTER ON VSPHERE WITH CUSTOMIZATIONS

In OpenShift Container Platform version 4.9, you can install a cluster on your VMware vSphere instance by using installer-provisioned infrastructure. To customize the installation, you modify parameters in the **install-config.yaml** file before you install the cluster.



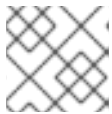
#### NOTE

OpenShift Container Platform supports deploying a cluster to a single VMware vCenter only. Deploying a cluster with machines/machine sets on multiple vCenters is not supported.

### 17.3.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.

- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You provisioned [persistent storage](#) for your cluster. To deploy a private image registry, your storage must provide **ReadWriteMany** access modes.
- The OpenShift Container Platform installer requires access to port 443 on the vCenter and ESXi hosts. You verified that port 443 is accessible.
- If you use a firewall, you confirmed with the administrator that port 443 is accessible. Control plane nodes must be able to reach vCenter and ESXi hosts on port 443 for the installation to succeed.
- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.

**NOTE**

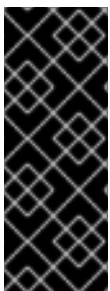
Be sure to also review this site list if you are configuring a proxy.

### 17.3.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

**IMPORTANT**

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

### 17.3.3. VMware vSphere infrastructure requirements

You must install the OpenShift Container Platform cluster on a VMware vSphere version 6 or 7 instance that meets the requirements for the components that you use.

**Table 17.9. Version requirements for vSphere virtual environments**

Virtual environment product	Required version
VM hardware version	13 or later
vSphere ESXi hosts	6.5 or later



Virtual environment product	Required version
vCenter host	6.5 or later



### IMPORTANT

Installing a cluster on VMware vSphere version 6.7U2 or earlier and virtual hardware version 13 is now deprecated. These versions are still fully supported, but support will be removed in a future version of OpenShift Container Platform. Hardware version 15 is now the default for vSphere virtual machines in OpenShift Container Platform. To update the hardware version for your vSphere nodes, see the "Updating hardware on nodes running in vSphere" article.

Table 17.10. Minimum supported vSphere version for VMware components

Component	Minimum supported versions	Description
Hypervisor	vSphere 6.5 and later with HW version 13	This version is the minimum version that Red Hat Enterprise Linux CoreOS (RHCOS) supports. See the <a href="#">Red Hat Enterprise Linux 8 supported hypervisors list</a> .
Storage with in-tree drivers	vSphere 6.5 and later	This plugin creates vSphere storage by using the in-tree storage drivers for vSphere included in OpenShift Container Platform.
Optional: Networking (NSX-T)	vSphere 6.5U3 or vSphere 6.7U2 and later	vSphere 6.5U3 or vSphere 6.7U2+ are required for OpenShift Container Platform. For more information about the compatibility of NSX and OpenShift Container Platform, see the Release Notes section of VMware's <a href="#">NSX container plugin documentation</a> .

If you use a vSphere version 6.5 instance, consider upgrading to 6.7U3 or 7.0 before you install OpenShift Container Platform.



### IMPORTANT

You must ensure that the time on your ESXi hosts is synchronized before you install OpenShift Container Platform. See [Edit Time Configuration for a Host](#) in the VMware documentation.

## 17.3.4. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate.

Review the following details about the required network ports.

**Table 17.11. Ports used for all-machine to all-machine communications**

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	<b>1936</b>	Metrics
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> and the Cluster Version Operator on port <b>9099</b> .
	<b>10250-10259</b>	The default ports that Kubernetes reserves
	<b>10256</b>	openshift-sdn
UDP	<b>4789</b>	virtual extensible LAN (VXLAN)
	<b>6081</b>	Geneve
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> .
	<b>500</b>	IPsec IKE packets
	<b>4500</b>	IPsec NAT-T packets
TCP/UDP	<b>30000-32767</b>	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

**Table 17.12. Ports used for all-machine to control plane communications**

Protocol	Port	Description
TCP	<b>6443</b>	Kubernetes API

**Table 17.13. Ports used for control plane machine to control plane machine communications**

Protocol	Port	Description
TCP	<b>2379-2380</b>	etcd server and peer ports

#### Additional resources

- To update the hardware version for your vSphere nodes, see [Updating hardware on nodes running in vSphere](#).

### 17.3.5. vCenter requirements

Before you install an OpenShift Container Platform cluster on your vCenter that uses infrastructure that the installer provisions, you must prepare your environment.

#### Required vCenter account privileges

To install an OpenShift Container Platform cluster in a vCenter, the installation program requires access to an account with privileges to read and create the required resources. Using an account that has global administrative privileges is the simplest way to access all of the necessary permissions.

If you cannot use an account with global administrative privileges, you must create roles to grant the privileges necessary for OpenShift Container Platform cluster installation. While most of the privileges are always required, some are required only if you plan for the installation program to provision a folder to contain the OpenShift Container Platform cluster on your vCenter instance, which is the default behavior. You must create or amend vSphere roles for the specified objects to grant the required privileges.

An additional role is required if the installation program is to create a vSphere virtual machine folder.

**Example 17.4. Roles and privileges required for installation in vSphere API**

vSphere object for role	When required	Required privileges in vSphere API
vSphere vCenter	Always	<b>Cns.Searchable</b> <b>InventoryService.Tagging.AttachTag</b> <b>InventoryService.Tagging.CreateCategory</b> <b>InventoryService.Tagging.CreateTag</b> <b>InventoryService.Tagging.DeleteCategory</b> <b>InventoryService.Tagging.DeleteTag</b> <b>InventoryService.Tagging.EditCategory</b> <b>InventoryService.Tagging.EditTag</b> <b>Sessions.ValidateSession</b> <b>StorageProfile.Update</b> <b>StorageProfile.View</b>
vSphere vCenter Cluster	Always	<b>Host.Config.StorageResource.AssignVMToPool</b> <b>VApp.AssignResourcePool</b> <b>VApp.Import</b> <b>VirtualMachine.Config.AddNewDisk</b>

vSphere object for role	When required	Required privileges in vSphere API
vSphere Datastore	Always	<b>Datastore.AllocateSpace</b> <b>Datastore.Browse</b> <b>Datastore.FileManagement</b> <b>InventoryService.Tagging.ObjectAttachable</b>
vSphere Port Group	Always	<b>Network.Assign</b>
Virtual Machine Folder	Always	<b>InventoryService.Tagging.ObjectAttachable</b> <b>Resource.AssignVMToPool</b> <b>VApp.Import</b> <b>VirtualMachine.Config.AddExistingDisk</b> <b>VirtualMachine.Config.AddNewDisk</b> <b>VirtualMachine.Config.AddRemoveDevice</b> <b>VirtualMachine.Config.AdvancedConfig</b> <b>VirtualMachine.Config.Annotation</b> <b>VirtualMachine.Config.CPUCount</b> <b>VirtualMachine.Config.DiskExtend</b> <b>VirtualMachine.Config.DiskLease</b> <b>VirtualMachine.Config.EditDevice</b> <b>VirtualMachine.Config.Memory</b> <b>VirtualMachine.Config.RemoveDisk</b> <b>VirtualMachine.Config.Rename</b> <b>VirtualMachine.Config.ResetGuestInfo</b> <b>VirtualMachine.Config.Resource</b> <b>VirtualMachine.Config.Settings</b> <b>VirtualMachine.Config.UpgradeVirtualHardware</b> <b>VirtualMachine.Interact.GuestControl</b> <b>VirtualMachine.Interact.PowerOff</b> <b>VirtualMachine.Interact.Pow</b>

vSphere object for role	When required	Required privileges in vSphere API
		<b>VirtualMachine.Inventory.Create</b> <b>VirtualMachine.Inventory.CreateFromExisting</b> <b>VirtualMachine.Inventory.Delete</b> <b>VirtualMachine.Provisioning.Clone</b> <b>VirtualMachine.Provisioning.MarkAsTemplate</b> <b>VirtualMachine.Provisioning.DeployTemplate</b>
vSphere vCenter Datacenter	If the installation program creates the virtual machine folder	<b>InventoryService.Tagging.ObjectAttachable</b> <b>Resource.AssignVMToPool</b> <b>VApp.Import</b> <b>VirtualMachine.Config.AddExistingDisk</b> <b>VirtualMachine.Config.AddNewDisk</b> <b>VirtualMachine.Config.AddRemoveDevice</b> <b>VirtualMachine.Config.AdvancedConfig</b> <b>VirtualMachine.Config.Annotation</b> <b>VirtualMachine.Config.CPUCount</b> <b>VirtualMachine.Config.DiskExtend</b> <b>VirtualMachine.Config.DiskLease</b> <b>VirtualMachine.Config.EditDevice</b> <b>VirtualMachine.Config.Memory</b> <b>VirtualMachine.Config.RemoveDisk</b> <b>VirtualMachine.Config.Rename</b> <b>VirtualMachine.Config.ResetGuestInfo</b> <b>VirtualMachine.Config.Resource</b> <b>VirtualMachine.Config.Settings</b> <b>VirtualMachine.Config.UpgradeVirtualHardware</b> <b>VirtualMachine.Interact.GuestControl</b> <b>VirtualMachine.Interact.PowerOff</b>

vSphere object for role	When required	Required privileges in vSphere API
		<b>VirtualMachine.Interact.PowerOff</b> <b>VirtualMachine.Interact.Reset</b> <b>VirtualMachine.Inventory.Create</b> <b>VirtualMachine.Inventory.CreateFromExisting</b> <b>VirtualMachine.Inventory.Delete</b> <b>VirtualMachine.Provisioning.Clone</b> <b>VirtualMachine.Provisioning.DeployTemplate</b> <b>VirtualMachine.Provisioning.MarkAsTemplate</b> <b>Folder.Create</b> <b>Folder.Delete</b>

Example 17.5. Roles and privileges required for installation in vCenter graphical user interface (GUI)

vSphere object for role	When required	Required privileges in vCenter GUI
vSphere vCenter	Always	<b>Cns.Searchable</b> <b>"vSphere Tagging"."Assign or Unassign vSphere Tag"</b> <b>"vSphere Tagging"."Create vSphere Tag Category"</b> <b>"vSphere Tagging"."Create vSphere Tag"</b> <b>vSphere Tagging"."Delete vSphere Tag Category"</b> <b>"vSphere Tagging"."Delete vSphere Tag"</b> <b>"vSphere Tagging"."Edit vSphere Tag Category"</b> <b>"vSphere Tagging"."Edit vSphere Tag"</b> <b>Sessions."Validate session"</b> <b>"Profile-driven storage"."Profile-driven storage update"</b> <b>"Profile-driven storage"."Profile-driven storage view"</b>

vSphere object for role	When required	Required privileges in vCenter GUI
vSphere vCenter Cluster	If VMs will be created in the cluster root	<b>Host.Configuration."Storage partition configuration" Resource."Assign virtual machine to resource pool" VApp."Assign resource pool" VApp.Import "Virtual machine"."Change Configuration". "Add new disk"</b>
vSphere vCenter Resource Pool	If an existing resource pool is provided	<b>Host.Configuration."Storage partition configuration" Resource."Assign virtual machine to resource pool" VApp."Assign resource pool" VApp.Import "Virtual machine"."Change Configuration". "Add new disk"</b>
vSphere Datastore	Always	<b>Datastore."Allocate space" Datastore."Browse datastore" Datastore."Low level file operations" "vSphere Tagging". "Assign or Unassign vSphere Tag on Object"</b>
vSphere Port Group	Always	<b>Network."Assign network"</b>
Virtual Machine Folder	Always	<b>"vSphere Tagging". "Assign or Unassign vSphere Tag on Object" Resource."Assign virtual machine to resource pool" VApp.Import "Virtual machine"."Change Configuration". "Add existing disk" "Virtual machine"."Change Configuration". "Add new disk" "Virtual machine"."Change Configuration". "Add or remove device" "Virtual machine"."Change Configuration". "Advanced"</b>

vSphere object for role	When required	configuration" Required privileges in vCenter GUI
		"Virtual machine"."Change Configuration"."Set annotation" "Virtual machine"."Change Configuration"."Change CPU count" "Virtual machine"."Change Configuration"."Extend virtual disk" "Virtual machine"."Change Configuration"."Acquire disk lease" "Virtual machine"."Change Configuration"."Modify device settings" "Virtual machine"."Change Configuration"."Change Memory" "Virtual machine"."Change Configuration"."Remove disk" "Virtual machine"."Change Configuration".Rename "Virtual machine"."Change Configuration"."Reset guest information" "Virtual machine"."Change Configuration"."Change resource" "Virtual machine"."Change Configuration"."Change Settings" "Virtual machine"."Change Configuration"."Upgrade virtual machine compatibility" "Virtual machine".Interaction."Gues t operating system management by VIX API" "Virtual machine".Interaction."Powe r off" "Virtual machine".Interaction."Powe r on" "Virtual machine".Interaction.Reset "Virtual machine"."Edit Inventory"."Create new" "Virtual machine"."Edit Inventory"."Create from existing" "Virtual machine"."Edit Inventory"."Remove"



vSphere object for role	When required	"Virtual machine".Provisioning."Create virtual machine" GUI
		"Virtual machine".Provisioning."Mark as template" "Virtual machine".Provisioning."Deploy template"
vSphere vCenter Datacenter	If the installation program creates the virtual machine folder	"vSphere Tagging"."Assign or Unassign vSphere Tag on Object" Resource."Assign virtual machine to resource pool" VApp.Import "Virtual machine"."Change Configuration"."Add existing disk" "Virtual machine"."Change Configuration"."Add new disk" "Virtual machine"."Change Configuration"."Add or remove device" "Virtual machine"."Change Configuration"."Advanced configuration" "Virtual machine"."Change Configuration"."Set annotation" "Virtual machine"."Change Configuration"."Change CPU count" "Virtual machine"."Change Configuration"."Extend virtual disk" "Virtual machine"."Change Configuration"."Acquire disk lease" "Virtual machine"."Change Configuration"."Modify device settings" "Virtual machine"."Change Configuration"."Change Memory" "Virtual machine"."Change Configuration"."Remove disk" "Virtual machine"."Change Configuration".Rename "Virtual machine"."Change Configuration"."Reset guest information" "Virtual machine"."Change Configuration"."Change resource"

vSphere object for role	When required	"Virtual machine"."Change Configuration"."Change Settings"
		"Virtual machine"."Change Configuration"."Upgrade virtual machine compatibility" "Virtual machine".Interaction."Guest operating system management by VIX API" "Virtual machine".Interaction."Power off" "Virtual machine".Interaction."Power on" "Virtual machine".Interaction.Reset "Virtual machine"."Edit Inventory"."Create new" "Virtual machine"."Edit Inventory"."Create from existing" "Virtual machine"."Edit Inventory"."Remove" "Virtual machine".Provisioning."Clone virtual machine" "Virtual machine".Provisioning."Deploy template" "Virtual machine".Provisioning."Mark as template" Folder."Create folder" Folder."Delete folder"

Additionally, the user requires some **ReadOnly** permissions, and some of the roles require permission to propagate the permissions to child objects. These settings vary depending on whether or not you install the cluster into an existing folder.

**Example 17.6. Required permissions and propagation settings**

vSphere object	Folder type	Propagate to children	Permissions required
vSphere vCenter	Always	False	Listed required privileges
vSphere vCenter Datacenter	Existing folder	False	<b>ReadOnly</b> permission

vSphere object	Folder type	Propagate to children	Permissions required
	Installation program creates the folder	True	Listed required privileges
vSphere vCenter Cluster	Always	True	Listed required privileges
vSphere vCenter Datastore	Always	False	Listed required privileges
vSphere Switch	Always	False	<b>ReadOnly</b> permission
vSphere Port Group	Always	False	Listed required privileges
vSphere vCenter Virtual Machine Folder	Existing folder	True	Listed required privileges

For more information about creating an account with only the required privileges, see [vSphere Permissions and User Management Tasks](#) in the vSphere documentation.

### Using OpenShift Container Platform with vMotion

If you intend on using vMotion in your vSphere environment, consider the following before installing a OpenShift Container Platform cluster.

- OpenShift Container Platform generally supports compute-only vMotion. Using Storage vMotion can cause issues and is not supported. To help ensure the uptime of your compute and control plane nodes, it is recommended that you follow the VMware best practices for vMotion. It is also recommended to use VMware anti-affinity rules to improve the availability of OpenShift Container Platform during maintenance or hardware issues.

For more information about vMotion and anti-affinity rules, see the VMware vSphere documentation for [vMotion networking requirements](#) and [VM anti-affinity rules](#).

- If you are using vSphere volumes in your pods, migrating a VM across datastores either manually or through Storage vMotion causes, invalid references within OpenShift Container Platform persistent volume (PV) objects. These references prevent affected pods from starting up and can result in data loss.
- Similarly, OpenShift Container Platform does not support selective migration of VMDKs across datastores, using datastore clusters for VM provisioning or for dynamic or static provisioning of PVs, or using a datastore that is part of a datastore cluster for dynamic or static provisioning of PVs.

### Cluster resources

When you deploy an OpenShift Container Platform cluster that uses installer-provisioned infrastructure, the installation program must be able to create several resources in your vCenter instance.

A standard OpenShift Container Platform installation creates the following vCenter resources:

- 1 Folder
- 1 Tag category
- 1 Tag
- Virtual machines:
  - 1 template
  - 1 temporary bootstrap node
  - 3 control plane nodes
  - 3 compute machines

Although these resources use 856 GB of storage, the bootstrap node is destroyed during the cluster installation process. A minimum of 800 GB of storage is required to use a standard cluster.

If you deploy more compute machines, the OpenShift Container Platform cluster will use more storage.

### Cluster limits

Available resources vary between clusters. The number of possible clusters within a vCenter is limited primarily by available storage space and any limitations on the number of required resources. Be sure to consider both limitations to the vCenter resources that the cluster creates and the resources that you require to deploy a cluster, such as IP addresses and networks.

### Networking requirements

You must use DHCP for the network and ensure that the DHCP server is configured to provide persistent IP addresses to the cluster machines. You must configure the default gateway to use the DHCP server. All nodes must be in the same VLAN. You cannot scale the cluster using a second VLAN as a Day 2 operation. Additionally, you must create the following networking resources before you install the OpenShift Container Platform cluster:



#### NOTE

It is recommended that each OpenShift Container Platform node in the cluster must have access to a Network Time Protocol (NTP) server that is discoverable via DHCP. Installation is possible without an NTP server. However, asynchronous server clocks will cause errors, which NTP server prevents.

### Required IP Addresses

An installer-provisioned vSphere installation requires two static IP addresses:

- The **API** address is used to access the cluster API.
- The **Ingress** address is used for cluster ingress traffic.

You must provide these IP addresses to the installation program when you install the OpenShift Container Platform cluster.

### DNS records

You must create DNS records for two static IP addresses in the appropriate DNS server for the vCenter instance that hosts your OpenShift Container Platform cluster. In each record, **<cluster\_name>** is the cluster name and **<base\_domain>** is the cluster base domain that you specify when you install the cluster. A complete DNS record takes the form: **<component>.<cluster\_name>.<base\_domain>..**

Table 17.14. Required DNS records

Component	Record	Description
API VIP	<b>api.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	This DNS A/AAAA or CNAME record must point to the load balancer for the control plane machines. This record must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
Ingress VIP	<b>*.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A wildcard DNS A/AAAA or CNAME record that points to the load balancer that targets the machines that run the Ingress router pods, which are the worker nodes by default. This record must be resolvable by both clients external to the cluster and from all the nodes within the cluster.

### 17.3.6. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.



#### IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



#### NOTE

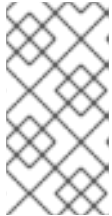
You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

#### Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.



#### NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

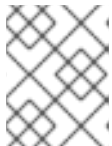
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.



#### NOTE

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

#### Example output

```
Agent pid 31874
```



#### NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1 Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

### Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

### Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

## 17.3.7. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

### Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space

### Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



#### IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



#### IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#). This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform

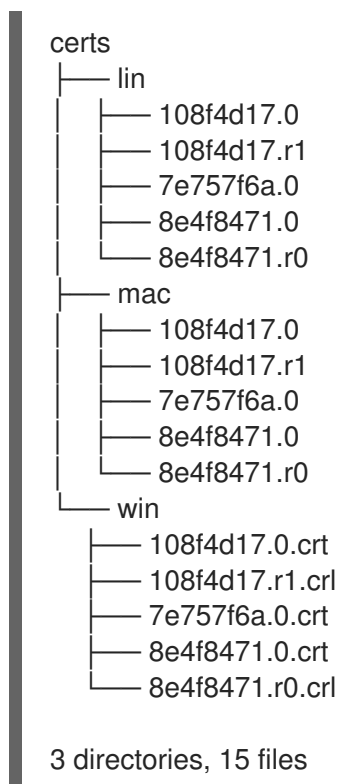
components.

### 17.3.8. Adding vCenter root CA certificates to your system trust

Because the installation program requires access to your vCenter's API, you must add your vCenter's trusted root CA certificates to your system trust before you install an OpenShift Container Platform cluster.

#### Procedure

1. From the vCenter home page, download the vCenter's root CA certificates. Click **Download trusted root CA certificates** in the vSphere Web Services SDK section. The **<vCenter>/certs/download.zip** file downloads.
2. Extract the compressed file that contains the vCenter root CA certificates. The contents of the compressed file resemble the following file structure:



3. Add the files for your operating system to the system trust. For example, on a Fedora operating system, run the following command:

```
# cp certs/lin/* /etc/pki/ca-trust/source/anchors
```

4. Update your system trust. For example, on a Fedora operating system, run the following command:

```
# update-ca-trust extract
```

### 17.3.9. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on VMware vSphere.



## Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

## Procedure

1. Create the **install-config.yaml** file.
  - a. Change to the directory that contains the installation program and run the following command:

```
$. /openshift-install create install-config --dir <installation_directory> 1
```

- 1** For **<installation\_directory>**, specify the directory name to store the files that the installation program creates.



### IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

- b. At the prompts, provide the configuration details for your cloud:
  - i. Optional: Select an SSH key to use to access your cluster machines.



### NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

- ii. Select **vsphere** as the platform to target.
- iii. Specify the name of your vCenter instance.
- iv. Specify the user name and password for the vCenter account that has the required permissions to create the cluster.  
The installation program connects to your vCenter instance.
- v. Select the datacenter in your vCenter instance to connect to.
- vi. Select the default vCenter datastore to use.
- vii. Select the vCenter cluster to install the OpenShift Container Platform cluster in. The installation program uses the root resource pool of the vSphere cluster as the default resource pool.

- viii. Select the network in the vCenter instance that contains the virtual IP addresses and DNS records that you configured.
  - ix. Enter the virtual IP address that you configured for control plane API access.
  - x. Enter the virtual IP address that you configured for cluster ingress.
  - xi. Enter the base domain. This base domain must be the same one that you used in the DNS records that you configured.
  - xii. Enter a descriptive name for your cluster. The cluster name must be the same one that you used in the DNS records that you configured.
  - xiii. Paste the [pull secret from the Red Hat OpenShift Cluster Manager](#) .
2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.
  3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

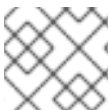


### IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

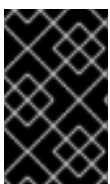
#### 17.3.9.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.



### NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.



### IMPORTANT

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

#### 17.3.9.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 17.15. Required parameters

Parameter	Description	Values
-----------	-------------	--------

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;</b> . <b>&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}</b> . <b>{{.baseDomain}}</b> .	String of lowercase letters and hyphens (-), such as <b>dev</b> .
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws</b> , <b>baremetal</b> , <b>azure</b> , <b>gcp</b> , <b>openstack</b> , <b>ovirt</b> , <b>vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object


Parameter	Description	Values
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } }</pre>


### 17.3.9.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

Table 17.16. Network parameters


Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	Object  <div style="margin-left: 20px;"> <p><b>NOTE</b></p> <p>You cannot modify parameters specified by the <b>networking</b> object after installation.</p> </div>
<b>networking.networkType</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .


Parameter	Description	Values
<b>networking.clusterNetwork</b>	<p>The IP address blocks for pods.</p> <p>The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b>.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   clusterNetwork:     - cidr: 10.128.0.0/14       hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	<p>Required if you use <b>networking.clusterNetwork</b>. An IP address block.</p> <p>An IPv4 network.</p>	<p>An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b>.</p>
<b>networking.clusterNetwork.hostPrefix</b>	<p>The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b>. A <b>hostPrefix</b> value of <b>23</b> provides 510 (<math>2^{(32 - 23)} - 2</math>) pod IP addresses.</p>	<p>A subnet prefix.</p> <p>The default value is <b>23</b>.</p>
<b>networking.serviceNetwork</b>	<p>The IP address block for services. The default value is <b>172.30.0.0/16</b>.</p> <p>The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.</p>	<p>An array with an IP address block in CIDR format. For example:</p> <pre>networking:   serviceNetwork:     - 172.30.0.0/16</pre>
<b>networking.machineNetwork</b>	<p>The IP address blocks for machines.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   machineNetwork:     - cidr: 10.0.0.0/16</pre>
<b>networking.machineNetwork.cidr</b>	<p>Required if you use <b>networking.machineNetwork</b>. An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b>.</p>	<p>An IP network block in CIDR notation.</p> <p>For example, <b>10.0.0.0/16</b>.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p> </div> </div>



## 17.3.9.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:



Table 17.17. Optional parameters


Parameter	Description	Values
<b>additionalTrustBundle</b>	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
<b>compute</b>	The configuration for the machines that comprise the compute nodes.	Array of <b>MachinePool</b> objects.
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String
<b>compute.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>

Parameter	Description	Values
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String
<b>controlPlane.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platform</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>controlPlane.replicas</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.

Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.</p> <p> <b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators reference content</i>.</p> <p> <b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p>	<b>Mint, Passthrough, Manual</b> or an empty string ("").



Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start;"> <div style="flex: 1;">  <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> <div style="flex: 1;">  <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<b>Internal</b> or <b>External</b> . The default value is <b>External</b> .  Setting this field to <b>Internal</b> is not supported on non-cloud platforms.

Parameter	Description	Values
<b>sshKey</b>	<p>The SSH key or keys to authenticate access your cluster machines.</p>  <p><b>NOTE</b></p> <p>For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.</p>	<p>One or more keys. For example:</p> <pre>sshKey: &lt;key1&gt; &lt;key2&gt; &lt;key3&gt;</pre>

#### 17.3.9.1.4. Additional VMware vSphere configuration parameters

Additional VMware vSphere configuration parameters are described in the following table:

Table 17.18. Additional VMware vSphere cluster parameters

Parameter	Description	Values
<b>platform.vsphere.vcenter</b>	The fully-qualified hostname or IP address of the vCenter server.	String
<b>platform.vsphere.username</b>	The user name to use to connect to the vCenter instance with. This user must have at least the roles and privileges that are required for <a href="#">static or dynamic persistent volume provisioning</a> in vSphere.	String
<b>platform.vsphere.password</b>	The password for the vCenter user name.	String
<b>platform.vsphere.datacenter</b>	The name of the datacenter to use in the vCenter instance.	String
<b>platform.vsphere.defaultDatastore</b>	The name of the default datastore to use for provisioning volumes.	String

Parameter	Description	Values
<b>platform.vsphere.folder</b>	<i>Optional.</i> The absolute path of an existing folder where the installation program creates the virtual machines. If you do not provide this value, the installation program creates a folder that is named with the infrastructure ID in the datacenter virtual machine folder.	String, for example, <code>/&lt;datacenter_name&gt;/vm/&lt;folder_name&gt;/&lt;subfolder_name&gt;</code> .
<b>platform.vsphere.network</b>	The network in the vCenter instance that contains the virtual IP addresses and DNS records that you configured.	String
<b>platform.vsphere.cluster</b>	The vCenter cluster to install the OpenShift Container Platform cluster in.	String
<b>platform.vsphere.apiVIP</b>	The virtual IP (VIP) address that you configured for control plane API access.	An IP address, for example <b>128.0.0.1</b> .
<b>platform.vsphere.ingressVIP</b>	The virtual IP (VIP) address that you configured for cluster ingress.	An IP address, for example <b>128.0.0.1</b> .

#### 17.3.9.1.5. Optional VMware vSphere machine pool configuration parameters

Optional VMware vSphere machine pool configuration parameters are described in the following table:

Table 17.19. Optional VMware vSphere machine pool parameters

Parameter	Description	Values
<b>platform.vsphere.clusterOSImage</b>	The location from which the installer downloads the RHCOS image. You must set this parameter to perform an installation in a restricted network.	An HTTP or HTTPS URL, optionally with a SHA-256 checksum. For example, <code>https://mirror.openshift.com/images/rhcos-&lt;version&gt;-vmware.&lt;architecture&gt;.ova</code> .
<b>platform.vsphere.osDisk.diskSizeGB</b>	The size of the disk in gigabytes.	Integer

Parameter	Description	Values
<b>platform.vsphere.cpus</b>	The total number of virtual processor cores to assign a virtual machine. The value of <b>platform.vsphere.cpus</b> must be a multiple of <b>platform.vsphere.coresPerSocket</b> value.	Integer
<b>platform.vsphere.coresPerSocket</b>	The number of cores per socket in a virtual machine. The number of virtual sockets on the virtual machine is <b>platform.vsphere.cpus/platform.vsphere.coresPerSocket</b> . The default value for control plane nodes and worker nodes is <b>4</b> and <b>2</b> , respectively.	Integer
<b>platform.vsphere.memoryMB</b>	The size of a virtual machine's memory in megabytes.	Integer

### 17.3.9.2. Sample install-config.yaml file for an installer-provisioned VMware vSphere cluster

You can customize the install-config.yaml file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```

apiVersion: v1
baseDomain: example.com ❶
compute: ❷
- hyperthreading: Enabled ❸
  name: worker
  replicas: 3
  platform:
    vsphere: ❹
      cpus: 2
      coresPerSocket: 2
      memoryMB: 8192
      osDisk:
        diskSizeGB: 120
controlPlane: ❺
  hyperthreading: Enabled ❻
  name: master
  replicas: 3
  platform:
    vsphere: ❼
      cpus: 4
      coresPerSocket: 2
      memoryMB: 16384
      osDisk:

```

```

diskSizeGB: 120
metadata:
  name: cluster 8
platform:
  vsphere:
    vcenter: your.vcenter.server
    username: username
    password: password
    datacenter: datacenter
    defaultDatastore: datastore
    folder: folder
    network: VM_Network
    cluster: vsphere_cluster_name 9
    apiVIP: api_vip
    ingressVIP: ingress_vip
fips: false
pullSecret: '{"auths": ...}'
sshKey: 'ssh-ed25519 AAAA...'

```

- 1** The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.
- 2** **5** The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. Only one control plane pool is used.
- 3** **6** Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.



### IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Your machines must use at least 8 CPUs and 32 GB of RAM if you disable simultaneous multithreading.

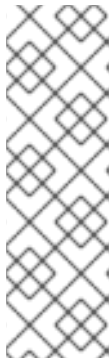
- 4** **7** Optional: Provide additional configuration for the machine pool parameters for the compute and control plane machines.
- 8** The cluster name that you specified in your DNS records.
- 9** The vSphere cluster to install the OpenShift Container Platform cluster in. The installation program uses the root resource pool of the vSphere cluster as the default resource pool.

#### 17.3.9.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

#### Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



## NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

## Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
  additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
...

```

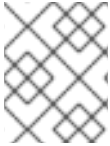
- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations. You must include vCenter's IP address and the IP range that you use for its machines.
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

**NOTE**

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

**NOTE**

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

### 17.3.10. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.

**IMPORTANT**

You can run the **create cluster** command of the installation program only once, during initial installation.

#### Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

#### Procedure

1. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ ❶
--log-level=info ❷
```

- ❶ For **<installation\_directory>**, specify the location of your customized **./install-config.yaml** file.
- ❷ To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

When the cluster deployment completes, directions for accessing your cluster, including a link to its web console and credentials for the **kubeadmin** user, display in your terminal.

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Ee6gm-ymBZj-Wt5AL"
INFO Time elapsed: 36m22s
```

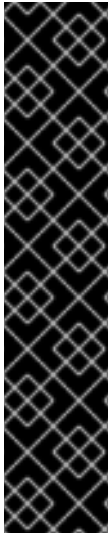
-

+

**NOTE**

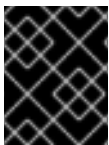
The cluster access and credential information also outputs to **<installation\_directory>/*.openshift\_install.log*** when an installation succeeds.

+

**IMPORTANT**

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

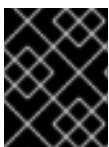
+

**IMPORTANT**

You must not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

### 17.3.11. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

**IMPORTANT**

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

#### Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

##### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.



3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

```
$ tar xvf <file>
```

5. Place the **oc** binary in a directory that is on your **PATH**.  
To check your **PATH**, execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

### Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your **PATH**.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### 17.3.12. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

#### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

#### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

#### Example output

```
system:admin
```

### 17.3.13. Creating registry storage

After you install the cluster, you must create storage for the registry Operator.

#### 17.3.13.1. Image registry removed during installation

On platforms that do not provide shareable object storage, the OpenShift Image Registry Operator bootstraps itself as **Removed**. This allows **openshift-installer** to complete installations on these platform types.

After installation, you must edit the Image Registry Operator configuration to switch the **managementState** from **Removed** to **Managed**.



## NOTE

The Prometheus console provides an **ImageRegistryRemoved** alert, for example:

"Image Registry has been removed. **ImageStreamTags**, **BuildConfigs** and **DeploymentConfigs** which reference **ImageStreamTags** may not work as expected. Please configure storage and update the config to **Managed** state by editing `configs.imageregistry.operator.openshift.io`."

### 17.3.13.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

#### 17.3.13.2.1. Configuring registry storage for VMware vSphere

As a cluster administrator, following installation you must configure your registry to use storage.

#### Prerequisites

- Cluster administrator permissions.
- A cluster on VMware vSphere.
- Persistent storage provisioned for your cluster, such as Red Hat OpenShift Container Storage.



## IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have "100Gi" capacity.



## IMPORTANT

Testing shows issues with using the NFS server on RHEL as storage backend for core services. This includes the OpenShift Container Registry and Quay, Prometheus for monitoring storage, and Elasticsearch for logging storage. Therefore, using RHEL NFS to back PVs used by core services is not recommended.

Other NFS implementations on the marketplace might not have these issues. Contact the individual NFS implementation vendor for more information on any testing that was possibly completed against these OpenShift Container Platform core components.

## Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.



### NOTE

When using shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

### Example output

```
No resources found in openshift-image-registry namespace
```



### NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

### Example output

```
storage:
  pvc:
    claim: 1
```

- 1** Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** persistent volume claim (PVC). The PVC is generated based on the default storage class. However, be aware that the default storage class might provide ReadWriteOnce (RWO) volumes, such as a RADOS Block Device (RBD), which can cause issues when replicating to more than one replica.

4. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED
image-registry	4.7	True	False	False

## 17.3.13.2.2. Configuring block registry storage for VMware vSphere

To allow the image registry to use block storage types such as vSphere Virtual Machine Disk (VMDK) during upgrades as a cluster administrator, you can use the **Recreate** rollout strategy.



## IMPORTANT

Block storage volumes are supported but not recommended for use with image registry on production clusters. An installation where the registry is configured on block storage is not highly available because the registry cannot have more than one replica.

## Procedure

1. To set the image registry storage as a block storage type, patch the registry so that it uses the **Recreate** rollout strategy and runs with only **1** replica:

```
$ oc patch config.imageregistry.operator.openshift.io/cluster --type=merge -p '{"spec": {"rolloutStrategy": "Recreate", "replicas": 1}}'
```

2. Provision the PV for the block storage device, and create a PVC for that volume. The requested block volume uses the ReadWriteOnce (RWO) access mode.
  - a. Create a **pvc.yaml** file with the following contents to define a VMware vSphere **PersistentVolumeClaim** object:

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: image-registry-storage 1
  namespace: openshift-image-registry 2
spec:
  accessModes:
    - ReadWriteOnce 3
  resources:
    requests:
      storage: 100Gi 4
```

- 1 A unique name that represents the **PersistentVolumeClaim** object.
- 2 The namespace for the **PersistentVolumeClaim** object, which is **openshift-image-registry**.
- 3 The access mode of the persistent volume claim. With **ReadWriteOnce**, the volume can be mounted with read and write permissions by a single node.
- 4 The size of the persistent volume claim.

- b. Create the **PersistentVolumeClaim** object from the file:

```
$ oc create -f pvc.yaml -n openshift-image-registry
```

3. Edit the registry configuration so that it references the correct PVC:

```
$ oc edit config.imageregistry.operator.openshift.io -o yaml
```

## Example output

```
storage:
  pvc:
    claim: 1
```

- 1 Creating a custom PVC allows you to leave the **claim** field blank for the default automatic creation of an **image-registry-storage** PVC.

For instructions about configuring registry storage so that it references the correct PVC, see [Configuring the registry for vSphere](#).

### 17.3.14. Backing up VMware vSphere volumes

OpenShift Container Platform provisions new volumes as independent persistent disks to freely attach and detach the volume on any node in the cluster. As a consequence, it is not possible to back up volumes that use snapshots, or to restore volumes from snapshots. See [Snapshot Limitations](#) for more information.

#### Procedure

To create a backup of persistent volumes:

1. Stop the application that is using the persistent volume.
2. Clone the persistent volume.
3. Restart the application.
4. Create a backup of the cloned volume.
5. Delete the cloned volume.

### 17.3.15. Steal clock accounting

By default, the installation program provisions the cluster's virtual machines without enabling the steal clock accounting parameter (**stealclock.enabled**). Enabling steal clock accounting can help with troubleshooting cluster issues. After the cluster is deployed, use the vSphere Client to enable this parameter on each of the virtual machines.

For more information, see this [Red Hat knowledge base article](#).

### 17.3.16. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

#### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

### 17.3.17. Next steps

- [Customize your cluster.](#)
- If necessary, you can [opt out of remote health reporting](#) .
- [Set up your registry and configure registry storage](#) .
- Optional: [View the events from the vSphere Problem Detector Operator](#) to determine if the cluster has permission or storage configuration issues.

## 17.4. INSTALLING A CLUSTER ON VSPHERE WITH NETWORK CUSTOMIZATIONS

In OpenShift Container Platform version 4.9, you can install a cluster on your VMware vSphere instance by using installer-provisioned infrastructure with customized network configuration options. By customizing your network configuration, your cluster can coexist with existing IP address allocations in your environment and integrate with existing MTU and VXLAN configurations. To customize the installation, you modify parameters in the **install-config.yaml** file before you install the cluster.

You must set most of the network configuration parameters during installation, and you can modify only **kubeProxy** configuration parameters in a running cluster.



### NOTE

OpenShift Container Platform supports deploying a cluster to a single VMware vCenter only. Deploying a cluster with machines/machine sets on multiple vCenters is not supported.

### 17.4.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You provisioned [persistent storage](#) for your cluster. To deploy a private image registry, your storage must provide **ReadWriteMany** access modes.
- The OpenShift Container Platform installer requires access to port 443 on the vCenter and ESXi hosts. You verified that port 443 is accessible.
- If you use a firewall, confirm with the administrator that port 443 is accessible. Control plane nodes must be able to reach vCenter and ESXi hosts on port 443 for the installation to succeed.
- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.



### NOTE

Be sure to also review this site list if you are configuring a proxy.

## 17.4.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



### IMPORTANT

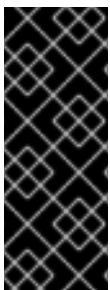
If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

## 17.4.3. VMware vSphere infrastructure requirements

You must install the OpenShift Container Platform cluster on a VMware vSphere version 6 or 7 instance that meets the requirements for the components that you use.

**Table 17.20. Version requirements for vSphere virtual environments**

Virtual environment product	Required version
VM hardware version	13 or later
vSphere ESXi hosts	6.5 or later
vCenter host	6.5 or later



### IMPORTANT

Installing a cluster on VMware vSphere version 6.7U2 or earlier and virtual hardware version 13 is now deprecated. These versions are still fully supported, but support will be removed in a future version of OpenShift Container Platform. Hardware version 15 is now the default for vSphere virtual machines in OpenShift Container Platform. To update the hardware version for your vSphere nodes, see the "Updating hardware on nodes running in vSphere" article.

**Table 17.21. Minimum supported vSphere version for VMware components**

Component	Minimum supported versions	Description
-----------	----------------------------	-------------



Component	Minimum supported versions	Description
Hypervisor	vSphere 6.5 and later with HW version 13	This version is the minimum version that Red Hat Enterprise Linux CoreOS (RHCOS) supports. See the <a href="#">Red Hat Enterprise Linux 8 supported hypervisors list</a> .
Storage with in-tree drivers	vSphere 6.5 and later	This plugin creates vSphere storage by using the in-tree storage drivers for vSphere included in OpenShift Container Platform.
Optional: Networking (NSX-T)	vSphere 6.5U3 or vSphere 6.7U2 and later	vSphere 6.5U3 or vSphere 6.7U2+ are required for OpenShift Container Platform. For more information about the compatibility of NSX and OpenShift Container Platform, see the Release Notes section of VMware's <a href="#">NSX container plugin documentation</a> .

If you use a vSphere version 6.5 instance, consider upgrading to 6.7U3 or 7.0 before you install OpenShift Container Platform.



### IMPORTANT

You must ensure that the time on your ESXi hosts is synchronized before you install OpenShift Container Platform. See [Edit Time Configuration for a Host](#) in the VMware documentation.

#### 17.4.4. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate.

Review the following details about the required network ports.

**Table 17.22. Ports used for all-machine to all-machine communications**

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	<b>1936</b>	Metrics
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> and the Cluster Version Operator on port <b>9099</b> .

Protocol	Port	Description
	<b>10250-10259</b>	The default ports that Kubernetes reserves
	<b>10256</b>	openshift-sdn
UDP	<b>4789</b>	virtual extensible LAN (VXLAN)
	<b>6081</b>	Geneve
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> .
	<b>500</b>	IPsec IKE packets
	<b>4500</b>	IPsec NAT-T packets
TCP/UDP	<b>30000-32767</b>	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 17.23. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	<b>6443</b>	Kubernetes API

Table 17.24. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	<b>2379-2380</b>	etcd server and peer ports

#### Additional resources

- To update the hardware version for your vSphere nodes, see [Updating hardware on nodes running in vSphere](#).

### 17.4.5. vCenter requirements

Before you install an OpenShift Container Platform cluster on your vCenter that uses infrastructure that the installer provisions, you must prepare your environment.

#### Required vCenter account privileges

To install an OpenShift Container Platform cluster in a vCenter, the installation program requires access to an account with privileges to read and create the required resources. Using an account that has global administrative privileges is the simplest way to access all of the necessary permissions.

If you cannot use an account with global administrative privileges, you must create roles to grant the privileges necessary for OpenShift Container Platform cluster installation. While most of the privileges are always required, some are required only if you plan for the installation program to provision a folder to contain the OpenShift Container Platform cluster on your vCenter instance, which is the default behavior. You must create or amend vSphere roles for the specified objects to grant the required privileges.

An additional role is required if the installation program is to create a vSphere virtual machine folder.

### Example 17.7. Roles and privileges required for installation in vSphere API

vSphere object for role	When required	Required privileges in vSphere API
vSphere vCenter	Always	<b>Cns.Searchable</b> <b>InventoryService.Tagging.AttachTag</b> <b>InventoryService.Tagging.CreateCategory</b> <b>InventoryService.Tagging.CreateTag</b> <b>InventoryService.Tagging.DeleteCategory</b> <b>InventoryService.Tagging.DeleteTag</b> <b>InventoryService.Tagging.EditCategory</b> <b>InventoryService.Tagging.EditTag</b> <b>Sessions.ValidateSession</b> <b>StorageProfile.Update</b> <b>StorageProfile.View</b>
vSphere vCenter Cluster	Always	<b>Host.Config.StorageResource.AssignVMToPool</b> <b>VApp.AssignResourcePool</b> <b>VApp.Import</b> <b>VirtualMachine.Config.AddNewDisk</b>
vSphere Datastore	Always	<b>Datastore.AllocateSpace</b> <b>Datastore.Browse</b> <b>Datastore.FileManagement</b> <b>InventoryService.Tagging.ObjectAttachable</b>
vSphere Port Group	Always	<b>Network.Assign</b>
Virtual Machine Folder	Always	<b>InventoryService.Tagging.ObjectAttachable</b> <b>Resource.AssignVMToPool</b> <b>VApp.Import</b> <b>VirtualMachine.Config.AddExistingDisk</b>

vSphere object for role	When required	VirtualMachine.Config.Add NewDisk VirtualMachine.Config.Add RemoveDevice VirtualMachine.Config.AdvancedConfig VirtualMachine.Config.Annotation VirtualMachine.Config.CPUCount VirtualMachine.Config.DiskExtend VirtualMachine.Config.DiskLease VirtualMachine.Config.EditDevice VirtualMachine.Config.Memory VirtualMachine.Config.RemoveDisk VirtualMachine.Config.Rename VirtualMachine.Config.ResetGuestInfo VirtualMachine.Config.Resource VirtualMachine.Config.Settings VirtualMachine.Config.UpgradeVirtualHardware VirtualMachine.Interact.GuestControl VirtualMachine.Interact.PowerOff VirtualMachine.Interact.PowerOn VirtualMachine.Interact.Reset VirtualMachine.Inventory.Create VirtualMachine.Inventory.CreateFromExisting VirtualMachine.Inventory.Delete VirtualMachine.Provisioning.Clone VirtualMachine.Provisioning.MarkAsTemplate VirtualMachine.Provisioning.DeployTemplate
vSphere vCenter Datacenter	If the installation program creates the virtual machine folder	InventoryService.Tagging.ObjectAttachable Resource.AssignVMToPool VApp.Import VirtualMachine.Config.Add

vSphere object for role	When required	ExistingDisk Required privileges in vSphere API
		VirtualMachine.Config.AddNewDisk VirtualMachine.Config.RemoveDevice VirtualMachine.Config.AdvancedConfig VirtualMachine.Config.Annotation VirtualMachine.Config.CPUCount VirtualMachine.Config.DiskExtend VirtualMachine.Config.DiskLease VirtualMachine.Config.EditDevice VirtualMachine.Config.Memory VirtualMachine.Config.RemoveDisk VirtualMachine.Config.Rename VirtualMachine.Config.ResetGuestInfo VirtualMachine.Config.Resource VirtualMachine.Config.Settings VirtualMachine.Config.UpgradeVirtualHardware VirtualMachine.Interact.GuestControl VirtualMachine.Interact.PowerOff VirtualMachine.Interact.PowerOn VirtualMachine.Interact.Reset VirtualMachine.Inventory.Create VirtualMachine.Inventory.CreateFromExisting VirtualMachine.Inventory.Delete VirtualMachine.Provisioning.Clone VirtualMachine.Provisioning.DeployTemplate VirtualMachine.Provisioning.MarkAsTemplate Folder.Create Folder.Delete

### Example 17.8. Roles and privileges required for installation in vCenter graphical user interface (GUI)

vSphere object for role	When required	Required privileges in vCenter GUI
vSphere vCenter	Always	<b>Cns.Searchable</b> "vSphere Tagging"."Assign or Unassign vSphere Tag" "vSphere Tagging"."Create vSphere Tag Category" "vSphere Tagging"."Create vSphere Tag" "vSphere Tagging"."Delete vSphere Tag Category" "vSphere Tagging"."Delete vSphere Tag" "vSphere Tagging"."Edit vSphere Tag Category" "vSphere Tagging"."Edit vSphere Tag" Sessions."Validate session" "Profile-driven storage"."Profile-driven storage update" "Profile-driven storage"."Profile-driven storage view"
vSphere vCenter Cluster	If VMs will be created in the cluster root	<b>Host.Configuration."Storage partition configuration"</b> <b>Resource."Assign virtual machine to resource pool"</b> <b>VApp."Assign resource pool"</b> <b>VApp.Import</b> <b>"Virtual machine"."Change Configuration"."Add new disk"</b>
vSphere vCenter Resource Pool	If an existing resource pool is provided	<b>Host.Configuration."Storage partition configuration"</b> <b>Resource."Assign virtual machine to resource pool"</b> <b>VApp."Assign resource pool"</b> <b>VApp.Import</b> <b>"Virtual machine"."Change Configuration"."Add new disk"</b>

vSphere object for role	When required	Required privileges in vCenter GUI
vSphere Datastore	Always	<b>Datastore."Allocate space"</b> <b>Datastore."Browse datastore"</b> <b>Datastore."Low level file operations"</b> <b>"vSphere Tagging"."Assign or Unassign vSphere Tag on Object"</b>
vSphere Port Group	Always	<b>Network."Assign network"</b>
Virtual Machine Folder	Always	<b>"vSphere Tagging"."Assign or Unassign vSphere Tag on Object"</b> <b>Resource."Assign virtual machine to resource pool"</b> <b>VApp.Import</b> <b>"Virtual machine"."Change Configuration"."Add existing disk"</b> <b>"Virtual machine"."Change Configuration"."Add new disk"</b> <b>"Virtual machine"."Change Configuration"."Add or remove device"</b> <b>"Virtual machine"."Change Configuration"."Advanced configuration"</b> <b>"Virtual machine"."Change Configuration"."Set annotation"</b> <b>"Virtual machine"."Change Configuration"."Change CPU count"</b> <b>"Virtual machine"."Change Configuration"."Extend virtual disk"</b> <b>"Virtual machine"."Change Configuration"."Acquire disk lease"</b> <b>"Virtual machine"."Change Configuration"."Modify device settings"</b> <b>"Virtual machine"."Change Configuration"."Change Memory"</b> <b>"Virtual machine"."Change Configuration"."Remove</b>

vSphere object for role	When required	Required privileges in vCenter GUI
		<p>disk"</p> <p>Virtual machine : Change Configuration".Rename</p> <p>"Virtual machine"."Change Configuration"."Reset guest information"</p> <p>"Virtual machine"."Change Configuration"."Change resource"</p> <p>"Virtual machine"."Change Configuration"."Change Settings"</p> <p>"Virtual machine"."Change Configuration"."Upgrade virtual machine compatibility"</p> <p>"Virtual machine".Interaction."Guest operating system management by VIX API"</p> <p>"Virtual machine".Interaction."Power off"</p> <p>"Virtual machine".Interaction."Power on"</p> <p>"Virtual machine".Interaction.Reset</p> <p>"Virtual machine"."Edit Inventory"."Create new"</p> <p>"Virtual machine"."Edit Inventory"."Create from existing"</p> <p>"Virtual machine"."Edit Inventory"."Remove"</p> <p>"Virtual machine".Provisioning."Clone virtual machine"</p> <p>"Virtual machine".Provisioning."Mark as template"</p> <p>"Virtual machine".Provisioning."Deploy template"</p>
vSphere vCenter Datacenter	If the installation program creates the virtual machine folder	<p>"vSphere Tagging"."Assign or Unassign vSphere Tag on Object"</p> <p>Resource."Assign virtual machine to resource pool"</p> <p>VApp.Import</p> <p>"Virtual machine"."Change Configuration"."Add existing disk"</p> <p>"Virtual machine"."Change</p>



vSphere object for role	When required	Configuration". "Add new Required privileges in vCenter GUI Virtual machine". "Change Configuration". "Add or remove device" "Virtual machine". "Change Configuration". "Advanced configuration" "Virtual machine". "Change Configuration". "Set annotation" "Virtual machine". "Change Configuration". "Change CPU count" "Virtual machine". "Change Configuration". "Extend virtual disk" "Virtual machine". "Change Configuration". "Acquire disk lease" "Virtual machine". "Change Configuration". "Modify device settings" "Virtual machine". "Change Configuration". "Change Memory" "Virtual machine". "Change Configuration". "Remove disk" "Virtual machine". "Change Configuration". "Rename" "Virtual machine". "Change Configuration". "Reset guest information" "Virtual machine". "Change Configuration". "Change resource" "Virtual machine". "Change Configuration". "Change Settings" "Virtual machine". "Change Configuration". "Upgrade virtual machine compatibility" "Virtual machine". Interaction. "Guest operating system management by VIX API" "Virtual machine". Interaction. "Power off" "Virtual machine". Interaction. "Power on" "Virtual machine". Interaction. "Reset

vSphere object for role	When required	"Virtual machine"."Edit Inventory"."Create new virtual machine"."Edit Inventory"."Create from existing" "Virtual machine"."Edit Inventory"."Remove" "Virtual machine".Provisioning."Clone virtual machine" "Virtual machine".Provisioning."Deploy template" "Virtual machine".Provisioning."Mark as template" Folder."Create folder" Folder."Delete folder"

Additionally, the user requires some **ReadOnly** permissions, and some of the roles require permission to propagate the permissions to child objects. These settings vary depending on whether or not you install the cluster into an existing folder.

**Example 17.9. Required permissions and propagation settings**

vSphere object	Folder type	Propagate to children	Permissions required
vSphere vCenter	Always	False	Listed required privileges
vSphere vCenter Datacenter	Existing folder	False	<b>ReadOnly</b> permission
	Installation program creates the folder	True	Listed required privileges
vSphere vCenter Cluster	Always	True	Listed required privileges
vSphere vCenter Datastore	Always	False	Listed required privileges
vSphere Switch	Always	False	<b>ReadOnly</b> permission
vSphere Port Group	Always	False	Listed required privileges
vSphere vCenter Virtual Machine Folder	Existing folder	True	Listed required privileges

For more information about creating an account with only the required privileges, see [vSphere Permissions and User Management Tasks](#) in the vSphere documentation.

### Using OpenShift Container Platform with vMotion

If you intend on using vMotion in your vSphere environment, consider the following before installing a OpenShift Container Platform cluster.

- OpenShift Container Platform generally supports compute-only vMotion. Using Storage vMotion can cause issues and is not supported.  
To help ensure the uptime of your compute and control plane nodes, it is recommended that you follow the VMware best practices for vMotion. It is also recommended to use VMware anti-affinity rules to improve the availability of OpenShift Container Platform during maintenance or hardware issues.

For more information about vMotion and anti-affinity rules, see the VMware vSphere documentation for [vMotion networking requirements](#) and [VM anti-affinity rules](#).

- If you are using vSphere volumes in your pods, migrating a VM across datastores either manually or through Storage vMotion causes, invalid references within OpenShift Container Platform persistent volume (PV) objects. These references prevent affected pods from starting up and can result in data loss.
- Similarly, OpenShift Container Platform does not support selective migration of VMDKs across datastores, using datastore clusters for VM provisioning or for dynamic or static provisioning of PVs, or using a datastore that is part of a datastore cluster for dynamic or static provisioning of PVs.

### Cluster resources

When you deploy an OpenShift Container Platform cluster that uses installer-provisioned infrastructure, the installation program must be able to create several resources in your vCenter instance.

A standard OpenShift Container Platform installation creates the following vCenter resources:

- 1 Folder
- 1 Tag category
- 1 Tag
- Virtual machines:
  - 1 template
  - 1 temporary bootstrap node
  - 3 control plane nodes
  - 3 compute machines

Although these resources use 856 GB of storage, the bootstrap node is destroyed during the cluster installation process. A minimum of 800 GB of storage is required to use a standard cluster.

If you deploy more compute machines, the OpenShift Container Platform cluster will use more storage.

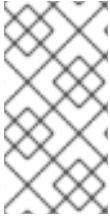
### Cluster limits

Available resources vary between clusters. The number of possible clusters within a vCenter is limited primarily by available storage space and any limitations on the number of required resources. Be sure to

consider both limitations to the vCenter resources that the cluster creates and the resources that you require to deploy a cluster, such as IP addresses and networks.

### Networking requirements

You must use DHCP for the network and ensure that the DHCP server is configured to provide persistent IP addresses to the cluster machines. You must configure the default gateway to use the DHCP server. All nodes must be in the same VLAN. You cannot scale the cluster using a second VLAN as a Day 2 operation. Additionally, you must create the following networking resources before you install the OpenShift Container Platform cluster:



#### NOTE

It is recommended that each OpenShift Container Platform node in the cluster must have access to a Network Time Protocol (NTP) server that is discoverable via DHCP. Installation is possible without an NTP server. However, asynchronous server clocks will cause errors, which NTP server prevents.

### Required IP Addresses

An installer-provisioned vSphere installation requires two static IP addresses:

- The **API** address is used to access the cluster API.
- The **Ingress** address is used for cluster ingress traffic.

You must provide these IP addresses to the installation program when you install the OpenShift Container Platform cluster.

### DNS records

You must create DNS records for two static IP addresses in the appropriate DNS server for the vCenter instance that hosts your OpenShift Container Platform cluster. In each record, **<cluster\_name>** is the cluster name and **<base\_domain>** is the cluster base domain that you specify when you install the cluster. A complete DNS record takes the form: **<component>.<cluster\_name>.<base\_domain>..**

Table 17.25. Required DNS records

Component	Record	Description
API VIP	<b>api.&lt;cluster_name&gt;.&lt;base_domain&gt;..</b>	This DNS A/AAAA or CNAME record must point to the load balancer for the control plane machines. This record must be resolvable by both clients external to the cluster and from all the nodes within the cluster.

Component	Record	Description
Ingress VIP	*.apps.<cluster_name>.<base_domain>.	A wildcard DNS A/AAAA or CNAME record that points to the load balancer that targets the machines that run the Ingress router pods, which are the worker nodes by default. This record must be resolvable by both clients external to the cluster and from all the nodes within the cluster.

### 17.4.6. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.



#### IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



#### NOTE

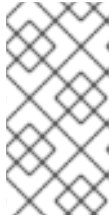
You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

#### Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.

**NOTE**

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.

**NOTE**

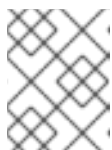
On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

**Example output**

```
Agent pid 31874
```

**NOTE**

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1** Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

**Example output**

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

**Next steps**

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

### 17.4.7. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

#### Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space

#### Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



#### IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



#### IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

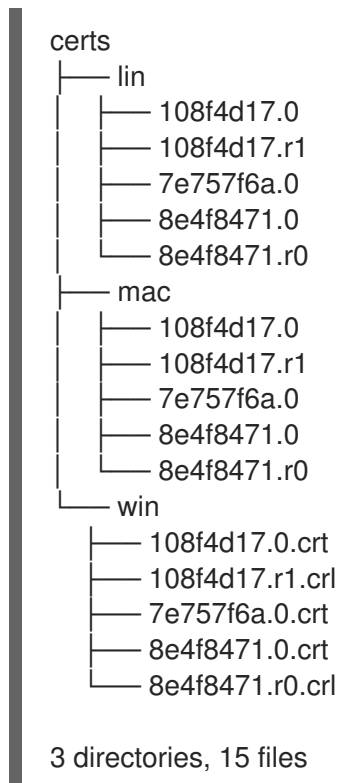
5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#). This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

### 17.4.8. Adding vCenter root CA certificates to your system trust

Because the installation program requires access to your vCenter's API, you must add your vCenter's trusted root CA certificates to your system trust before you install an OpenShift Container Platform cluster.

#### Procedure

1. From the vCenter home page, download the vCenter's root CA certificates. Click **Download trusted root CA certificates** in the vSphere Web Services SDK section. The **<vCenter>/certs/download.zip** file downloads.
2. Extract the compressed file that contains the vCenter root CA certificates. The contents of the compressed file resemble the following file structure:



3. Add the files for your operating system to the system trust. For example, on a Fedora operating system, run the following command:

```
# cp certs/lin/* /etc/pki/ca-trust/source/anchors
```

4. Update your system trust. For example, on a Fedora operating system, run the following command:

```
# update-ca-trust extract
```

### 17.4.9. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on VMware vSphere.

#### Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

#### Procedure

1. Create the **install-config.yaml** file.
  - a. Change to the directory that contains the installation program and run the following



command:

```
$. /openshift-install create install-config --dir <installation_directory> 1
```

- 1** For **<installation\_directory>**, specify the directory name to store the files that the installation program creates.



### IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

- b. At the prompts, provide the configuration details for your cloud:
- i. Optional: Select an SSH key to use to access your cluster machines.

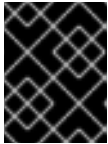


### NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

- ii. Select **vsphere** as the platform to target.
- iii. Specify the name of your vCenter instance.
- iv. Specify the user name and password for the vCenter account that has the required permissions to create the cluster.  
The installation program connects to your vCenter instance.
- v. Select the datacenter in your vCenter instance to connect to.
- vi. Select the default vCenter datastore to use.
- vii. Select the vCenter cluster to install the OpenShift Container Platform cluster in. The installation program uses the root resource pool of the vSphere cluster as the default resource pool.
- viii. Select the network in the vCenter instance that contains the virtual IP addresses and DNS records that you configured.
- ix. Enter the virtual IP address that you configured for control plane API access.
- x. Enter the virtual IP address that you configured for cluster ingress.
- xi. Enter the base domain. This base domain must be the same one that you used in the DNS records that you configured.

- xii. Enter a descriptive name for your cluster. The cluster name must be the same one that you used in the DNS records that you configured.
  - xiii. Paste the [pull secret from the Red Hat OpenShift Cluster Manager](#) .
2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.
  3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



### IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

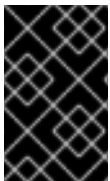
#### 17.4.9.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.



### NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.



### IMPORTANT

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

##### 17.4.9.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 17.26. Required parameters

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String


Parameter	Description	Values
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;.&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}</b> . <b>{{.baseDomain}}</b> .	String of lowercase letters and hyphens (-), such as <b>dev</b> .
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws</b> , <b>baremetal</b> , <b>azure</b> , <b>gcp</b> , <b>openstack</b> , <b>ovirt</b> , <b>vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre> {   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } } </pre>


### 17.4.9.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

Table 17.27. Network parameters

Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	Object   <b>NOTE</b> You cannot modify parameters specified by the <b>networking</b> object after installation.
<b>networking.network Type</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .
<b>networking.clusterNetwork</b>	The IP address blocks for pods.  The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b> .  If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example:  <pre>networking:   clusterNetwork:     - cidr: 10.128.0.0/14       hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	Required if you use <b>networking.clusterNetwork</b> . An IP address block.  An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b> .
<b>networking.clusterNetwork.hostPrefix</b>	The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b> . A <b>hostPrefix</b> value of <b>23</b> provides 510 ( $2^{(32 - 23)} - 2$ ) pod IP addresses.	A subnet prefix.  The default value is <b>23</b> .


Parameter	Description	Values
<b>networking.serviceNetwork</b>	<p>The IP address block for services. The default value is <b>172.30.0.0/16</b>.</p> <p>The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.</p>	<p>An array with an IP address block in CIDR format. For example:</p> <pre>networking:   serviceNetwork:     - 172.30.0.0/16</pre>
<b>networking.machineNetwork</b>	<p>The IP address blocks for machines.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   machineNetwork:     - cidr: 10.0.0.0/16</pre>
<b>networking.machineNetwork.cidr</b>	<p>Required if you use <b>networking.machineNetwork</b>. An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b>.</p>	<p>An IP network block in CIDR notation.</p> <p>For example, <b>10.0.0.0/16</b>.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p> </div> </div>


### 17.4.9.1.3. Optional configuration parameters



Optional installation configuration parameters are described in the following table:

Table 17.28. Optional parameters

Parameter	Description	Values
<b>additionalTrustBundle</b>	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
<b>compute</b>	The configuration for the machines that comprise the compute nodes.	Array of <b>MachinePool</b> objects.


Parameter	Description	Values
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String
<b>compute.hyperthreading</b>	Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b> , on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.   <b>IMPORTANT</b>  If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b>
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String

Parameter	Description	Values
<b>controlPlane.hypert hreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platfor m</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>controlPlane.replica s</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.

Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.</p> <p> <b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators reference content</i>.</p> <p> <b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p>	<b>Mint, Passthrough, Manual</b> or an empty string ("").



Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start;"> <div style="width: 30px; height: 30px; background-color: black; margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 30px; height: 30px; background-color: black; margin-right: 10px;"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<b>Internal</b> or <b>External</b> . The default value is <b>External</b> .  Setting this field to <b>Internal</b> is not supported on non-cloud platforms.

Parameter	Description	Values
<b>sshKey</b>	<p>The SSH key or keys to authenticate access your cluster machines.</p>  <p><b>NOTE</b></p> <p>For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.</p>	<p>One or more keys. For example:</p> <pre>sshKey:   &lt;key1&gt;   &lt;key2&gt;   &lt;key3&gt;</pre>

#### 17.4.9.1.4. Additional VMware vSphere configuration parameters

Additional VMware vSphere configuration parameters are described in the following table:

Table 17.29. Additional VMware vSphere cluster parameters

Parameter	Description	Values
<b>platform.vsphere.vCenter</b>	The fully-qualified hostname or IP address of the vCenter server.	String
<b>platform.vsphere.username</b>	The user name to use to connect to the vCenter instance with. This user must have at least the roles and privileges that are required for <a href="#">static or dynamic persistent volume provisioning</a> in vSphere.	String
<b>platform.vsphere.password</b>	The password for the vCenter user name.	String
<b>platform.vsphere.datacenter</b>	The name of the datacenter to use in the vCenter instance.	String
<b>platform.vsphere.defaultDatastore</b>	The name of the default datastore to use for provisioning volumes.	String

Parameter	Description	Values
<b>platform.vsphere.folder</b>	<i>Optional.</i> The absolute path of an existing folder where the installation program creates the virtual machines. If you do not provide this value, the installation program creates a folder that is named with the infrastructure ID in the datacenter virtual machine folder.	String, for example, <b>/&lt;datacenter_name&gt;/vm/&lt;folder_name&gt;/&lt;subfolder_name&gt;</b> .
<b>platform.vsphere.network</b>	The network in the vCenter instance that contains the virtual IP addresses and DNS records that you configured.	String
<b>platform.vsphere.cluster</b>	The vCenter cluster to install the OpenShift Container Platform cluster in.	String
<b>platform.vsphere.apiVIP</b>	The virtual IP (VIP) address that you configured for control plane API access.	An IP address, for example <b>128.0.0.1</b> .
<b>platform.vsphere.ingressVIP</b>	The virtual IP (VIP) address that you configured for cluster ingress.	An IP address, for example <b>128.0.0.1</b> .

#### 17.4.9.1.5. Optional VMware vSphere machine pool configuration parameters

Optional VMware vSphere machine pool configuration parameters are described in the following table:

Table 17.30. Optional VMware vSphere machine pool parameters

Parameter	Description	Values
<b>platform.vsphere.clusterOSImage</b>	The location from which the installer downloads the RHCOS image. You must set this parameter to perform an installation in a restricted network.	An HTTP or HTTPS URL, optionally with a SHA-256 checksum. For example, <b>https://mirror.openshift.com/images/rhcos-&lt;version&gt;-vmware.&lt;architecture&gt;.ova</b> .
<b>platform.vsphere.osDisk.diskSizeGB</b>	The size of the disk in gigabytes.	Integer

Parameter	Description	Values
<b>platform.vsphere.cpus</b>	The total number of virtual processor cores to assign a virtual machine. The value of <b>platform.vsphere.cpus</b> must be a multiple of <b>platform.vsphere.coresPerSocket</b> value.	Integer
<b>platform.vsphere.coresPerSocket</b>	The number of cores per socket in a virtual machine. The number of virtual sockets on the virtual machine is <b>platform.vsphere.cpus/platform.vsphere.coresPerSocket</b> . The default value for control plane nodes and worker nodes is <b>4</b> and <b>2</b> , respectively.	Integer
<b>platform.vsphere.memoryMB</b>	The size of a virtual machine's memory in megabytes.	Integer

#### 17.4.9.2. Sample install-config.yaml file for an installer-provisioned VMware vSphere cluster

You can customize the install-config.yaml file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```

apiVersion: v1
baseDomain: example.com ①
compute: ②
- hyperthreading: Enabled ③
  name: worker
  replicas: 3
  platform:
    vsphere: ④
      cpus: 2
      coresPerSocket: 2
      memoryMB: 8192
      osDisk:
        diskSizeGB: 120
controlPlane: ⑤
  hyperthreading: Enabled ⑥
  name: master
  replicas: 3
  platform:
    vsphere: ⑦
      cpus: 4
      coresPerSocket: 2
      memoryMB: 16384
      osDisk:
        diskSizeGB: 120
metadata:

```

```

name: cluster 8
networking:
  clusterNetwork:
    - cidr: 10.128.0.0/14
      hostPrefix: 23
  machineNetwork:
    - cidr: 10.0.0.0/16
  networkType: OpenShiftSDN
  serviceNetwork:
    - 172.30.0.0/16
platform:
  vsphere:
    vcenter: your.vcenter.server
    username: username
    password: password
    datacenter: datacenter
    defaultDatastore: datastore
    folder: folder
    network: VM_Network
    cluster: vsphere_cluster_name 9
    apiVIP: api_vip
    ingressVIP: ingress_vip
fips: false
pullSecret: '{"auths": ...}'
sshKey: 'ssh-ed25519 AAAA...'

```

- 1** The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.
- 2 5** The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. Only one control plane pool is used.
- 3 6** Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.



### IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Your machines must use at least 8 CPUs and 32 GB of RAM if you disable simultaneous multithreading.

- 4 7** Optional: Provide additional configuration for the machine pool parameters for the compute and control plane machines.
- 8** The cluster name that you specified in your DNS records.
- 9** The vSphere cluster to install the OpenShift Container Platform cluster in. The installation program uses the root resource pool of the vSphere cluster as the default resource pool.

#### 17.4.9.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

## Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



### NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

## Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
  additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
  ...
```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations. You must include vCenter's IP address and the IP range that you use for its machines.
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network

Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.



#### NOTE

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



#### NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

### 17.4.10. Network configuration phases

There are two phases prior to OpenShift Container Platform installation where you can customize the network configuration.

#### Phase 1

You can customize the following network-related fields in the **install-config.yaml** file before you create the manifest files:

- **networking.networkType**
- **networking.clusterNetwork**
- **networking.serviceNetwork**
- **networking.machineNetwork**

For more information on these fields, refer to *Installation configuration parameters*.



#### NOTE

Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

#### Phase 2

After creating the manifest files by running **openshift-install create manifests**, you can define a customized Cluster Network Operator manifest with only the fields you want to modify. You can use the manifest to specify advanced network configuration.

You cannot override the values specified in phase 1 in the **install-config.yaml** file during phase 2. However, you can further customize the cluster network provider during phase 2.

### 17.4.11. Specifying advanced network configuration

You can use advanced network configuration for your cluster network provider to integrate your cluster into your existing network environment. You can specify advanced network configuration only before you install the cluster.



## IMPORTANT

Customizing your network configuration by modifying the OpenShift Container Platform manifest files created by the installation program is not supported. Applying a manifest file that you create, as in the following procedure, is supported.

### Prerequisites

- You have created the **install-config.yaml** file and completed any modifications to it.

### Procedure

- Change to the directory that contains the installation program and create the manifests:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

- 1 **<installation\_directory>** specifies the name of the directory that contains the **install-config.yaml** file for your cluster.

- Create a stub manifest file for the advanced network configuration that is named **cluster-network-03-config.yml** in the **<installation\_directory>/manifests/** directory:

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
```

- Specify the advanced network configuration for your cluster in the **cluster-network-03-config.yml** file, such as in the following examples:

#### Specify a different VXLAN port for the OpenShift SDN network provider

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    openshiftSDNConfig:
      vxlanPort: 4800
```

#### Enable IPsec for the OVN-Kubernetes network provider

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
```



```

defaultNetwork:
  ovnKubernetesConfig:
    ipsecConfig: {}

```

- Optional: Back up the **manifests/cluster-network-03-config.yml** file. The installation program consumes the **manifests/** directory when you create the Ignition config files.

## 17.4.12. Cluster Network Operator configuration

The configuration for the cluster network is specified as part of the Cluster Network Operator (CNO) configuration and stored in a custom resource (CR) object that is named **cluster**. The CR specifies the fields for the **Network** API in the **operator.openshift.io** API group.

The CNO configuration inherits the following fields during cluster installation from the **Network** API in the **Network.config.openshift.io** API group and these fields cannot be changed:

### clusterNetwork

IP address pools from which pod IP addresses are allocated.

### serviceNetwork

IP address pool for services.

### defaultNetwork.type

Cluster network provider, such as OpenShift SDN or OVN-Kubernetes.

You can specify the cluster network provider configuration for your cluster by setting the fields for the **defaultNetwork** object in the CNO object named **cluster**.

### 17.4.12.1. Cluster Network Operator configuration object

The fields for the Cluster Network Operator (CNO) are described in the following table:

**Table 17.31. Cluster Network Operator configuration object**


Field	Type	Description
<b>metadata.name</b>	<b>string</b>	The name of the CNO object. This name is always <b>cluster</b> .
<b>spec.clusterNetwork</b>	<b>array</b>	<p>A list specifying the blocks of IP addresses from which pod IP addresses are allocated and the subnet prefix length assigned to each individual node in the cluster. For example:</p> <pre> spec:   clusterNetwork:     - cidr: 10.128.0.0/19       hostPrefix: 23     - cidr: 10.128.32.0/19       hostPrefix: 23 </pre> <p>You can customize this field only in the <b>install-config.yaml</b> file before you create the manifests. The value is read-only in the manifest file.</p>

Field	Type	Description
<b>spec.serviceNetwork</b>	<b>array</b>	<p>A block of IP addresses for services. The OpenShift SDN and OVN-Kubernetes Container Network Interface (CNI) network providers support only a single IP address block for the service network. For example:</p> <pre>spec:   serviceNetwork:   - 172.30.0.0/14</pre> <p>You can customize this field only in the <b>install-config.yaml</b> file before you create the manifests. The value is read-only in the manifest file.</p>
<b>spec.defaultNetwork</b>	<b>object</b>	Configures the Container Network Interface (CNI) cluster network provider for the cluster network.
<b>spec.kubeProxyConfig</b>	<b>object</b>	The fields for this object specify the kube-proxy configuration. If you are using the OVN-Kubernetes cluster network provider, the kube-proxy configuration has no effect.

#### defaultNetwork object configuration

The values for the **defaultNetwork** object are defined in the following table:

Table 17.32. **defaultNetwork** object

Field	Type	Description
<b>type</b>	<b>string</b>	<p>Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b>. The cluster network provider is selected during installation. This value cannot be changed after cluster installation.</p> <div style="display: flex; align-items: flex-start;"> <div style="flex: 1;">  </div> <div style="flex: 2;"> <p><b>NOTE</b></p> <p>OpenShift Container Platform uses the OpenShift SDN Container Network Interface (CNI) cluster network provider by default.</p> </div> </div>
<b>openshiftSDNConfig</b>	<b>object</b>	This object is only valid for the OpenShift SDN cluster network provider.
<b>ovnKubernetesConfig</b>	<b>object</b>	This object is only valid for the OVN-Kubernetes cluster network provider.

#### Configuration for the OpenShift SDN CNI cluster network provider

The following table describes the configuration fields for the OpenShift SDN Container Network Interface (CNI) cluster network provider.

**Table 17.33. openshiftSDNConfig object**

Field	Type	Description
<b>mode</b>	<b>string</b>	<p>Configures the network isolation mode for OpenShift SDN. The default value is <b>NetworkPolicy</b>.</p> <p>The values <b>Multitenant</b> and <b>Subnet</b> are available for backwards compatibility with OpenShift Container Platform 3.x but are not recommended. This value cannot be changed after cluster installation.</p>
<b>mtu</b>	<b>integer</b>	<p>The maximum transmission unit (MTU) for the VXLAN overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU.</p> <p>If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes.</p> <p>If your cluster requires different MTU values for different nodes, you must set this value to <b>50</b> less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of <b>9001</b>, and some have an MTU of <b>1500</b>, you must set this value to <b>1450</b>.</p> <p>This value cannot be changed after cluster installation.</p>
<b>vxlanPort</b>	<b>integer</b>	<p>The port to use for all VXLAN packets. The default value is <b>4789</b>. This value cannot be changed after cluster installation.</p> <p>If you are running in a virtualized environment with existing nodes that are part of another VXLAN network, then you might be required to change this. For example, when running an OpenShift SDN overlay on top of VMware NSX-T, you must select an alternate port for the VXLAN, because both SDNs use the same default VXLAN port number.</p> <p>On Amazon Web Services (AWS), you can select an alternate port for the VXLAN between port <b>9000</b> and port <b>9999</b>.</p>

### Example OpenShift SDN configuration

```
defaultNetwork:
  type: OpenShiftSDN
  openshiftSDNConfig:
    mode: NetworkPolicy
    mtu: 1450
    vxlanPort: 4789
```

**Configuration for the OVN-Kubernetes CNI cluster network provider**

The following table describes the configuration fields for the OVN-Kubernetes CNI cluster network provider.

**Table 17.34. ovnKubernetesConfig object**

Field	Type	Description
<b>mtu</b>	<b>integer</b>	<p>The maximum transmission unit (MTU) for the Geneve (Generic Network Virtualization Encapsulation) overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU.</p> <p>If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes.</p> <p>If your cluster requires different MTU values for different nodes, you must set this value to <b>100</b> less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of <b>9001</b>, and some have an MTU of <b>1500</b>, you must set this value to <b>1400</b>.</p> <p>This value cannot be changed after cluster installation.</p>
<b>genevePort</b>	<b>integer</b>	The port to use for all Geneve packets. The default value is <b>6081</b> . This value cannot be changed after cluster installation.
<b>ipsecConfig</b>	<b>object</b>	Specify an empty object to enable IPsec encryption. This value cannot be changed after cluster installation.
<b>policyAuditConfig</b>	<b>object</b>	Specify a configuration object for customizing network policy audit logging. If unset, the defaults audit log settings are used.

**Table 17.35. policyAuditConfig object**

Field	Type	Description
<b>rateLimit</b>	integer	The maximum number of messages to generate every second per node. The default value is <b>20</b> messages per second.
<b>maxFileSize</b>	integer	The maximum size for the audit log in bytes. The default value is <b>50000000</b> or 50 MB.

Field	Type	Description
<b>destination</b>	string	<p>One of the following additional audit log targets:</p> <p><b>libc</b> The libc <b>syslog()</b> function of the journald process on the host.</p> <p><b>udp:&lt;host&gt;:&lt;port&gt;</b> A syslog server. Replace <b>&lt;host&gt;:&lt;port&gt;</b> with the host and port of the syslog server.</p> <p><b>unix:&lt;file&gt;</b> A Unix Domain Socket file specified by <b>&lt;file&gt;</b>.</p> <p><b>null</b> Do not send the audit logs to any additional target.</p>
<b>syslogFacility</b>	string	The syslog facility, such as <b>kern</b> , as defined by RFC5424. The default value is <b>local0</b> .

### Example OVN-Kubernetes configuration

```


defaultNetwork:
  type: OVNKubernetes
  ovnKubernetesConfig:
    mtu: 1400
    genevePort: 6081
    ipsecConfig: {}

```

### kubeProxyConfig object configuration

The values for the **kubeProxyConfig** object are defined in the following table:

Table 17.36. **kubeProxyConfig** object

Field	Type	Description
<b>iptablesSyncPeriod</b>	<b>string</b>	<p>The refresh period for <b>iptables</b> rules. The default value is <b>30s</b>. Valid suffixes include <b>s</b>, <b>m</b>, and <b>h</b> and are described in the <a href="#">Go time package</a> documentation.</p> <div style="display: flex; align-items: flex-start;"> <div style="flex: 1;">  </div> <div style="flex: 2;"> <p><b>NOTE</b></p> <p>Because of performance improvements introduced in OpenShift Container Platform 4.3 and greater, adjusting the <b>iptablesSyncPeriod</b> parameter is no longer necessary.</p> </div> </div>

Field	Type	Description
<b>proxyArguments.iptables-min-sync-period</b>	<b>array</b>	<p>The minimum duration before refreshing <b>iptables</b> rules. This field ensures that the refresh does not happen too frequently. Valid suffixes include <b>s</b>, <b>m</b>, and <b>h</b> and are described in the <a href="#">Go time package</a>. The default value is:</p> <pre>kubeProxyConfig:   proxyArguments:     iptables-min-sync-period:       - 0s</pre>

### 17.4.13. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



#### IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

#### Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

#### Procedure

1. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
--log-level=info 2
```

- 1 For **<installation\_directory>**, specify the location of your customized **./install-config.yaml** file.
- 2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

When the cluster deployment completes, directions for accessing your cluster, including a link to its web console and credentials for the **kubeadmin** user, display in your terminal.

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
```

```
console.apps.mycluster.example.com
```

```
INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Ee6gm-ymBZj-Wt5AL"
```

```
INFO Time elapsed: 36m22s
```

+

**NOTE**

The cluster access and credential information also outputs to `<installation_directory>/openshift_install.log` when an installation succeeds.

+

**IMPORTANT**

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

+

**IMPORTANT**

You must not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

#### 17.4.14. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

**IMPORTANT**

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

##### Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

##### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.

2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

```
$ tar xvf <file>
```

5. Place the **oc** binary in a directory that is on your **PATH**.  
To check your **PATH**, execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

### Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.



5. Move the **oc** binary to a directory on your PATH.

To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### 17.4.15. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

#### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

#### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

#### Example output

```
system:admin
```

### 17.4.16. Creating registry storage

After you install the cluster, you must create storage for the registry Operator.

#### 17.4.16.1. Image registry removed during installation

On platforms that do not provide shareable object storage, the OpenShift Image Registry Operator bootstraps itself as **Removed**. This allows **openshift-installer** to complete installations on these platform types.

After installation, you must edit the Image Registry Operator configuration to switch the **managementState** from **Removed** to **Managed**.

**NOTE**

The Prometheus console provides an **ImageRegistryRemoved** alert, for example:

"Image Registry has been removed. **ImageStreamTags**, **BuildConfigs** and **DeploymentConfigs** which reference **ImageStreamTags** may not work as expected. Please configure storage and update the config to **Managed** state by editing `configs.imageregistry.operator.openshift.io`."

**17.4.16.2. Image registry storage configuration**

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

**17.4.16.2.1. Configuring registry storage for VMware vSphere**

As a cluster administrator, following installation you must configure your registry to use storage.

**Prerequisites**

- Cluster administrator permissions.
- A cluster on VMware vSphere.
- Persistent storage provisioned for your cluster, such as Red Hat OpenShift Container Storage.

**IMPORTANT**

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have "100Gi" capacity.

**IMPORTANT**

Testing shows issues with using the NFS server on RHEL as storage backend for core services. This includes the OpenShift Container Registry and Quay, Prometheus for monitoring storage, and Elasticsearch for logging storage. Therefore, using RHEL NFS to back PVs used by core services is not recommended.

Other NFS implementations on the marketplace might not have these issues. Contact the individual NFS implementation vendor for more information on any testing that was possibly completed against these OpenShift Container Platform core components.

## Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.



### NOTE

When using shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

### Example output

```
No resources found in openshift-image-registry namespace
```



### NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

### Example output

```
storage:
  pvc:
    claim: 1
```

- 1** Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** persistent volume claim (PVC). The PVC is generated based on the default storage class. However, be aware that the default storage class might provide ReadWriteOnce (RWO) volumes, such as a RADOS Block Device (RBD), which can cause issues when replicating to more than one replica.

4. Check the **clusteroperator** status:

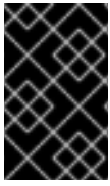
```
$ oc get clusteroperator image-registry
```

### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED
image-registry	4.7	True	False	False

#### 17.4.16.2.2. Configuring block registry storage for VMware vSphere

To allow the image registry to use block storage types such as vSphere Virtual Machine Disk (VMDK) during upgrades as a cluster administrator, you can use the **Recreate** rollout strategy.



## IMPORTANT

Block storage volumes are supported but not recommended for use with image registry on production clusters. An installation where the registry is configured on block storage is not highly available because the registry cannot have more than one replica.

## Procedure

- To set the image registry storage as a block storage type, patch the registry so that it uses the **Recreate** rollout strategy and runs with only **1** replica:

```
$ oc patch config.imageregistry.operator.openshift.io/cluster --type=merge -p '{"spec": {"rolloutStrategy": "Recreate", "replicas": 1}}'
```

- Provision the PV for the block storage device, and create a PVC for that volume. The requested block volume uses the ReadWriteOnce (RWO) access mode.
  - Create a **pvc.yaml** file with the following contents to define a VMware vSphere **PersistentVolumeClaim** object:

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: image-registry-storage 1
  namespace: openshift-image-registry 2
spec:
  accessModes:
  - ReadWriteOnce 3
  resources:
    requests:
      storage: 100Gi 4
```

- A unique name that represents the **PersistentVolumeClaim** object.
- The namespace for the **PersistentVolumeClaim** object, which is **openshift-image-registry**.
- The access mode of the persistent volume claim. With **ReadWriteOnce**, the volume can be mounted with read and write permissions by a single node.
- The size of the persistent volume claim.

- Create the **PersistentVolumeClaim** object from the file:

```
$ oc create -f pvc.yaml -n openshift-image-registry
```

- Edit the registry configuration so that it references the correct PVC:

```
$ oc edit config.imageregistry.operator.openshift.io -o yaml
```

## Example output

```
storage:
  pvc:
    claim: ❶
```

- ❶ Creating a custom PVC allows you to leave the **claim** field blank for the default automatic creation of an **image-registry-storage** PVC.

For instructions about configuring registry storage so that it references the correct PVC, see [Configuring the registry for vSphere](#).

### 17.4.17. Backing up VMware vSphere volumes

OpenShift Container Platform provisions new volumes as independent persistent disks to freely attach and detach the volume on any node in the cluster. As a consequence, it is not possible to back up volumes that use snapshots, or to restore volumes from snapshots. See [Snapshot Limitations](#) for more information.

#### Procedure

To create a backup of persistent volumes:

1. Stop the application that is using the persistent volume.
2. Clone the persistent volume.
3. Restart the application.
4. Create a backup of the cloned volume.
5. Delete the cloned volume.

### 17.4.18. Steal clock accounting

By default, the installation program provisions the cluster's virtual machines without enabling the steal clock accounting parameter (**stealclock.enabled**). Enabling steal clock accounting can help with troubleshooting cluster issues. After the cluster is deployed, use the vSphere Client to enable this parameter on each of the virtual machines.

For more information, see this [Red Hat knowledge base article](#).

### 17.4.19. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

#### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

### 17.4.20. Next steps

- [Customize your cluster.](#)
- If necessary, you can [opt out of remote health reporting](#) .
- [Set up your registry and configure registry storage](#) .
- Optional: [View the events from the vSphere Problem Detector Operator](#) to determine if the cluster has permission or storage configuration issues.

## 17.5. INSTALLING A CLUSTER ON VSPHERE WITH USER-PROVISIONED INFRASTRUCTURE

In OpenShift Container Platform version 4.9, you can install a cluster on VMware vSphere infrastructure that you provision.



### NOTE

OpenShift Container Platform supports deploying a cluster to a single VMware vCenter only. Deploying a cluster with machines/machine sets on multiple vCenters is not supported.

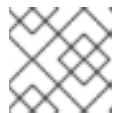


### IMPORTANT

The steps for performing a user-provisioned infrastructure installation are provided as an example only. Installing a cluster with infrastructure you provide requires knowledge of the vSphere platform and the installation process of OpenShift Container Platform. Use the user-provisioned infrastructure installation instructions as a guide; you are free to create the required resources through other methods.

### 17.5.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You provisioned [persistent storage](#) for your cluster. To deploy a private image registry, your storage must provide **ReadWriteMany** access modes.
- Completing the installation requires that you upload the Red Hat Enterprise Linux CoreOS (RHCOS) OVA on vSphere hosts. The machine from which you complete this process requires access to port 443 on the vCenter and ESXi hosts. You verified that port 443 is accessible.
- If you use a firewall, you confirmed with the administrator that port 443 is accessible. Control plane nodes must be able to reach vCenter and ESXi hosts on port 443 for the installation to succeed.
- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.

**NOTE**

Be sure to also review this site list if you are configuring a proxy.

**17.5.2. Internet access for OpenShift Container Platform**

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

**IMPORTANT**

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

**17.5.3. VMware vSphere infrastructure requirements**

You must install the OpenShift Container Platform cluster on a VMware vSphere version 6 or 7 instance that meets the requirements for the components that you use.

**Table 17.37. Version requirements for vSphere virtual environments**

Virtual environment product	Required version
VM hardware version	13 or later
vSphere ESXi hosts	6.5 or later
vCenter host	6.5 or later

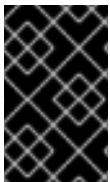
**IMPORTANT**

Installing a cluster on VMware vSphere version 6.7U2 or earlier and virtual hardware version 13 is now deprecated. These versions are still fully supported, but support will be removed in a future version of OpenShift Container Platform. Hardware version 15 is now the default for vSphere virtual machines in OpenShift Container Platform. To update the hardware version for your vSphere nodes, see the "Updating hardware on nodes running in vSphere" article.

**Table 17.38. Minimum supported vSphere version for VMware components**

Component	Minimum supported versions	Description
Hypervisor	vSphere 6.5 and later with HW version 13	This version is the minimum version that Red Hat Enterprise Linux CoreOS (RHCOS) supports. See the <a href="#">Red Hat Enterprise Linux 8 supported hypervisors list</a> .
Storage with in-tree drivers	vSphere 6.5 and later	This plugin creates vSphere storage by using the in-tree storage drivers for vSphere included in OpenShift Container Platform.
Optional: Networking (NSX-T)	vSphere 6.5U3 or vSphere 6.7U2 and later	vSphere 6.5U3 or vSphere 6.7U2+ are required for OpenShift Container Platform. For more information about the compatibility of NSX and OpenShift Container Platform, see the Release Notes section of VMware's <a href="#">NSX container plugin documentation</a> .

If you use a vSphere version 6.5 instance, consider upgrading to 6.7U3 or 7.0 before you install OpenShift Container Platform.



### IMPORTANT

You must ensure that the time on your ESXi hosts is synchronized before you install OpenShift Container Platform. See [Edit Time Configuration for a Host](#) in the VMware documentation.

#### Additional resources

- To update the hardware version for your vSphere nodes, see [Updating hardware on nodes running in vSphere](#).

## 17.5.4. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

### 17.5.4.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

**Table 17.39. Minimum required hosts**



Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.

**IMPORTANT**

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 7.9, or RHEL 8.4.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See [Red Hat Enterprise Linux technology capabilities and limits](#) .

**IMPORTANT**

All virtual machines must reside in the same datastore and in the same folder as the installer.

#### 17.5.4.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

**Table 17.40. Minimum resource requirements**

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 7.9, or RHEL 8.4 [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio:  $(\text{threads per core} \times \text{cores}) \times \text{sockets} = \text{vCPUs}$ .
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.

### 17.5.4.3. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

### 17.5.4.4. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.

It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.



#### NOTE

If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

#### 17.5.4.4.1. Setting the cluster node hostnames through DHCP

On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

#### 17.5.4.4.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.



### IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

**Table 17.41. Ports used for all-machine to all-machine communications**

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	<b>1936</b>	Metrics
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> and the Cluster Version Operator on port <b>9099</b> .
	<b>10250-10259</b>	The default ports that Kubernetes reserves
	<b>10256</b>	openshift-sdn
UDP	<b>4789</b>	VXLAN and Geneve
	<b>6081</b>	VXLAN and Geneve
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> .
	<b>500</b>	IPsec IKE packets
	<b>4500</b>	IPsec NAT-T packets

Protocol	Port	Description
TCP/UDP	<b>30000-32767</b>	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 17.42. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	<b>6443</b>	Kubernetes API

Table 17.43. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	<b>2379-2380</b>	etcd server and peer ports

### Ethernet adaptor hardware address requirements

When provisioning VMs for the cluster, the ethernet interfaces configured for each VM must use a MAC address from the VMware Organizationally Unique Identifier (OUI) allocation ranges:

- **00:05:69:00:00:00 to 00:05:69:FF:FF:FF**
- **00:0c:29:00:00:00 to 00:0c:29:FF:FF:FF**
- **00:1c:14:00:00:00 to 00:1c:14:FF:FF:FF**
- **00:50:56:00:00:00 to 00:50:56:FF:FF:FF**

If a MAC address outside the VMware OUI is used, the cluster installation will not succeed.

### NTP configuration for user-provisioned infrastructure

OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service*.

If a DHCP server provides NTP server information, the chrony time service on the Red Hat Enterprise Linux CoreOS (RHCOS) machines read the information and can sync the clock with the NTP servers.

### Additional resources

- [Configuring chrony time service](#)

### 17.5.4.5. User-provisioned DNS requirements

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API

- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines

Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.



#### NOTE

It is recommended to use a DHCP server to provide the hostnames to each cluster node. See the *DHCP recommendations for user-provisioned infrastructure* section for more information.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, **<cluster\_name>** is the cluster name and **<base\_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster\_name>.<base\_domain>..**

Table 17.44. Required DNS records

Component	Record	Description
Kubernetes API	<b>api.&lt;cluster_name&gt;.&lt;base_domain&gt;..</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
	<b>api-int.&lt;cluster_name&gt;.&lt;base_domain&gt;..</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster.

#### IMPORTANT

The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.

Component	Record	Description
Routes	<b>*.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.  For example, <b>console-openshift-console.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;</b> is used as a wildcard route to the OpenShift Container Platform console.
Bootstrap machine	<b>bootstrap.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.
Control plane machines	<b>&lt;master&gt;&lt;n&gt;.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.
Compute machines	<b>&lt;worker&gt;&lt;n&gt;.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.



## NOTE

In OpenShift Container Platform 4.4 and later, you do not need to specify etcd host and SRV records in your DNS configuration.

## TIP

You can use the **dig** command to verify name and reverse name resolution. See the section on *Validating DNS resolution for user-provisioned infrastructure* for detailed validation steps.

### 17.5.4.5.1. Example DNS configuration for user-provisioned clusters

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is **ocp4** and the base domain is **example.com**.

#### Example DNS A record configuration for a user-provisioned cluster

The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

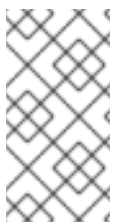
#### Example 17.10. Sample DNS zone database

```

$TTL 1W
@ IN SOA ns1.example.com. root (
    2019070700 ; serial
    3H ; refresh (3 hours)
    30M ; retry (30 minutes)
    2W ; expiry (2 weeks)
    1W ) ; minimum (1 week)
IN NS ns1.example.com.
IN MX 10 smtp.example.com.
;
;
ns1.example.com. IN A 192.168.1.5
smtp.example.com. IN A 192.168.1.5
;
helper.example.com. IN A 192.168.1.5
helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com. IN A 192.168.1.5 1
api-int.ocp4.example.com. IN A 192.168.1.5 2
;
*.apps.ocp4.example.com. IN A 192.168.1.5 3
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 4
;
master0.ocp4.example.com. IN A 192.168.1.97 5
master1.ocp4.example.com. IN A 192.168.1.98 6
master2.ocp4.example.com. IN A 192.168.1.99 7
;
worker0.ocp4.example.com. IN A 192.168.1.11 8
worker1.ocp4.example.com. IN A 192.168.1.7 9
;
;EOF

```

- 1 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.
- 2 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.
- 3 Provides name resolution for the wildcard routes. The record refers to the IP address of the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



#### NOTE

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

- 4 Provides name resolution for the bootstrap machine.
- 5 6 7 Provides name resolution for the control plane machines.

**8 9** Provides name resolution for the compute machines.

### Example DNS PTR record configuration for a user-provisioned cluster

The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

#### Example 17.11. Sample DNS zone database for reverse records

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H ; refresh (3 hours)
  30M ; retry (30 minutes)
  2W ; expiry (2 weeks)
  1W ) ; minimum (1 week)
IN NS ns1.example.com.
;
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. 2
;
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. 3
;
97.1.168.192.in-addr.arpa. IN PTR master0.ocp4.example.com. 4
98.1.168.192.in-addr.arpa. IN PTR master1.ocp4.example.com. 5
99.1.168.192.in-addr.arpa. IN PTR master2.ocp4.example.com. 6
;
11.1.168.192.in-addr.arpa. IN PTR worker0.ocp4.example.com. 7
7.1.168.192.in-addr.arpa. IN PTR worker1.ocp4.example.com. 8
;
;EOF
```

- 1** Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.
- 2** Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.
- 3** Provides reverse DNS resolution for the bootstrap machine.
- 4 5 6** Provides reverse DNS resolution for the control plane machines.
- 7 8** Provides reverse DNS resolution for the compute machines.



#### NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard.

### 17.5.4.6. Load balancing requirements for user-provisioned infrastructure



Before you install OpenShift Container Platform, you must provision the API and application ingress load balancing infrastructure. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.



## NOTE

If you want to deploy the API and application ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer.** Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:
  - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the API routes.
  - A stateless load balancing algorithm. The options vary based on the load balancer implementation.



## NOTE

Session persistence is not required for the API load balancer to function properly.

Configure the following ports on both the front and back of the load balancers:

**Table 17.45. API load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
<b>6443</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the <b>/readyz</b> endpoint for the API server health check probe.	X	X	Kubernetes API server
<b>22623</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server



## NOTE

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the **/readyz** endpoint to the removal of the API server instance from the pool. Within the time frame after **/readyz** returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application ingress load balancer.** Provides an ingress point for application traffic flowing in from outside the cluster. Configure the following conditions:
  - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the ingress routes.
  - A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

### TIP

If the true IP address of the client can be seen by the application ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

Configure the following ports on both the front and back of the load balancers:

**Table 17.46. Application ingress load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
<b>443</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic
<b>80</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic
<b>1936</b>	The worker nodes that run the Ingress Controller pods, by default. You must configure the <b>/healthz/ready</b> endpoint for the ingress health check probe.	X	X	HTTP traffic



### NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.



### NOTE

A working configuration for the Ingress router is required for an OpenShift Container Platform cluster. You must configure the Ingress router after the control plane initializes.

#### 17.5.4.6.1. Example load balancer configuration for user-provisioned clusters

This section provides an example API and application ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an **/etc/haproxy/haproxy.cfg** configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing

one load balancing solution over another.



## NOTE

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

### Example 17.12. Sample API and application ingress load balancer configuration

```

global
log      127.0.0.1 local2
pidfile  /var/run/haproxy.pid
maxconn  4000
daemon

defaults
mode            http
log             global
option          dontlognull
option http-server-close
option          redispatch
retries        3
timeout http-request 10s
timeout queue    1m
timeout connect  10s
timeout client   1m
timeout server   1m
timeout http-keep-alive 10s
timeout check    10s
maxconn        3000

frontend stats
bind *:1936
mode            http
log             global
maxconn 10
stats enable
stats hide-version
stats refresh 30s
stats show-node
stats show-desc Stats for ocp4 cluster 1
stats auth admin:ocp4
stats uri /stats

listen api-server-6443 2
bind *:6443
mode tcp
server bootstrap bootstrap.ocp4.example.com:6443 check inter 1s backup 3
server master0 master0.ocp4.example.com:6443 check inter 1s
server master1 master1.ocp4.example.com:6443 check inter 1s
server master2 master2.ocp4.example.com:6443 check inter 1s

listen machine-config-server-22623 4
bind *:22623
mode tcp
server bootstrap bootstrap.ocp4.example.com:22623 check inter 1s backup 5

```

```

server master0 master0.ocp4.example.com:22623 check inter 1s
server master1 master1.ocp4.example.com:22623 check inter 1s
server master2 master2.ocp4.example.com:22623 check inter 1s
listen ingress-router-443 6
bind *:443
mode tcp
balance source
server worker0 worker0.ocp4.example.com:443 check inter 1s
server worker1 worker1.ocp4.example.com:443 check inter 1s
listen ingress-router-80 7
bind *:80
mode tcp
balance source
server worker0 worker0.ocp4.example.com:80 check inter 1s
server worker1 worker1.ocp4.example.com:80 check inter 1s

```

- 1** In the example, the cluster name is **ocp4**.
- 2** Port **6443** handles the Kubernetes API traffic and points to the control plane machines.
- 3** **5** The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.
- 4** Port **22623** handles the machine config server traffic and points to the control plane machines.
- 6** Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.
- 7** Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



#### NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

#### TIP

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltp** on the HAProxy node.



#### NOTE

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running **setsebool -P haproxy\_connect\_any=1**.

### 17.5.5. Preparing the user-provisioned infrastructure

Before you install OpenShift Container Platform on user-provisioned infrastructure, you must prepare the underlying infrastructure.

This section provides details about the high-level steps required to set up your cluster infrastructure in preparation for an OpenShift Container Platform installation. This includes configuring IP networking and network connectivity for your cluster nodes, enabling the required ports through your firewall, and setting up the required DNS and load balancing infrastructure.

After preparation, your cluster infrastructure must meet the requirements outlined in the *Requirements for a cluster with user-provisioned infrastructure* section.

## Prerequisites

- You have reviewed the [OpenShift Container Platform 4.x Tested Integrations](#) page.
- You have reviewed the infrastructure requirements detailed in the *Requirements for a cluster with user-provisioned infrastructure* section.

## Procedure

1. If you are using DHCP to provide the IP networking configuration to your cluster nodes, configure your DHCP service.
  - a. Add persistent IP addresses for the nodes to your DHCP server configuration. In your configuration, match the MAC address of the relevant network interface to the intended IP address for each node.
  - b. When you use DHCP to configure IP addressing for the cluster machines, the machines also obtain the DNS server information through DHCP. Define the persistent DNS server address that is used by the cluster nodes through your DHCP server configuration.



### NOTE

If you are not using a DHCP service, you must provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

- c. Define the hostnames of your cluster nodes in your DHCP server configuration. See the *Setting the cluster node hostnames through DHCP* section for details about hostname considerations.



### NOTE

If you are not using a DHCP service, the cluster nodes obtain their hostname through a reverse DNS lookup.

2. Ensure that your network infrastructure provides the required network connectivity between the cluster components. See the *Networking requirements for user-provisioned infrastructure* section for details about the requirements.

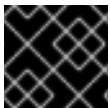
3. Configure your firewall to enable the ports required for the OpenShift Container Platform cluster components to communicate. See *Networking requirements for user-provisioned infrastructure* section for details about the ports that are required.
4. Setup the required DNS infrastructure for your cluster.
  - a. Configure DNS name resolution for the Kubernetes API, the application wildcard, the bootstrap machine, the control plane machines, and the compute machines.
  - b. Configure reverse DNS resolution for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.  
See the *User-provisioned DNS requirements* section for more information about the OpenShift Container Platform DNS requirements.
5. Validate your DNS configuration.
  - a. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses in the responses correspond to the correct components.
  - b. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names in the responses correspond to the correct components.  
See the *Validating DNS resolution for user-provisioned infrastructure* section for detailed DNS validation steps.
6. Provision the required API and application ingress load balancing infrastructure. See the *Load balancing requirements for user-provisioned infrastructure* section for more information about the requirements.

**NOTE**

Some load balancing solutions require the DNS name resolution for the cluster nodes to be in place before the load balancing is initialized.

### 17.5.6. Validating DNS resolution for user-provisioned infrastructure

You can validate your DNS configuration before installing OpenShift Container Platform on user-provisioned infrastructure.

**IMPORTANT**

The validation steps detailed in this section must succeed before you install your cluster.

**Prerequisites**

- You have configured the required DNS records for your user-provisioned infrastructure.

**Procedure**

1. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses contained in the responses correspond to the correct components.
  - a. Perform a lookup against the Kubernetes API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api.<cluster_name>.<base_domain> 1
```

- 1 Replace **<nameserver\_ip>** with the IP address of the nameserver, **<cluster\_name>** with your cluster name, and **<base\_domain>** with your base domain name.

### Example output

```
api.ocp4.example.com. 0 IN A 192.168.1.5
```

- b. Perform a lookup against the Kubernetes internal API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api-int.<cluster_name>.<base_domain>
```

### Example output

```
api-int.ocp4.example.com. 0 IN A 192.168.1.5
```

- c. Test an example **\*.apps.<cluster\_name>.<base\_domain>** DNS wildcard lookup. All of the application wildcard lookups must resolve to the IP address of the application ingress load balancer:

```
$ dig +noall +answer @<nameserver_ip> random.apps.<cluster_name>.<base_domain>
```

### Example output

```
random.apps.ocp4.example.com. 0 IN A 192.168.1.5
```



### NOTE

In the example outputs, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

You can replace **random** with another wildcard value. For example, you can query the route to the OpenShift Container Platform console:

```
$ dig +noall +answer @<nameserver_ip> console-openshift-console.apps.<cluster_name>.<base_domain>
```

### Example output

```
console-openshift-console.apps.ocp4.example.com. 0 IN A 192.168.1.5
```

- d. Run a lookup against the bootstrap DNS record name. Check that the result points to the IP address of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> bootstrap.<cluster_name>.<base_domain>
```

### Example output

```
bootstrap.ocp4.example.com. 0 IN A 192.168.1.96
```

- e. Use this method to perform lookups against the DNS record names for the control plane and compute nodes. Check that the results correspond to the IP addresses of each node.
2. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names contained in the responses correspond to the correct components.
    - a. Perform a reverse lookup against the IP address of the API load balancer. Check that the response includes the record names for the Kubernetes API and the Kubernetes internal API:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.5
```

### Example output

```
5.1.168.192.in-addr.arpa. 0 IN PTR api-int.ocp4.example.com. 1  
5.1.168.192.in-addr.arpa. 0 IN PTR api.ocp4.example.com. 2
```

- 1** Provides the record name for the Kubernetes internal API.
- 2** Provides the record name for the Kubernetes API.



### NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard. No validation step is needed for reverse DNS resolution against the IP address of the application ingress load balancer.

- b. Perform a reverse lookup against the IP address of the bootstrap node. Check that the result points to the DNS record name of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.96
```

### Example output

```
96.1.168.192.in-addr.arpa. 0 IN PTR bootstrap.ocp4.example.com.
```

- c. Use this method to perform reverse lookups against the IP addresses for the control plane and compute nodes. Check that the results correspond to the DNS record names of each node.

## 17.5.7. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added



to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.



### IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



### NOTE

You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

## Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.



### NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.

**NOTE**

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

**Example output**

```
Agent pid 31874
```

**NOTE**

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1** Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

**Example output**

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

**Next steps**

- When you install OpenShift Container Platform, provide the SSH public key to the installation program. If you install a cluster on infrastructure that you provision, you must provide the key to the installation program.

**17.5.8. Obtaining the installation program**

Before you install OpenShift Container Platform, download the installation file on a local computer.

**Prerequisites**

- You have a computer that runs Linux or macOS, with 500 MB of local disk space

**Procedure**

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.

3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



### IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



### IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#) . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

## 17.5.9. Manually creating the installation configuration file

For user-provisioned installations of OpenShift Container Platform, you manually generate your installation configuration file.

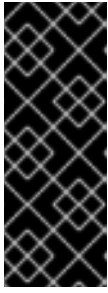
### Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

### Procedure

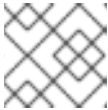
1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```

**IMPORTANT**

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation\_directory>**.

**NOTE**

You must name this configuration file **install-config.yaml**.

**NOTE**

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation\_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

**IMPORTANT**

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

**17.5.9.1. Sample install-config.yaml file for VMware vSphere**

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```

apiVersion: v1
baseDomain: example.com 1
compute:
- hyperthreading: Enabled 2 3
  name: worker
  replicas: 0 4
controlPlane:
  hyperthreading: Enabled 5 6
  name: master
  replicas: 3 7
metadata:
  name: test 8
platform:
  vsphere:
    vcenter: your.vcenter.server 9
    username: username 10
    password: password 11
    datacenter: datacenter 12

```

```

defaultDatastore: datastore 13
folder: "/<datacenter_name>/vm/<folder_name>/<subfolder_name>" 14
fips: false 15
pullSecret: '{"auths": ...}' 16
sshKey: 'ssh-ed25519 AAAA...' 17

```

- 1** The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.
- 2** **5** The **controlPlane** section is a single mapping, but the compute section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. Although both sections currently define a single machine pool, it is possible that future versions of OpenShift Container Platform will support defining multiple compute pools during installation. Only one control plane pool is used.
- 3** **6** Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.



### IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Your machines must use at least 8 CPUs and 32 GB of RAM if you disable simultaneous multithreading.

- 4** You must set the value of the **replicas** parameter to **0**. This parameter controls the number of workers that the cluster creates and manages for you, which are functions that the cluster does not perform when you use user-provisioned infrastructure. You must manually deploy worker machines for the cluster to use before you finish installing OpenShift Container Platform.
- 7** The number of control plane machines that you add to the cluster. Because the cluster uses this values as the number of etcd endpoints in the cluster, the value must match the number of control plane machines that you deploy.
- 8** The cluster name that you specified in your DNS records.
- 9** The fully-qualified hostname or IP address of the vCenter server.
- 10** The name of the user for accessing the server. This user must have at least the roles and privileges that are required for [static or dynamic persistent volume provisioning](#) in vSphere.
- 11** The password associated with the vSphere user.
- 12** The vSphere datacenter.
- 13** The default vSphere datastore to use.
- 14** Optional: For installer-provisioned infrastructure, the absolute path of an existing folder where the installation program creates the virtual machines, for example, `/<datacenter_name>/vm/<folder_name>/<subfolder_name>`. If you do not provide this value, the installation program creates a top-level folder in the datacenter virtual machine folder that is named with the infrastructure ID. If you are providing the infrastructure for the cluster, omit this parameter.

- 15 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container



### IMPORTANT

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

- 16 The pull secret that you obtained from [OpenShift Cluster Manager](#). This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.
- 17 The public portion of the default SSH key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).

### 17.5.9.2. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

#### Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



### NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

#### Procedure

- Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
  additionalTrustBundle: | 4
```

```
-----BEGIN CERTIFICATE-----
<MY_TRUSTED_CA_CERT>
-----END CERTIFICATE-----
```

...

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations. You must include vCenter's IP address and the IP range that you use for its machines.
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.



#### NOTE

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



#### NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

### 17.5.10. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.



## IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

## Prerequisites

- You obtained the OpenShift Container Platform installation program.
- You created the **install-config.yaml** installation configuration file.

## Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

- 1 For **<installation\_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

2. Remove the Kubernetes manifest files that define the control plane machines and compute machine sets:

```
$ rm -f openshift/99_openshift-cluster-api_master-machines-*.yaml openshift/99_openshift-cluster-api_worker-machineset-*.yaml
```

Because you create and manage these resources yourself, you do not have to initialize them.

- You can preserve the machine set files to create compute machines by using the machine API, but you must update references to them to match your environment.
3. Check that the **mastersSchedulable** parameter in the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:
    - a. Open the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** file.
    - b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.
    - c. Save and exit the file.

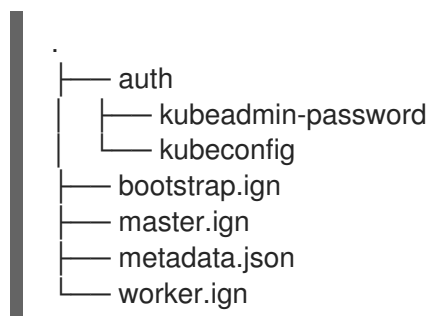


- To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

- For **<installation\_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation\_directory>/auth** directory:



### 17.5.11. Extracting the infrastructure name

The Ignition config files contain a unique cluster identifier that you can use to uniquely identify your cluster in VMware vSphere. If you plan to use the cluster identifier as the name of your virtual machine folder, you must extract it.

#### Prerequisites

- You obtained the OpenShift Container Platform installation program and the pull secret for your cluster.
- You generated the Ignition config files for your cluster.
- You installed the **jq** package.

#### Procedure

- To extract and view the infrastructure name from the Ignition config file metadata, run the following command:

```
$ jq -r .infraID <installation_directory>/metadata.json 1
```

- For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

#### Example output

```
openshift-vw9j6 1
```

- The output of this command is your cluster name and a random string.

## 17.5.12. Installing RHCOS and starting the OpenShift Container Platform bootstrap process

To install OpenShift Container Platform on user-provisioned infrastructure on VMware vSphere, you must install Red Hat Enterprise Linux CoreOS (RHCOS) on vSphere hosts. When you install RHCOS, you must provide the Ignition config file that was generated by the OpenShift Container Platform installation program for the type of machine you are installing. If you have configured suitable networking, DNS, and load balancing infrastructure, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS machines have rebooted.

### Prerequisites

- You have obtained the Ignition config files for your cluster.
- You have access to an HTTP server that you can access from your computer and that the machines that you create can access.
- You have created a [vSphere cluster](#).

### Procedure

1. Upload the bootstrap Ignition config file, which is named **<installation\_directory>/bootstrap.ign**, that the installation program created to your HTTP server. Note the URL of this file.
2. Save the following secondary Ignition config file for your bootstrap node to your computer as **<installation\_directory>/merge-bootstrap.ign**:

```
{
  "ignition": {
    "config": {
      "merge": [
        {
          "source": "<bootstrap_ignition_config_url>", 1
          "verification": {}
        }
      ]
    },
    "timeouts": {},
    "version": "3.2.0"
  },
  "networkd": {},
  "passwd": {},
  "storage": {},
  "systemd": {}
}
```

- 1** Specify the URL of the bootstrap Ignition config file that you hosted.

When you create the virtual machine (VM) for the bootstrap machine, you use this Ignition config file.

3. Locate the following Ignition config files that the installation program created:
  - **<installation\_directory>/master.ign**

- `<installation_directory>/worker.ign`
  - `<installation_directory>/merge-bootstrap.ign`
4. Convert the Ignition config files to Base64 encoding. Later in this procedure, you must add these files to the extra configuration parameter **guestinfo.ignition.config.data** in your VM. For example, if you use a Linux operating system, you can use the **base64** command to encode the files.

```
$ base64 -w0 <installation_directory>/master.ign > <installation_directory>/master.64
```

```
$ base64 -w0 <installation_directory>/worker.ign > <installation_directory>/worker.64
```

```
$ base64 -w0 <installation_directory>/merge-bootstrap.ign > <installation_directory>/merge-bootstrap.64
```



### IMPORTANT

If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

5. Obtain the RHCOS OVA image. Images are available from the [RHCOS image mirror](#) page.



### IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download an image with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image version that matches your OpenShift Container Platform version if it is available.

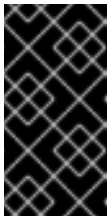
The filename contains the OpenShift Container Platform version number in the format **rhcos-vmware.<architecture>.ova**.

6. In the vSphere Client, create a folder in your datacenter to store your VMs.
- a. Click the **VMs and Templates** view.
  - b. Right-click the name of your datacenter.
  - c. Click **New Folder → New VM and Template Folder**.
  - d. In the window that is displayed, enter the folder name. If you did not specify an existing folder in the **install-config.yaml** file, then create a folder with the same name as the infrastructure ID. You use this folder name so vCenter dynamically provisions storage in the appropriate location for its Workspace configuration.
7. In the vSphere Client, create a template for the OVA image and then clone the template as needed.

**NOTE**

In the following steps, you create a template and then clone the template for all of your cluster machines. You then provide the location for the Ignition config file for that cloned machine type when you provision the VMs.

- a. From the **Hosts and Clusters** tab, right-click your cluster name and select **Deploy OVF Template**.
- b. On the **Select an OVF** tab, specify the name of the RHCOS OVA file that you downloaded.
- c. On the **Select a name and folder** tab, set a **Virtual machine name** for your template, such as **Template-RHCOS**. Click the name of your vSphere cluster and select the folder you created in the previous step.
- d. On the **Select a compute resource** tab, click the name of your vSphere cluster.
- e. On the **Select storage** tab, configure the storage options for your VM.
  - Select **Thin Provision** or **Thick Provision**, based on your storage preferences.
  - Select the datastore that you specified in your **install-config.yaml** file.
- f. On the **Select network** tab, specify the network that you configured for the cluster, if available.
- g. When creating the OVF template, do not specify values on the **Customize template** tab or configure the template any further.

**IMPORTANT**

Do not start the original VM template. The VM template must remain off and must be cloned for new RHCOS machines. Starting the VM template configures the VM template as a VM on the platform, which prevents it from being used as a template that machine sets can apply configurations to.

8. Optional: Update the configured virtual hardware version in the VM template, if necessary. Follow [Upgrading a virtual machine to the latest hardware version](#) in the VMware documentation for more information.

**IMPORTANT**

It is recommended that you update the hardware version of the VM template to version 15 before creating VMs from it, if necessary. Using hardware version 13 for your cluster nodes running on vSphere is now deprecated. If your imported template defaults to hardware version 13, you must ensure that your ESXi host is on 6.7U3 or later before upgrading the VM template to hardware version 15. If your vSphere version is less than 6.7U3, you can skip this upgrade step; however, a future version of OpenShift Container Platform is scheduled to remove support for hardware version 13 and vSphere versions less than 6.7U3.

9. After the template deploys, deploy a VM for a machine in the cluster.
  - a. Right-click the template name and click **Clone** → **Clone to Virtual Machine**

- b. On the **Select a name and folder** tab, specify a name for the VM. You might include the machine type in the name, such as **control-plane-0** or **compute-1**.
- c. On the **Select a name and folder** tab, select the name of the folder that you created for the cluster.
- d. On the **Select a compute resource** tab, select the name of a host in your datacenter.
- e. Optional: On the **Select storage** tab, customize the storage options.
- f. On the **Select clone options**, select **Customize this virtual machine's hardware**.
- g. On the **Customize hardware** tab, click **VM Options** → **Advanced**.
  - Optional: Override default DHCP networking in vSphere. To enable static IP networking:

- i. Set your static IP configuration:

```
$ export IPCFG="ip=<ip>::<gateway>:<netmask>:<hostname>:<iface>:none
nameserver=svr1 [nameserver=svr2 [nameserver=svr3 [...]]]"
```

#### Example command

```
$ export IPCFG="ip=192.168.100.101::192.168.100.254:255.255.255.0::none
nameserver=8.8.8.8"
```

- ii. Set the **guestinfo.afterburn.initrd.network-kargs** property before booting a VM from an OVA in vSphere:

```
$ govc vm.change -vm "<vm_name>" -e "guestinfo.afterburn.initrd.network-
kargs=${IPCFG}"
```

- Optional: In the event of cluster performance issues, from the **Latency Sensitivity** list, select **High**. Ensure that your VM's CPU and memory reservation have the following values:
  - Memory reservation value must be equal to its configured memory size.
  - CPU reservation value must be at least the number of low latency virtual CPUs multiplied by the measured physical CPU speed.
- Click **Edit Configuration**, and on the **Configuration Parameters** window, search the list of available parameters for steal clock accounting (**stealclock.enable**). If it is available, set its value to **TRUE**. Enabling steal clock accounting can help with troubleshooting cluster issues.
- Click **Add Configuration Params**. Define the following parameter names and values:
  - **guestinfo.ignition.config.data**: Locate the base-64 encoded files that you created previously in this procedure, and paste the contents of the base64-encoded Ignition config file for this machine type.
  - **guestinfo.ignition.config.data.encoding**: Specify **base64**.
  - **disk.EnableUUID**: Specify **TRUE**.

- **stealclock.enable**: If this parameter was not defined, add it and specify **TRUE**.
- h. In the **Virtual Hardware** panel of the **Customize hardware** tab, modify the specified values as required. Ensure that the amount of RAM, CPU, and disk storage meets the minimum requirements for the machine type.
  - i. Complete the configuration and power on the VM.
10. Create the rest of the machines for your cluster by following the preceding steps for each machine.



### IMPORTANT

You must create the bootstrap and control plane machines at this time. Because some pods are deployed on compute machines by default, also create at least two compute machines before you install the cluster.

## 17.5.13. Adding more compute machines to a cluster in vSphere

You can add more compute machines to a user-provisioned OpenShift Container Platform cluster on VMware vSphere.

### Prerequisites

- Obtain the base64-encoded Ignition file for your compute machines.
- You have access to the vSphere template that you created for your cluster.

### Procedure

1. After the template deploys, deploy a VM for a machine in the cluster.
  - a. Right-click the template's name and click **Clone → Clone to Virtual Machine**
  - b. On the **Select a name and folder** tab, specify a name for the VM. You might include the machine type in the name, such as **compute-1**.
  - c. On the **Select a name and folder** tab, select the name of the folder that you created for the cluster.
  - d. On the **Select a compute resource** tab, select the name of a host in your datacenter.
  - e. Optional: On the **Select storage** tab, customize the storage options.
  - f. On the **Select clone options**, select **Customize this virtual machine's hardware**
  - g. On the **Customize hardware** tab, click **VM Options → Advanced**.
    - From the **Latency Sensitivity** list, select **High**.
    - Click **Edit Configuration**, and on the **Configuration Parameters** window, click **Add Configuration Params**. Define the following parameter names and values:
      - **guestinfo.ignition.config.data**: Paste the contents of the base64-encoded compute Ignition config file for this machine type.

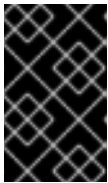
- **guestinfo.ignition.config.data.encoding**: Specify **base64**.
  - **disk.EnableUUID**: Specify **TRUE**.
- h. In the **Virtual Hardware** panel of the **Customize hardware** tab, modify the specified values as required. Ensure that the amount of RAM, CPU, and disk storage meets the minimum requirements for the machine type. Also, make sure to select the correct network under **Add network adapter** if there are multiple networks available.
  - i. Complete the configuration and power on the VM.
2. Continue to create more compute machines for your cluster.

### 17.5.14. Disk partitioning

In most cases, data partitions are originally created by installing RHCOS, rather than by installing another operating system. In such cases, the OpenShift Container Platform installer should be allowed to configure your disk partitions.

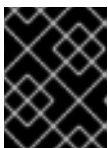
However, there are two cases where you might want to intervene to override the default partitioning when installing an OpenShift Container Platform node:

- **Create separate partitions**: For greenfield installations on an empty disk, you might want to add separate storage to a partition. This is officially supported for making **/var** or a subdirectory of **/var**, such as **/var/lib/etcd**, a separate partition, but not both.



#### IMPORTANT

For disk sizes larger than 100GB, and especially disk sizes larger than 1TB, create a separate **/var** partition. See "Creating a separate **/var** partition" and this [Red Hat Knowledgebase article](#) for more information.



#### IMPORTANT

Kubernetes supports only two file system partitions. If you add more than one partition to the original configuration, Kubernetes cannot monitor all of them.

- **Retain existing partitions**: For a brownfield installation where you are reinstalling OpenShift Container Platform on an existing node and want to retain data partitions installed from your previous operating system, there are both boot arguments and options to **coreos-installer** that allow you to retain existing data partitions.

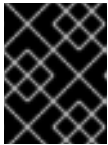
### Creating a separate **/var** partition

In general, disk partitioning for OpenShift Container Platform should be left to the installer. However, there are cases where you might want to create separate partitions in a part of the filesystem that you expect to grow.

OpenShift Container Platform supports the addition of a single partition to attach storage to either the **/var** partition or a subdirectory of **/var**. For example:

- **/var/lib/containers**: Holds container-related content that can grow as more images and containers are added to a system.
- **/var/lib/etcd**: Holds data that you might want to keep separate for purposes such as performance optimization of etcd storage.

- **/var**: Holds data that you might want to keep separate for purposes such as auditing.



## IMPORTANT

For disk sizes larger than 100GB, and especially larger than 1TB, create a separate **/var** partition.

Storing the contents of a **/var** directory separately makes it easier to grow storage for those areas as needed and reinstall OpenShift Container Platform at a later date and keep that data intact. With this method, you will not have to pull all your containers again, nor will you have to copy massive log files when you update systems.

Because **/var** must be in place before a fresh installation of Red Hat Enterprise Linux CoreOS (RHCOS), the following procedure sets up the separate **/var** partition by creating a machine config manifest that is inserted during the **openshift-install** preparation phases of an OpenShift Container Platform installation.

### Procedure

1. Create a directory to hold the OpenShift Container Platform installation files:

```
$ mkdir $HOME/clusterconfig
```

2. Run **openshift-install** to create a set of files in the **manifest** and **openshift** subdirectories. Answer the system questions as you are prompted:

```
$ openshift-install create manifests --dir $HOME/clusterconfig
? SSH Public Key ...
$ ls $HOME/clusterconfig/openshift/
99_kubeadmin-password-secret.yaml
99_openshift-cluster-api_master-machines-0.yaml
99_openshift-cluster-api_master-machines-1.yaml
99_openshift-cluster-api_master-machines-2.yaml
...
```

3. Create a Butane config that configures the additional partition. For example, name the file **\$HOME/clusterconfig/98-var-partition.bu**, change the disk device name to the name of the storage device on the **worker** systems, and set the storage size as appropriate. This example places the **/var** directory on a separate partition:

```
variant: openshift
version: 4.9.0
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 98-var-partition
storage:
  disks:
    - device: /dev/<device_name> 1
      partitions:
        - label: var
          start_mib: <partition_start_offset> 2
          size_mib: <partition_size> 3
  filesystems:
```



```
- device: /dev/disk/by-partlabel/var
  path: /var
  format: xfs
  mount_options: [defaults, prjquota] 4
  with_mount_unit: true
```

- 1 The storage device name of the disk that you want to partition.
- 2 When adding a data partition to the boot disk, a minimum value of 25000 mebibytes is recommended. The root file system is automatically resized to fill all available space up to the specified offset. If no value is specified, or if the specified value is smaller than the recommended minimum, the resulting root file system will be too small, and future reinstalls of RHCOS might overwrite the beginning of the data partition.
- 3 The size of the data partition in mebibytes.
- 4 The **prjquota** mount option must be enabled for filesystems used for container storage.



#### NOTE

When creating a separate **/var** partition, you cannot use different instance types for worker nodes, if the different instance types do not have the same device name.

4. Create a manifest from the Butane config and save it to the **clusterconfig/openshift** directory. For example, run the following command:

```
$ butane $HOME/clusterconfig/98-var-partition.bu -o $HOME/clusterconfig/openshift/98-var-partition.yaml
```

5. Run **openshift-install** again to create Ignition configs from a set of files in the **manifest** and **openshift** subdirectories:

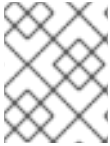
```
$ openshift-install create ignition-configs --dir $HOME/clusterconfig
$ ls $HOME/clusterconfig/
auth bootstrap.ign master.ign metadata.json worker.ign
```

Now you can use the Ignition config files as input to the vSphere installation procedures to install Red Hat Enterprise Linux CoreOS (RHCOS) systems.

### 17.5.15. Updating the bootloader using bootupd

To update the bootloader by using **bootupd**, you must either install **bootupd** on RHCOS machines manually or provide a machine config with the enabled **systemd** unit. Unlike **grubby** or other bootloader tools, **bootupd** does not manage kernel space configuration such as passing kernel arguments.

After you have installed **bootupd**, you can manage it remotely from the OpenShift Container Platform cluster.



## NOTE

It is recommended that you use **bootupd** only on bare metal or virtualized hypervisor installations, such as for protection against the BootHole vulnerability.

## Manual install method

You can manually install **bootupd** by using the **bootctl** command-line tool.

1. Inspect the system status:

```
# bootupctl status
```

### Example output

```
Component EFI
Installed: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
Update: At latest version
```

2. RHCOS images created without **bootupd** installed on them require an explicit adoption phase. If the system status is **Adoptable**, perform the adoption:

```
# bootupctl adopt-and-update
```

### Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

3. If an update is available, apply the update so that the changes take effect on the next reboot:

```
# bootupctl update
```

### Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

## Machine config method

Another way to enable **bootupd** is by providing a machine config.

- Provide a machine config file with the enabled **systemd** unit, as shown in the following example:

### Example output

```
variant: rhcos
version: 1.1.0
systemd:
units:
- name: custom-bootupd-auto.service
  enabled: true
  contents: |
    [Unit]
    Description=Bootupd automatic update
```

```
[Service]
ExecStart=/usr/bin/bootupctl update
RemainAfterExit=yes
```

```
[Install]
WantedBy=multi-user.target
```

### 17.5.16. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



#### IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

#### Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

##### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

```
$ tar xvf <file>
```

5. Place the **oc** binary in a directory that is on your **PATH**.  
To check your **PATH**, execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

#### Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

##### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.

3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

### Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### 17.5.17. Waiting for the bootstrap process to complete

The OpenShift Container Platform bootstrap process begins after the cluster nodes first boot into the persistent RHCOS environment that has been installed to disk. The configuration information provided through the Ignition config files is used to initialize the bootstrap process and install OpenShift Container Platform on the machines. You must wait for the bootstrap process to complete.

#### Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have obtained the installation program and generated the Ignition config files for your cluster.
- You installed RHCOS on your cluster machines and provided the Ignition config files that the OpenShift Container Platform installation program generated.

- Your machines have direct internet access or have an HTTP or HTTPS proxy available.

## Procedure

1. Monitor the bootstrap process:

```
$ ./openshift-install --dir <installation_directory> wait-for bootstrap-complete \ 1
--log-level=info 2
```

- 1 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

- 2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

## Example output

```
INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...
INFO API v1.22.1 up
INFO Waiting up to 30m0s for bootstrapping to complete...
INFO It is now safe to remove the bootstrap resources
```

The command succeeds when the Kubernetes API server signals that it has been bootstrapped on the control plane machines.

2. After bootstrap process is complete, remove the bootstrap machine from the load balancer.



### IMPORTANT

You must remove the bootstrap machine from the load balancer at this point. You can also remove or reformat the bootstrap machine itself.

## 17.5.18. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

## Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

- Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

### Example output

```
system:admin
```

## 17.5.19. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

### Prerequisites

- You added machines to your cluster.

### Procedure

- Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

### Example output

```
NAME      STATUS  ROLES  AGE  VERSION
master-0  Ready   master 63m  v1.22.1
master-1  Ready   master 63m  v1.22.1
master-2  Ready   master 64m  v1.22.1
```

The output lists all of the machines that you created.



### NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

- Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

### Example output

```
NAME      AGE  REQUESTOR                                     CONDITION
csr-8b2br  15m  system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper  Pending
csr-8vnps  15m  system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper  Pending
...
```

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

- If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:



#### NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.



#### NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{"\n"}\n{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```



#### NOTE

Some Operators might not become available until some CSRs are approved.

- Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

#### Example output

```

NAME      AGE   REQUESTOR                                     CONDITION
csr-bfd72 5m26s system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv 5m26s system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...

```

- If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** `<csr_name>` is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{"\n"}\n{{end}}{{end}}' | xargs oc adm certificate approve
```

- After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

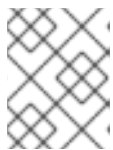
```
$ oc get nodes
```

### Example output

```

NAME      STATUS   ROLES    AGE   VERSION
master-0  Ready   master   73m   v1.22.1
master-1  Ready   master   73m   v1.22.1
master-2  Ready   master   74m   v1.22.1
worker-0  Ready   worker   11m   v1.22.1
worker-1  Ready   worker   11m   v1.22.1

```



### NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

### Additional information

- For more information on CSRs, see [Certificate Signing Requests](#).

## 17.5.20. Initial Operator configuration

After the control plane initializes, you must immediately configure some Operators so that they all become available.

### Prerequisites

- Your control plane has initialized.



## Procedure

1. Watch the cluster components come online:

```
$ watch -n5 oc get clusteroperators
```

### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
authentication	4.9.0	True	False	False	19m
baremetal	4.9.0	True	False	False	37m
cloud-credential	4.9.0	True	False	False	40m
cluster-autoscaler	4.9.0	True	False	False	37m
config-operator	4.9.0	True	False	False	38m
console	4.9.0	True	False	False	26m
csi-snapshot-controller	4.9.0	True	False	False	37m
dns	4.9.0	True	False	False	37m
etcd	4.9.0	True	False	False	36m
image-registry	4.9.0	True	False	False	31m
ingress	4.9.0	True	False	False	30m
insights	4.9.0	True	False	False	31m
kube-apiserver	4.9.0	True	False	False	26m
kube-controller-manager	4.9.0	True	False	False	36m
kube-scheduler	4.9.0	True	False	False	36m
kube-storage-version-migrator	4.9.0	True	False	False	37m
machine-api	4.9.0	True	False	False	29m
machine-approver	4.9.0	True	False	False	37m
machine-config	4.9.0	True	False	False	36m
marketplace	4.9.0	True	False	False	37m
monitoring	4.9.0	True	False	False	29m
network	4.9.0	True	False	False	38m
node-tuning	4.9.0	True	False	False	37m
openshift-apiserver	4.9.0	True	False	False	32m
openshift-controller-manager	4.9.0	True	False	False	30m
openshift-samples	4.9.0	True	False	False	32m
operator-lifecycle-manager	4.9.0	True	False	False	37m
operator-lifecycle-manager-catalog	4.9.0	True	False	False	37m
operator-lifecycle-manager-packageserver	4.9.0	True	False	False	32m
service-ca	4.9.0	True	False	False	38m
storage	4.9.0	True	False	False	37m

2. Configure the Operators that are not available.

### 17.5.20.1. Image registry removed during installation

On platforms that do not provide shareable object storage, the OpenShift Image Registry Operator bootstraps itself as **Removed**. This allows **openshift-installer** to complete installations on these platform types.

After installation, you must edit the Image Registry Operator configuration to switch the **managementState** from **Removed** to **Managed**.

**NOTE**

The Prometheus console provides an **ImageRegistryRemoved** alert, for example:

"Image Registry has been removed. **ImageStreamTags**, **BuildConfigs** and **DeploymentConfigs** which reference **ImageStreamTags** may not work as expected. Please configure storage and update the config to **Managed** state by editing `configs.imageregistry.operator.openshift.io`."

**17.5.20.2. Image registry storage configuration**

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

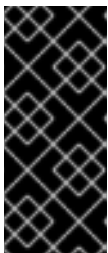
Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

**17.5.20.2.1. Configuring registry storage for VMware vSphere**

As a cluster administrator, following installation you must configure your registry to use storage.

**Prerequisites**

- Cluster administrator permissions.
- A cluster on VMware vSphere.
- Persistent storage provisioned for your cluster, such as Red Hat OpenShift Container Storage.

**IMPORTANT**

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have "100Gi" capacity.

**IMPORTANT**

Testing shows issues with using the NFS server on RHEL as storage backend for core services. This includes the OpenShift Container Registry and Quay, Prometheus for monitoring storage, and Elasticsearch for logging storage. Therefore, using RHEL NFS to back PVs used by core services is not recommended.

Other NFS implementations on the marketplace might not have these issues. Contact the individual NFS implementation vendor for more information on any testing that was possibly completed against these OpenShift Container Platform core components.

## Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.



### NOTE

When using shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

### Example output

```
No resources found in openshift-image-registry namespace
```



### NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

### Example output

```
storage:
  pvc:
    claim: 1
```

- 1** Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** persistent volume claim (PVC). The PVC is generated based on the default storage class. However, be aware that the default storage class might provide ReadWriteOnce (RWO) volumes, such as a RADOS Block Device (RBD), which can cause issues when replicating to more than one replica.

4. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED
image-registry	4.7	True	False	False

## 17.5.20.2.2. Configuring storage for the image registry in non-production clusters

You must configure storage for the Image Registry Operator. For non-production clusters, you can set the image registry to an empty directory. If you do so, all images are lost if you restart the registry.

## Procedure

- To set the image registry storage to an empty directory:

```
$ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec": {"storage":{"emptyDir":{}}}'
```



### WARNING

Configure this option for only non-production clusters.

If you run this command before the Image Registry Operator initializes its components, the **oc patch** command fails with the following error:

```
Error from server (NotFound): configs.imageregistry.operator.openshift.io "cluster" not found
```

Wait a few minutes and run the command again.

### 17.5.20.2.3. Configuring block registry storage for VMware vSphere

To allow the image registry to use block storage types such as vSphere Virtual Machine Disk (VMDK) during upgrades as a cluster administrator, you can use the **Recreate** rollout strategy.



### IMPORTANT

Block storage volumes are supported but not recommended for use with image registry on production clusters. An installation where the registry is configured on block storage is not highly available because the registry cannot have more than one replica.

## Procedure

- To set the image registry storage as a block storage type, patch the registry so that it uses the **Recreate** rollout strategy and runs with only **1** replica:

```
$ oc patch config.imageregistry.operator.openshift.io/cluster --type=merge -p '{"spec": {"rolloutStrategy":"Recreate","replicas":1}}'
```

- Provision the PV for the block storage device, and create a PVC for that volume. The requested block volume uses the ReadWriteOnce (RWO) access mode.
  - Create a **pvc.yaml** file with the following contents to define a VMware vSphere **PersistentVolumeClaim** object:

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
```

```

name: image-registry-storage ❶
namespace: openshift-image-registry ❷
spec:
  accessModes:
  - ReadWriteOnce ❸
  resources:
    requests:
      storage: 100Gi ❹

```

- ❶ A unique name that represents the **PersistentVolumeClaim** object.
- ❷ The namespace for the **PersistentVolumeClaim** object, which is **openshift-image-registry**.
- ❸ The access mode of the persistent volume claim. With **ReadWriteOnce**, the volume can be mounted with read and write permissions by a single node.
- ❹ The size of the persistent volume claim.

- b. Create the **PersistentVolumeClaim** object from the file:

```
$ oc create -f pvc.yaml -n openshift-image-registry
```

3. Edit the registry configuration so that it references the correct PVC:

```
$ oc edit config.imageregistry.operator.openshift.io -o yaml
```

### Example output

```

storage:
  pvc:
    claim: ❶

```

- ❶ Creating a custom PVC allows you to leave the **claim** field blank for the default automatic creation of an **image-registry-storage** PVC.

For instructions about configuring registry storage so that it references the correct PVC, see [Configuring the registry for vSphere](#).

## 17.5.21. Completing installation on user-provisioned infrastructure

After you complete the Operator configuration, you can finish installing the cluster on infrastructure that you provide.

### Prerequisites

- Your control plane has initialized.
- You have completed the initial Operator configuration.

### Procedure

1. Confirm that all the cluster components are online with the following command:

```
$ watch -n5 oc get clusteroperators
```

### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
authentication	4.9.0	True	False	False	19m
baremetal	4.9.0	True	False	False	37m
cloud-credential	4.9.0	True	False	False	40m
cluster-autoscaler	4.9.0	True	False	False	37m
config-operator	4.9.0	True	False	False	38m
console	4.9.0	True	False	False	26m
csi-snapshot-controller	4.9.0	True	False	False	37m
dns	4.9.0	True	False	False	37m
etcd	4.9.0	True	False	False	36m
image-registry	4.9.0	True	False	False	31m
ingress	4.9.0	True	False	False	30m
insights	4.9.0	True	False	False	31m
kube-apiserver	4.9.0	True	False	False	26m
kube-controller-manager	4.9.0	True	False	False	36m
kube-scheduler	4.9.0	True	False	False	36m
kube-storage-version-migrator	4.9.0	True	False	False	37m
machine-api	4.9.0	True	False	False	29m
machine-approver	4.9.0	True	False	False	37m
machine-config	4.9.0	True	False	False	36m
marketplace	4.9.0	True	False	False	37m
monitoring	4.9.0	True	False	False	29m
network	4.9.0	True	False	False	38m
node-tuning	4.9.0	True	False	False	37m
openshift-apiserver	4.9.0	True	False	False	32m
openshift-controller-manager	4.9.0	True	False	False	30m
openshift-samples	4.9.0	True	False	False	32m
operator-lifecycle-manager	4.9.0	True	False	False	37m
operator-lifecycle-manager-catalog	4.9.0	True	False	False	37m
operator-lifecycle-manager-packageserver	4.9.0	True	False	False	32m
service-ca	4.9.0	True	False	False	38m
storage	4.9.0	True	False	False	37m

Alternatively, the following command notifies you when all of the clusters are available. It also retrieves and displays credentials:

```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

### Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

The command succeeds when the Cluster Version Operator finishes deploying the OpenShift

The command succeeds when the Cluster Version Operator finishes deploying the OpenShift Container Platform cluster from Kubernetes API server.



## IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Confirm that the Kubernetes API server is communicating with the pods.
  - a. To view a list of all pods, use the following command:

```
$ oc get pods --all-namespaces
```

### Example output

```

NAMESPACE           NAME                                     READY  STATUS
RESTARTS  AGE
openshift-apiserver-operator  openshift-apiserver-operator-85cb746d55-zqhs8  1/1
Running   1    9m
openshift-apiserver          apiserver-67b9g                                1/1  Running  0
3m
openshift-apiserver          apiserver-ljcmx                                1/1  Running  0
1m
openshift-apiserver          apiserver-z25h4                                1/1  Running  0
2m
openshift-authentication-operator  authentication-operator-69d5d8bf84-vh2n8      1/1
Running   0    5m
...

```

- b. View the logs for a pod that is listed in the output of the previous command by using the following command:

```
$ oc logs <pod_name> -n <namespace> 1
```

- 1** Specify the pod name and namespace, as shown in the output of the previous command.

If the pod logs display, the Kubernetes API server can communicate with the cluster machines.

3. For an installation with Fibre Channel Protocol (FCP), additional steps are required to enable

3. For an installation with Fibre Channel Protocol (FCP), additional steps are required to enable multipathing. Do not enable multipathing during installation. See "Enabling multipathing with kernel arguments on RHCOS" in the *Post-installation machine configuration tasks* documentation for more information.

You can add extra compute machines after the cluster installation is completed by following [Adding compute machines to vSphere](#).

### 17.5.22. Backing up VMware vSphere volumes

OpenShift Container Platform provisions new volumes as independent persistent disks to freely attach and detach the volume on any node in the cluster. As a consequence, it is not possible to back up volumes that use snapshots, or to restore volumes from snapshots. See [Snapshot Limitations](#) for more information.

#### Procedure

To create a backup of persistent volumes:

1. Stop the application that is using the persistent volume.
2. Clone the persistent volume.
3. Restart the application.
4. Create a backup of the cloned volume.
5. Delete the cloned volume.

### 17.5.23. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

#### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

### 17.5.24. Next steps

- [Customize your cluster](#).
- If necessary, you can [opt out of remote health reporting](#).
- [Set up your registry and configure registry storage](#).
- Optional: [View the events from the vSphere Problem Detector Operator](#) to determine if the cluster has permission or storage configuration issues.



## 17.6. INSTALLING A CLUSTER ON VSPHERE WITH NETWORK CUSTOMIZATIONS

In OpenShift Container Platform version 4.9, you can install a cluster on VMware vSphere infrastructure that you provision with customized network configuration options. By customizing your network configuration, your cluster can coexist with existing IP address allocations in your environment and integrate with existing MTU and VXLAN configurations.

You must set most of the network configuration parameters during installation, and you can modify only **kubeProxy** configuration parameters in a running cluster.



### NOTE

OpenShift Container Platform supports deploying a cluster to a single VMware vCenter only. Deploying a cluster with machines/machine sets on multiple vCenters is not supported.



### IMPORTANT

The steps for performing a user-provisioned infrastructure installation are provided as an example only. Installing a cluster with infrastructure you provide requires knowledge of the vSphere platform and the installation process of OpenShift Container Platform. Use the user-provisioned infrastructure installation instructions as a guide; you are free to create the required resources through other methods.

### 17.6.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- Completing the installation requires that you upload the Red Hat Enterprise Linux CoreOS (RHCOS) OVA on vSphere hosts. The machine from which you complete this process requires access to port 443 on the vCenter and ESXi hosts. Verify that port 443 is accessible.
- If you use a firewall, you confirmed with the administrator that port 443 is accessible. Control plane nodes must be able to reach vCenter and ESXi hosts on port 443 for the installation to succeed.
- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.

### 17.6.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.

- Obtain the packages that are required to perform cluster updates.



### IMPORTANT

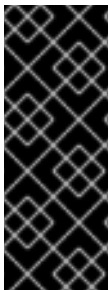
If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

### 17.6.3. VMware vSphere infrastructure requirements

You must install the OpenShift Container Platform cluster on a VMware vSphere version 6 or 7 instance that meets the requirements for the components that you use.

**Table 17.47. Version requirements for vSphere virtual environments**

Virtual environment product	Required version
VM hardware version	13 or later
vSphere ESXi hosts	6.5 or later
vCenter host	6.5 or later



### IMPORTANT

Installing a cluster on VMware vSphere version 6.7U2 or earlier and virtual hardware version 13 is now deprecated. These versions are still fully supported, but support will be removed in a future version of OpenShift Container Platform. Hardware version 15 is now the default for vSphere virtual machines in OpenShift Container Platform. To update the hardware version for your vSphere nodes, see the "Updating hardware on nodes running in vSphere" article.

**Table 17.48. Minimum supported vSphere version for VMware components**

Component	Minimum supported versions	Description
Hypervisor	vSphere 6.5 and later with HW version 13	This version is the minimum version that Red Hat Enterprise Linux CoreOS (RHCOS) supports. See the <a href="#">Red Hat Enterprise Linux 8 supported hypervisors list</a> .
Storage with in-tree drivers	vSphere 6.5 and later	This plugin creates vSphere storage by using the in-tree storage drivers for vSphere included in OpenShift Container Platform.

Component	Minimum supported versions	Description
Optional: Networking (NSX-T)	vSphere 6.5U3 or vSphere 6.7U2 and later	vSphere 6.5U3 or vSphere 6.7U2+ are required for OpenShift Container Platform. For more information about the compatibility of NSX and OpenShift Container Platform, see the Release Notes section of VMware's <a href="#">NSX container plugin documentation</a> .

If you use a vSphere version 6.5 instance, consider upgrading to 6.7U3 or 7.0 before you install OpenShift Container Platform.



### IMPORTANT

You must ensure that the time on your ESXi hosts is synchronized before you install OpenShift Container Platform. See [Edit Time Configuration for a Host](#) in the VMware documentation.

#### Additional resources

- To update the hardware version for your vSphere nodes, see [Updating hardware on nodes running in vSphere](#).

## 17.6.4. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

### 17.6.4.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

**Table 17.49. Minimum required hosts**

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.

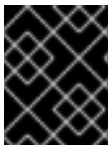
Hosts	Description
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.

**IMPORTANT**

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 7.9, or RHEL 8.4.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See [Red Hat Enterprise Linux technology capabilities and limits](#) .

**IMPORTANT**

All virtual machines must reside in the same datastore and in the same folder as the installer.

#### 17.6.4.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

**Table 17.50. Minimum resource requirements**

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 7.9, or RHEL 8.4 [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = vCPUs.
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance,

including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.

### 17.6.4.3. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

### 17.6.4.4. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.

It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.



#### NOTE

If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

#### 17.6.4.4.1. Setting the cluster node hostnames through DHCP

On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

### 17.6.4.4.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.



#### IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

**Table 17.51. Ports used for all-machine to all-machine communications**

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	<b>1936</b>	Metrics
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> and the Cluster Version Operator on port <b>9099</b> .
	<b>10250-10259</b>	The default ports that Kubernetes reserves
	<b>10256</b>	openshift-sdn
UDP	<b>4789</b>	VXLAN and Geneve
	<b>6081</b>	VXLAN and Geneve
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> .
	<b>500</b>	IPsec IKE packets
	<b>4500</b>	IPsec NAT-T packets
TCP/UDP	<b>30000-32767</b>	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

**Table 17.52. Ports used for all-machine to control plane communications**

Protocol	Port	Description
TCP	<b>6443</b>	Kubernetes API

**Table 17.53. Ports used for control plane machine to control plane machine communications**

Protocol	Port	Description
TCP	<b>2379-2380</b>	etcd server and peer ports

**Ethernet adaptor hardware address requirements**

When provisioning VMs for the cluster, the ethernet interfaces configured for each VM must use a MAC address from the VMware Organizationally Unique Identifier (OUI) allocation ranges:

- **00:05:69:00:00:00 to 00:05:69:FF:FF:FF**
- **00:0c:29:00:00:00 to 00:0c:29:FF:FF:FF**
- **00:1c:14:00:00:00 to 00:1c:14:FF:FF:FF**
- **00:50:56:00:00:00 to 00:50:56:FF:FF:FF**

If a MAC address outside the VMware OUI is used, the cluster installation will not succeed.

**NTP configuration for user-provisioned infrastructure**

OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service*.

If a DHCP server provides NTP server information, the chrony time service on the Red Hat Enterprise Linux CoreOS (RHCOS) machines read the information and can sync the clock with the NTP servers.

**Additional resources**

- [Configuring chrony time service](#)

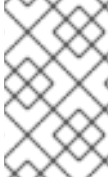
**17.6.4.5. User-provisioned DNS requirements**

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API
- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines

Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.


DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.

**NOTE**

It is recommended to use a DHCP server to provide the hostnames to each cluster node. See the *DHCP recommendations for user-provisioned infrastructure* section for more information.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, **<cluster\_name>** is the cluster name and **<base\_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster\_name>.<base\_domain>.**

**Table 17.54. Required DNS records**

Component	Record	Description
Kubernetes API	<b>api.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
	<b>api-int.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster.
		 <p><b>IMPORTANT</b></p> <p>The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.</p>
Routes	<b>*.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
		For example, <b>console-openshift-console.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;</b> is used as a wildcard route to the OpenShift Container Platform console.
Bootstrap machine	<b>bootstrap.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.



Component	Record	Description
Control plane machines	<b>&lt;master&gt;&lt;n&gt;. &lt;cluster_name&gt;. &lt;base_domain&gt;.</b>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.
Compute machines	<b>&lt;worker&gt;&lt;n&gt;. &lt;cluster_name&gt;. &lt;base_domain&gt;.</b>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.

**NOTE**

In OpenShift Container Platform 4.4 and later, you do not need to specify `etcd` host and SRV records in your DNS configuration.

**TIP**

You can use the **dig** command to verify name and reverse name resolution. See the section on *Validating DNS resolution for user-provisioned infrastructure* for detailed validation steps.

**17.6.4.5.1. Example DNS configuration for user-provisioned clusters**

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is **ocp4** and the base domain is **example.com**.

**Example DNS A record configuration for a user-provisioned cluster**

The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

**Example 17.13. Sample DNS zone database**

```
$TTL 1W
@ IN SOA ns1.example.com. root (
    2019070700 ; serial
    3H ; refresh (3 hours)
    30M ; retry (30 minutes)
    2W ; expiry (2 weeks)
    1W ) ; minimum (1 week)
IN NS ns1.example.com.
IN MX 10 smtp.example.com.
;
;
ns1.example.com. IN A 192.168.1.5
smtp.example.com. IN A 192.168.1.5
;
```

```

helper.example.com. IN A 192.168.1.5
helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com. IN A 192.168.1.5 1
api-int.ocp4.example.com. IN A 192.168.1.5 2
;
*.apps.ocp4.example.com. IN A 192.168.1.5 3
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 4
;
master0.ocp4.example.com. IN A 192.168.1.97 5
master1.ocp4.example.com. IN A 192.168.1.98 6
master2.ocp4.example.com. IN A 192.168.1.99 7
;
worker0.ocp4.example.com. IN A 192.168.1.11 8
worker1.ocp4.example.com. IN A 192.168.1.7 9
;
;EOF

```

- 1 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.
- 2 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.
- 3 Provides name resolution for the wildcard routes. The record refers to the IP address of the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



#### NOTE

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

- 4 Provides name resolution for the bootstrap machine.
- 5 6 7 Provides name resolution for the control plane machines.
- 8 9 Provides name resolution for the compute machines.

### Example DNS PTR record configuration for a user-provisioned cluster

The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

#### Example 17.14. Sample DNS zone database for reverse records

```

$TTL 1W
@ IN SOA ns1.example.com. root (

```

```

2019070700 ; serial
3H ; refresh (3 hours)
30M ; retry (30 minutes)
2W ; expiry (2 weeks)
1W ) ; minimum (1 week)
IN NS ns1.example.com.
;
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. 2
;
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. 3
;
97.1.168.192.in-addr.arpa. IN PTR master0.ocp4.example.com. 4
98.1.168.192.in-addr.arpa. IN PTR master1.ocp4.example.com. 5
99.1.168.192.in-addr.arpa. IN PTR master2.ocp4.example.com. 6
;
11.1.168.192.in-addr.arpa. IN PTR worker0.ocp4.example.com. 7
7.1.168.192.in-addr.arpa. IN PTR worker1.ocp4.example.com. 8
;
;EOF

```

- 1 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.
- 2 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.
- 3 Provides reverse DNS resolution for the bootstrap machine.
- 4 5 6 Provides reverse DNS resolution for the control plane machines.
- 7 8 Provides reverse DNS resolution for the compute machines.

**NOTE**

A PTR record is not required for the OpenShift Container Platform application wildcard.

#### 17.6.4.6. Load balancing requirements for user-provisioned infrastructure

Before you install OpenShift Container Platform, you must provision the API and application ingress load balancing infrastructure. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

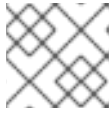
**NOTE**

If you want to deploy the API and application ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer.** Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:

- Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the API routes.
- A stateless load balancing algorithm. The options vary based on the load balancer implementation.

**NOTE**

Session persistence is not required for the API load balancer to function properly.

Configure the following ports on both the front and back of the load balancers:

**Table 17.55. API load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
<b>6443</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the <b>/readyz</b> endpoint for the API server health check probe.	X	X	Kubernetes API server
<b>22623</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server

**NOTE**

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the **/readyz** endpoint to the removal of the API server instance from the pool. Within the time frame after **/readyz** returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application ingress load balancer.** Provides an ingress point for application traffic flowing in from outside the cluster. Configure the following conditions:
  - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the ingress routes.
  - A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

**TIP**

If the true IP address of the client can be seen by the application ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

Configure the following ports on both the front and back of the load balancers:

**Table 17.56. Application ingress load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
<b>443</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic
<b>80</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic
<b>1936</b>	The worker nodes that run the Ingress Controller pods, by default. You must configure the <b>/healthz/ready</b> endpoint for the ingress health check probe.	X	X	HTTP traffic

**NOTE**

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

**NOTE**

A working configuration for the Ingress router is required for an OpenShift Container Platform cluster. You must configure the Ingress router after the control plane initializes.

#### 17.6.4.6.1. Example load balancer configuration for user-provisioned clusters

This section provides an example API and application ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an **/etc/haproxy/haproxy.cfg** configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing one load balancing solution over another.

**NOTE**

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

## Example 17.15. Sample API and application ingress load balancer configuration

```
global
log      127.0.0.1 local2
pidfile  /var/run/haproxy.pid
maxconn  4000
daemon

defaults
mode      http
log        global
option     dontlognull
option     http-server-close
option     redispatch
retries    3
timeout   http-request 10s
timeout   queue        1m
timeout   connect      10s
timeout   client        1m
timeout   server        1m
timeout   http-keep-alive 10s
timeout   check         10s
maxconn   3000

frontend stats
bind *:1936
mode      http
log        global
maxconn 10
stats enable
stats hide-version
stats refresh 30s
stats show-node
stats show-desc Stats for ocp4 cluster 1
stats auth admin:ocp4
stats uri /stats

listen api-server-6443 2
bind *:6443
mode tcp
server bootstrap bootstrap.ocp4.example.com:6443 check inter 1s backup 3
server master0 master0.ocp4.example.com:6443 check inter 1s
server master1 master1.ocp4.example.com:6443 check inter 1s
server master2 master2.ocp4.example.com:6443 check inter 1s

listen machine-config-server-22623 4
bind *:22623
mode tcp
server bootstrap bootstrap.ocp4.example.com:22623 check inter 1s backup 5
server master0 master0.ocp4.example.com:22623 check inter 1s
server master1 master1.ocp4.example.com:22623 check inter 1s
server master2 master2.ocp4.example.com:22623 check inter 1s

listen ingress-router-443 6
bind *:443
mode tcp
balance source
server worker0 worker0.ocp4.example.com:443 check inter 1s
server worker1 worker1.ocp4.example.com:443 check inter 1s

listen ingress-router-80 7
```

```
bind *:80
mode tcp
balance source
server worker0 worker0.ocp4.example.com:80 check inter 1s
server worker1 worker1.ocp4.example.com:80 check inter 1s
```

- 1 In the example, the cluster name is **ocp4**.
- 2 Port **6443** handles the Kubernetes API traffic and points to the control plane machines.
- 3 5 The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.
- 4 Port **22623** handles the machine config server traffic and points to the control plane machines.
- 6 Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.
- 7 Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

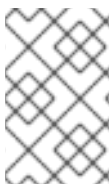


#### NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

#### TIP

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltp** on the HAProxy node.



#### NOTE

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running **setsebool -P haproxy\_connect\_any=1**.

### 17.6.5. Preparing the user-provisioned infrastructure

Before you install OpenShift Container Platform on user-provisioned infrastructure, you must prepare the underlying infrastructure.

This section provides details about the high-level steps required to set up your cluster infrastructure in preparation for an OpenShift Container Platform installation. This includes configuring IP networking and network connectivity for your cluster nodes, enabling the required ports through your firewall, and setting up the required DNS and load balancing infrastructure.

After preparation, your cluster infrastructure must meet the requirements outlined in the *Requirements for a cluster with user-provisioned infrastructure* section.

## Prerequisites

- You have reviewed the [OpenShift Container Platform 4.x Tested Integrations](#) page.
- You have reviewed the infrastructure requirements detailed in the *Requirements for a cluster with user-provisioned infrastructure* section.

## Procedure

1. If you are using DHCP to provide the IP networking configuration to your cluster nodes, configure your DHCP service.
  - a. Add persistent IP addresses for the nodes to your DHCP server configuration. In your configuration, match the MAC address of the relevant network interface to the intended IP address for each node.
  - b. When you use DHCP to configure IP addressing for the cluster machines, the machines also obtain the DNS server information through DHCP. Define the persistent DNS server address that is used by the cluster nodes through your DHCP server configuration.



### NOTE

If you are not using a DHCP service, you must provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

- c. Define the hostnames of your cluster nodes in your DHCP server configuration. See the *Setting the cluster node hostnames through DHCP* section for details about hostname considerations.



### NOTE

If you are not using a DHCP service, the cluster nodes obtain their hostname through a reverse DNS lookup.

2. Ensure that your network infrastructure provides the required network connectivity between the cluster components. See the *Networking requirements for user-provisioned infrastructure* section for details about the requirements.
3. Configure your firewall to enable the ports required for the OpenShift Container Platform cluster components to communicate. See *Networking requirements for user-provisioned infrastructure* section for details about the ports that are required.
4. Setup the required DNS infrastructure for your cluster.
  - a. Configure DNS name resolution for the Kubernetes API, the application wildcard, the bootstrap machine, the control plane machines, and the compute machines.
  - b. Configure reverse DNS resolution for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.  
See the *User-provisioned DNS requirements* section for more information about the OpenShift Container Platform DNS requirements.



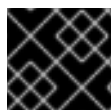
5. Validate your DNS configuration.
  - a. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses in the responses correspond to the correct components.
  - b. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names in the responses correspond to the correct components.  
See the *Validating DNS resolution for user-provisioned infrastructure* section for detailed DNS validation steps.
6. Provision the required API and application ingress load balancing infrastructure. See the *Load balancing requirements for user-provisioned infrastructure* section for more information about the requirements.

**NOTE**

Some load balancing solutions require the DNS name resolution for the cluster nodes to be in place before the load balancing is initialized.

### 17.6.6. Validating DNS resolution for user-provisioned infrastructure

You can validate your DNS configuration before installing OpenShift Container Platform on user-provisioned infrastructure.

**IMPORTANT**

The validation steps detailed in this section must succeed before you install your cluster.

**Prerequisites**

- You have configured the required DNS records for your user-provisioned infrastructure.

**Procedure**

1. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses contained in the responses correspond to the correct components.
  - a. Perform a lookup against the Kubernetes API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api.<cluster_name>.<base_domain> 1
```

- 1** Replace **<nameserver\_ip>** with the IP address of the nameserver, **<cluster\_name>** with your cluster name, and **<base\_domain>** with your base domain name.

**Example output**

```
api.ocp4.example.com. 0 IN A 192.168.1.5
```

- b. Perform a lookup against the Kubernetes internal API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api-int.<cluster_name>.<base_domain>
```

#### Example output

```
api-int.ocp4.example.com. 0 IN A 192.168.1.5
```

- c. Test an example **\*.apps.<cluster\_name>.<base\_domain>** DNS wildcard lookup. All of the application wildcard lookups must resolve to the IP address of the application ingress load balancer:

```
$ dig +noall +answer @<nameserver_ip> random.apps.<cluster_name>.<base_domain>
```

#### Example output

```
random.apps.ocp4.example.com. 0 IN A 192.168.1.5
```



#### NOTE

In the example outputs, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

You can replace **random** with another wildcard value. For example, you can query the route to the OpenShift Container Platform console:

```
$ dig +noall +answer @<nameserver_ip> console-openshift-console.apps.<cluster_name>.<base_domain>
```

#### Example output

```
console-openshift-console.apps.ocp4.example.com. 0 IN A 192.168.1.5
```

- d. Run a lookup against the bootstrap DNS record name. Check that the result points to the IP address of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> bootstrap.<cluster_name>.<base_domain>
```

#### Example output

```
bootstrap.ocp4.example.com. 0 IN A 192.168.1.96
```

- e. Use this method to perform lookups against the DNS record names for the control plane and compute nodes. Check that the results correspond to the IP addresses of each node.
2. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names contained in the responses correspond to the correct components.

- a. Perform a reverse lookup against the IP address of the API load balancer. Check that the response includes the record names for the Kubernetes API and the Kubernetes internal API:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.5
```

### Example output

```
5.1.168.192.in-addr.arpa. 0 IN PTR api-int.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. 0 IN PTR api.ocp4.example.com. 2
```

- 1 Provides the record name for the Kubernetes internal API.
- 2 Provides the record name for the Kubernetes API.



### NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard. No validation step is needed for reverse DNS resolution against the IP address of the application ingress load balancer.

- b. Perform a reverse lookup against the IP address of the bootstrap node. Check that the result points to the DNS record name of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.96
```

### Example output

```
96.1.168.192.in-addr.arpa. 0 IN PTR bootstrap.ocp4.example.com.
```

- c. Use this method to perform reverse lookups against the IP addresses for the control plane and compute nodes. Check that the results correspond to the DNS record names of each node.

## 17.6.7. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The **./openshift-install gather** command also requires the SSH public key to be in place on the cluster nodes.

**IMPORTANT**

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

**NOTE**

You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

**Procedure**

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.

**NOTE**

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.

**NOTE**

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

**Example output**

Agent pid 31874



#### NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1** Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

#### Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

#### Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

### 17.6.8. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

#### Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space

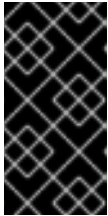
#### Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



#### IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



### IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#) . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

## 17.6.9. Manually creating the installation configuration file

For user-provisioned installations of OpenShift Container Platform, you manually generate your installation configuration file.

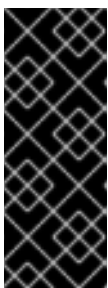
### Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

### Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```



### IMPORTANT

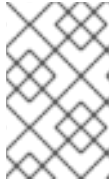
You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation\_directory>**.



### NOTE

You must name this configuration file **install-config.yaml**.

**NOTE**

For some platform types, you can alternatively run `./openshift-install create install-config --dir <installation_directory>` to generate an `install-config.yaml` file. You can provide details about your cluster configuration at the prompts.

3. Back up the `install-config.yaml` file so that you can use it to install multiple clusters.

**IMPORTANT**

The `install-config.yaml` file is consumed during the next step of the installation process. You must back it up now.

### 17.6.9.1. Sample `install-config.yaml` file for VMware vSphere

You can customize the `install-config.yaml` file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```

apiVersion: v1
baseDomain: example.com 1
compute:
- hyperthreading: Enabled 2 3
  name: worker
  replicas: 0 4
controlPlane:
  hyperthreading: Enabled 5 6
  name: master
  replicas: 3 7
metadata:
  name: test 8
platform:
  vsphere:
    vcenter: your.vcenter.server 9
    username: username 10
    password: password 11
    datacenter: datacenter 12
    defaultDatastore: datastore 13
    folder: "/<datacenter_name>/vm/<folder_name>/<subfolder_name>" 14
  fips: false 15
  pullSecret: '{"auths": ...}' 16
  sshKey: 'ssh-ed25519 AAAA...' 17

```

- 1 The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.
- 2 5 The **controlPlane** section is a single mapping, but the compute section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. Although both sections currently define a single machine pool, it is possible that future versions of OpenShift Container Platform will support defining multiple compute pools during installation. Only one control plane pool is used.

- 3 6 Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You



### IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Your machines must use at least 8 CPUs and 32 GB of RAM if you disable simultaneous multithreading.

- 4 You must set the value of the **replicas** parameter to **0**. This parameter controls the number of workers that the cluster creates and manages for you, which are functions that the cluster does not perform when you use user-provisioned infrastructure. You must manually deploy worker machines for the cluster to use before you finish installing OpenShift Container Platform.
- 7 The number of control plane machines that you add to the cluster. Because the cluster uses this values as the number of etcd endpoints in the cluster, the value must match the number of control plane machines that you deploy.
- 8 The cluster name that you specified in your DNS records.
- 9 The fully-qualified hostname or IP address of the vCenter server.
- 10 The name of the user for accessing the server. This user must have at least the roles and privileges that are required for [static or dynamic persistent volume provisioning](#) in vSphere.
- 11 The password associated with the vSphere user.
- 12 The vSphere datacenter.
- 13 The default vSphere datastore to use.
- 14 Optional: For installer-provisioned infrastructure, the absolute path of an existing folder where the installation program creates the virtual machines, for example, `/<datacenter_name>/vm/<folder_name>/<subfolder_name>`. If you do not provide this value, the installation program creates a top-level folder in the datacenter virtual machine folder that is named with the infrastructure ID. If you are providing the infrastructure for the cluster, omit this parameter.
- 15 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.



### IMPORTANT

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

- 16 The pull secret that you obtained from [OpenShift Cluster Manager](#). This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.
- 17 The public portion of the default SSH key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).



### 17.6.9.2. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

#### Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



#### NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

#### Procedure

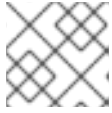
1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
  additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
...

```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations. You must include vCenter's IP address and the IP range that you use for its machines.
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to

**additionalTrustBundle** and at least one proxy setting, the **proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.



#### NOTE

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



#### NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

### 17.6.10. Network configuration phases

There are two phases prior to OpenShift Container Platform installation where you can customize the network configuration.

#### Phase 1

You can customize the following network-related fields in the **install-config.yaml** file before you create the manifest files:

- **networking.networkType**
- **networking.clusterNetwork**
- **networking.serviceNetwork**
- **networking.machineNetwork**

For more information on these fields, refer to *Installation configuration parameters*.



#### NOTE

Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

#### Phase 2

After creating the manifest files by running **openshift-install create manifests**, you can define a customized Cluster Network Operator manifest with only the fields you want to modify. You can use the manifest to specify advanced network configuration.

You cannot override the values specified in phase 1 in the **install-config.yaml** file during phase 2. However, you can further customize the cluster network provider during phase 2.

## 17.6.11. Specifying advanced network configuration

You can use advanced network configuration for your cluster network provider to integrate your cluster into your existing network environment. You can specify advanced network configuration only before you install the cluster.



### IMPORTANT

Customizing your network configuration by modifying the OpenShift Container Platform manifest files created by the installation program is not supported. Applying a manifest file that you create, as in the following procedure, is supported.

### Prerequisites

- You have created the **install-config.yaml** file and completed any modifications to it.

### Procedure

- Change to the directory that contains the installation program and create the manifests:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

- 1** **<installation\_directory>** specifies the name of the directory that contains the **install-config.yaml** file for your cluster.

- Create a stub manifest file for the advanced network configuration that is named **cluster-network-03-config.yml** in the **<installation\_directory>/manifests/** directory:

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
```

- Specify the advanced network configuration for your cluster in the **cluster-network-03-config.yml** file, such as in the following examples:

#### Specify a different VXLAN port for the OpenShift SDN network provider

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    openshiftSDNConfig:
      vxlanPort: 4800
```

#### Enable IPsec for the OVN-Kubernetes network provider

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
```

```

name: cluster
spec:
  defaultNetwork:
    ovnKubernetesConfig:
      ipsecConfig: {}

```

4. Optional: Back up the **manifests/cluster-network-03-config.yml** file. The installation program consumes the **manifests/** directory when you create the Ignition config files.
5. Remove the Kubernetes manifest files that define the control plane machines and compute machineSets:

```
$ rm -f openshift/99_openshift-cluster-api_master-machines-*.yaml openshift/99_openshift-cluster-api_worker-machineset-*.yaml
```

Because you create and manage these resources yourself, you do not have to initialize them.

- You can preserve the MachineSet files to create compute machines by using the machine API, but you must update references to them to match your environment.

## 17.6.12. Cluster Network Operator configuration

The configuration for the cluster network is specified as part of the Cluster Network Operator (CNO) configuration and stored in a custom resource (CR) object that is named **cluster**. The CR specifies the fields for the **Network** API in the **operator.openshift.io** API group.

The CNO configuration inherits the following fields during cluster installation from the **Network** API in the **Network.config.openshift.io** API group and these fields cannot be changed:

### **clusterNetwork**

IP address pools from which pod IP addresses are allocated.

### **serviceNetwork**

IP address pool for services.

### **defaultNetwork.type**

Cluster network provider, such as OpenShift SDN or OVN-Kubernetes.

You can specify the cluster network provider configuration for your cluster by setting the fields for the **defaultNetwork** object in the CNO object named **cluster**.

### 17.6.12.1. Cluster Network Operator configuration object

The fields for the Cluster Network Operator (CNO) are described in the following table:

**Table 17.57. Cluster Network Operator configuration object**

Field	Type	Description
<b>metadata.name</b>	<b>string</b>	The name of the CNO object. This name is always <b>cluster</b> .


Field	Type	Description
<b>spec.clusterNetwork</b>	<b>array</b>	<p>A list specifying the blocks of IP addresses from which pod IP addresses are allocated and the subnet prefix length assigned to each individual node in the cluster. For example:</p> <pre>spec:   clusterNetwork:   - cidr: 10.128.0.0/19     hostPrefix: 23   - cidr: 10.128.32.0/19     hostPrefix: 23</pre> <p>You can customize this field only in the <b>install-config.yaml</b> file before you create the manifests. The value is read-only in the manifest file.</p>
<b>spec.serviceNetwork</b>	<b>array</b>	<p>A block of IP addresses for services. The OpenShift SDN and OVN-Kubernetes Container Network Interface (CNI) network providers support only a single IP address block for the service network. For example:</p> <pre>spec:   serviceNetwork:   - 172.30.0.0/14</pre> <p>You can customize this field only in the <b>install-config.yaml</b> file before you create the manifests. The value is read-only in the manifest file.</p>
<b>spec.defaultNetwork</b>	<b>object</b>	Configures the Container Network Interface (CNI) cluster network provider for the cluster network.
<b>spec.kubeProxy Config</b>	<b>object</b>	The fields for this object specify the kube-proxy configuration. If you are using the OVN-Kubernetes cluster network provider, the kube-proxy configuration has no effect.

### defaultNetwork object configuration

The values for the **defaultNetwork** object are defined in the following table:

Table 17.58. **defaultNetwork** object

Field	Type	Description
-------	------	-------------

Field	Type	Description
<b>type</b>	<b>string</b>	<p>Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b>. The cluster network provider is selected during installation. This value cannot be changed after cluster installation.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>OpenShift Container Platform uses the OpenShift SDN Container Network Interface (CNI) cluster network provider by default.</p> </div> </div>
<b>openshiftSDNConfig</b>	<b>object</b>	This object is only valid for the OpenShift SDN cluster network provider.
<b>ovnKubernetesConfig</b>	<b>object</b>	This object is only valid for the OVN-Kubernetes cluster network provider.

#### Configuration for the OpenShift SDN CNI cluster network provider

The following table describes the configuration fields for the OpenShift SDN Container Network Interface (CNI) cluster network provider.

**Table 17.59. openshiftSDNConfig object**

Field	Type	Description
<b>mode</b>	<b>string</b>	<p>Configures the network isolation mode for OpenShift SDN. The default value is <b>NetworkPolicy</b>.</p> <p>The values <b>Multitenant</b> and <b>Subnet</b> are available for backwards compatibility with OpenShift Container Platform 3.x but are not recommended. This value cannot be changed after cluster installation.</p>

Field	Type	Description
<b>mtu</b>	<b>integer</b>	<p>The maximum transmission unit (MTU) for the VXLAN overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU.</p> <p>If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes.</p> <p>If your cluster requires different MTU values for different nodes, you must set this value to <b>50</b> less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of <b>9001</b>, and some have an MTU of <b>1500</b>, you must set this value to <b>1450</b>.</p> <p>This value cannot be changed after cluster installation.</p>
<b>vxlanPort</b>	<b>integer</b>	<p>The port to use for all VXLAN packets. The default value is <b>4789</b>. This value cannot be changed after cluster installation.</p> <p>If you are running in a virtualized environment with existing nodes that are part of another VXLAN network, then you might be required to change this. For example, when running an OpenShift SDN overlay on top of VMware NSX-T, you must select an alternate port for the VXLAN, because both SDNs use the same default VXLAN port number.</p> <p>On Amazon Web Services (AWS), you can select an alternate port for the VXLAN between port <b>9000</b> and port <b>9999</b>.</p>

### Example OpenShift SDN configuration

```
defaultNetwork:
  type: OpenShiftSDN
  openshiftSDNConfig:
    mode: NetworkPolicy
    mtu: 1450
    vxlanPort: 4789
```

### Configuration for the OVN-Kubernetes CNI cluster network provider

The following table describes the configuration fields for the OVN-Kubernetes CNI cluster network provider.

Table 17.60. `ovnKubernetesConfig` object

Field	Type	Description
-------	------	-------------

Field	Type	Description
<b>mtu</b>	<b>integer</b>	<p>The maximum transmission unit (MTU) for the Geneve (Generic Network Virtualization Encapsulation) overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU.</p> <p>If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes.</p> <p>If your cluster requires different MTU values for different nodes, you must set this value to <b>100</b> less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of <b>9001</b>, and some have an MTU of <b>1500</b>, you must set this value to <b>1400</b>.</p> <p>This value cannot be changed after cluster installation.</p>
<b>genevePort</b>	<b>integer</b>	The port to use for all Geneve packets. The default value is <b>6081</b> . This value cannot be changed after cluster installation.
<b>ipsecConfig</b>	<b>object</b>	Specify an empty object to enable IPsec encryption. This value cannot be changed after cluster installation.
<b>policyAuditConfig</b>	<b>object</b>	Specify a configuration object for customizing network policy audit logging. If unset, the defaults audit log settings are used.

Table 17.61. **policyAuditConfig** object

Field	Type	Description
<b>rateLimit</b>	integer	The maximum number of messages to generate every second per node. The default value is <b>20</b> messages per second.
<b>maxFileSize</b>	integer	The maximum size for the audit log in bytes. The default value is <b>50000000</b> or 50 MB.



Field	Type	Description
<b>destination</b>	string	<p>One of the following additional audit log targets:</p> <p><b>libc</b> The libc <b>syslog()</b> function of the journald process on the host.</p> <p><b>udp:&lt;host&gt;:&lt;port&gt;</b> A syslog server. Replace <b>&lt;host&gt;:&lt;port&gt;</b> with the host and port of the syslog server.</p> <p><b>unix:&lt;file&gt;</b> A Unix Domain Socket file specified by <b>&lt;file&gt;</b>.</p> <p><b>null</b> Do not send the audit logs to any additional target.</p>
<b>syslogFacility</b>	string	The syslog facility, such as <b>kern</b> , as defined by RFC5424. The default value is <b>local0</b> .

### Example OVN-Kubernetes configuration

```


defaultNetwork:
  type: OVNKubernetes
  ovnKubernetesConfig:
    mtu: 1400
    genevePort: 6081
    ipsecConfig: {}

```

### kubeProxyConfig object configuration

The values for the **kubeProxyConfig** object are defined in the following table:

Table 17.62. **kubeProxyConfig** object

Field	Type	Description
<b>iptablesSyncPeriod</b>	<b>string</b>	<p>The refresh period for <b>iptables</b> rules. The default value is <b>30s</b>. Valid suffixes include <b>s</b>, <b>m</b>, and <b>h</b> and are described in the <a href="#">Go time package</a> documentation.</p> <div style="display: flex; align-items: flex-start;"> <div style="flex: 1;">  </div> <div style="flex: 2;"> <p><b>NOTE</b></p> <p>Because of performance improvements introduced in OpenShift Container Platform 4.3 and greater, adjusting the <b>iptablesSyncPeriod</b> parameter is no longer necessary.</p> </div> </div>

Field	Type	Description
<b>proxyArguments.iptables-min-sync-period</b>	<b>array</b>	<p>The minimum duration before refreshing <b>iptables</b> rules. This field ensures that the refresh does not happen too frequently. Valid suffixes include <b>s</b>, <b>m</b>, and <b>h</b> and are described in the <a href="#">Go time package</a>. The default value is:</p> <pre>kubeProxyConfig:   proxyArguments:     iptables-min-sync-period:       - 0s</pre>

### 17.6.13. Creating the Ignition config files

Because you must manually start the cluster machines, you must generate the Ignition config files that the cluster needs to make its machines.



#### IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

#### Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

#### Procedure

- Obtain the Ignition config files:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

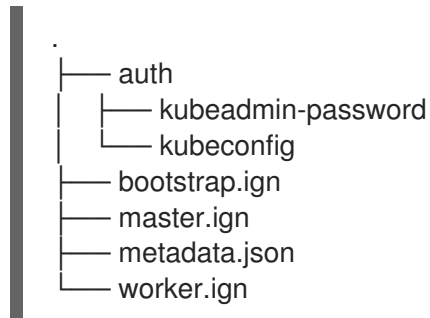
- 1** For **<installation\_directory>**, specify the directory name to store the files that the installation program creates.



## IMPORTANT

If you created an **install-config.yaml** file, specify the directory that contains it. Otherwise, specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

The following files are generated in the directory:



### 17.6.14. Extracting the infrastructure name

The Ignition config files contain a unique cluster identifier that you can use to uniquely identify your cluster in VMware vSphere. If you plan to use the cluster identifier as the name of your virtual machine folder, you must extract it.

#### Prerequisites

- You obtained the OpenShift Container Platform installation program and the pull secret for your cluster.
- You generated the Ignition config files for your cluster.
- You installed the **jq** package.

#### Procedure

- To extract and view the infrastructure name from the Ignition config file metadata, run the following command:

```
$ jq -r .infraID <installation_directory>/metadata.json 1
```

- 1 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

#### Example output

```
openshift-vw9j6 1
```

- 1 The output of this command is your cluster name and a random string.

## 17.6.15. Installing RHCOS and starting the OpenShift Container Platform bootstrap process

To install OpenShift Container Platform on user-provisioned infrastructure on VMware vSphere, you must install Red Hat Enterprise Linux CoreOS (RHCOS) on vSphere hosts. When you install RHCOS, you must provide the Ignition config file that was generated by the OpenShift Container Platform installation program for the type of machine you are installing. If you have configured suitable networking, DNS, and load balancing infrastructure, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS machines have rebooted.

### Prerequisites

- You have obtained the Ignition config files for your cluster.
- You have access to an HTTP server that you can access from your computer and that the machines that you create can access.
- You have created a [vSphere cluster](#).

### Procedure

1. Upload the bootstrap Ignition config file, which is named **<installation\_directory>/bootstrap.ign**, that the installation program created to your HTTP server. Note the URL of this file.
2. Save the following secondary Ignition config file for your bootstrap node to your computer as **<installation\_directory>/merge-bootstrap.ign**:

```
{
  "ignition": {
    "config": {
      "merge": [
        {
          "source": "<bootstrap_ignition_config_url>", 1
          "verification": {}
        }
      ]
    },
    "timeouts": {},
    "version": "3.2.0"
  },
  "networkd": {},
  "passwd": {},
  "storage": {},
  "systemd": {}
}
```

- 1** Specify the URL of the bootstrap Ignition config file that you hosted.

When you create the virtual machine (VM) for the bootstrap machine, you use this Ignition config file.

3. Locate the following Ignition config files that the installation program created:
  - **<installation\_directory>/master.ign**

- `<installation_directory>/worker.ign`
  - `<installation_directory>/merge-bootstrap.ign`
4. Convert the Ignition config files to Base64 encoding. Later in this procedure, you must add these files to the extra configuration parameter **guestinfo.ignition.config.data** in your VM. For example, if you use a Linux operating system, you can use the **base64** command to encode the files.

```
$ base64 -w0 <installation_directory>/master.ign > <installation_directory>/master.64
```

```
$ base64 -w0 <installation_directory>/worker.ign > <installation_directory>/worker.64
```

```
$ base64 -w0 <installation_directory>/merge-bootstrap.ign > <installation_directory>/merge-bootstrap.64
```



### IMPORTANT

If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

5. Obtain the RHCOS OVA image. Images are available from the [RHCOS image mirror](#) page.



### IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download an image with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image version that matches your OpenShift Container Platform version if it is available.

The filename contains the OpenShift Container Platform version number in the format **rhcos-vmware.<architecture>.ova**.

6. In the vSphere Client, create a folder in your datacenter to store your VMs.
- a. Click the **VMs and Templates** view.
  - b. Right-click the name of your datacenter.
  - c. Click **New Folder** → **New VM and Template Folder**
  - d. In the window that is displayed, enter the folder name. If you did not specify an existing folder in the **install-config.yaml** file, then create a folder with the same name as the infrastructure ID. You use this folder name so vCenter dynamically provisions storage in the appropriate location for its Workspace configuration.
7. In the vSphere Client, create a template for the OVA image and then clone the template as needed.

**NOTE**

In the following steps, you create a template and then clone the template for all of your cluster machines. You then provide the location for the Ignition config file for that cloned machine type when you provision the VMs.

- a. From the **Hosts and Clusters** tab, right-click your cluster name and select **Deploy OVF Template**.
- b. On the **Select an OVF** tab, specify the name of the RHCOS OVA file that you downloaded.
- c. On the **Select a name and folder** tab, set a **Virtual machine name** for your template, such as **Template-RHCOS**. Click the name of your vSphere cluster and select the folder you created in the previous step.
- d. On the **Select a compute resource** tab, click the name of your vSphere cluster.
- e. On the **Select storage** tab, configure the storage options for your VM.
  - Select **Thin Provision** or **Thick Provision**, based on your storage preferences.
  - Select the datastore that you specified in your **install-config.yaml** file.
- f. On the **Select network** tab, specify the network that you configured for the cluster, if available.
- g. When creating the OVF template, do not specify values on the **Customize template** tab or configure the template any further.

**IMPORTANT**

Do not start the original VM template. The VM template must remain off and must be cloned for new RHCOS machines. Starting the VM template configures the VM template as a VM on the platform, which prevents it from being used as a template that machine sets can apply configurations to.

8. Optional: Update the configured virtual hardware version in the VM template, if necessary. Follow [Upgrading a virtual machine to the latest hardware version](#) in the VMware documentation for more information.

**IMPORTANT**

It is recommended that you update the hardware version of the VM template to version 15 before creating VMs from it, if necessary. Using hardware version 13 for your cluster nodes running on vSphere is now deprecated. If your imported template defaults to hardware version 13, you must ensure that your ESXi host is on 6.7U3 or later before upgrading the VM template to hardware version 15. If your vSphere version is less than 6.7U3, you can skip this upgrade step; however, a future version of OpenShift Container Platform is scheduled to remove support for hardware version 13 and vSphere versions less than 6.7U3.

9. After the template deploys, deploy a VM for a machine in the cluster.
  - a. Right-click the template name and click **Clone** → **Clone to Virtual Machine**

- b. On the **Select a name and folder** tab, specify a name for the VM. You might include the machine type in the name, such as **control-plane-0** or **compute-1**.
- c. On the **Select a name and folder** tab, select the name of the folder that you created for the cluster.
- d. On the **Select a compute resource** tab, select the name of a host in your datacenter.
- e. Optional: On the **Select storage** tab, customize the storage options.
- f. On the **Select clone options**, select **Customize this virtual machine's hardware**.
- g. On the **Customize hardware** tab, click **VM Options** → **Advanced**.
  - Optional: Override default DHCP networking in vSphere. To enable static IP networking:

- i. Set your static IP configuration:

```
$ export IPCFG="ip=<ip>::<gateway>:<netmask>:<hostname>:<iface>:none
nameserver=svr1 [nameserver=svr2 [nameserver=svr3 [...]]]"
```

#### Example command

```
$ export IPCFG="ip=192.168.100.101::192.168.100.254:255.255.255.0::none
nameserver=8.8.8.8"
```

- ii. Set the **guestinfo.afterburn.initrd.network-kargs** property before booting a VM from an OVA in vSphere:

```
$ govc vm.change -vm "<vm_name>" -e "guestinfo.afterburn.initrd.network-
kargs=${IPCFG}"
```

- Optional: In the event of cluster performance issues, from the **Latency Sensitivity** list, select **High**. Ensure that your VM's CPU and memory reservation have the following values:
  - Memory reservation value must be equal to its configured memory size.
  - CPU reservation value must be at least the number of low latency virtual CPUs multiplied by the measured physical CPU speed.
- Click **Edit Configuration**, and on the **Configuration Parameters** window, search the list of available parameters for steal clock accounting (**stealclock.enable**). If it is available, set its value to **TRUE**. Enabling steal clock accounting can help with troubleshooting cluster issues.
- Click **Add Configuration Params**. Define the following parameter names and values:
  - **guestinfo.ignition.config.data**: Locate the base-64 encoded files that you created previously in this procedure, and paste the contents of the base64-encoded Ignition config file for this machine type.
  - **guestinfo.ignition.config.data.encoding**: Specify **base64**.
  - **disk.EnableUUID**: Specify **TRUE**.

- o **stealclock.enable**: If this parameter was not defined, add it and specify **TRUE**.
- h. In the **Virtual Hardware** panel of the **Customize hardware** tab, modify the specified values as required. Ensure that the amount of RAM, CPU, and disk storage meets the minimum requirements for the machine type.
  - i. Complete the configuration and power on the VM.
10. Create the rest of the machines for your cluster by following the preceding steps for each machine.



### IMPORTANT

You must create the bootstrap and control plane machines at this time. Because some pods are deployed on compute machines by default, also create at least two compute machines before you install the cluster.

## 17.6.16. Adding more compute machines to a cluster in vSphere

You can add more compute machines to a user-provisioned OpenShift Container Platform cluster on VMware vSphere.

### Prerequisites

- Obtain the base64-encoded Ignition file for your compute machines.
- You have access to the vSphere template that you created for your cluster.

### Procedure

1. After the template deploys, deploy a VM for a machine in the cluster.
  - a. Right-click the template's name and click **Clone → Clone to Virtual Machine**
  - b. On the **Select a name and folder** tab, specify a name for the VM. You might include the machine type in the name, such as **compute-1**.
  - c. On the **Select a name and folder** tab, select the name of the folder that you created for the cluster.
  - d. On the **Select a compute resource** tab, select the name of a host in your datacenter.
  - e. Optional: On the **Select storage** tab, customize the storage options.
  - f. On the **Select clone options**, select **Customize this virtual machine's hardware**
  - g. On the **Customize hardware** tab, click **VM Options → Advanced**.
    - From the **Latency Sensitivity** list, select **High**.
    - Click **Edit Configuration**, and on the **Configuration Parameters** window, click **Add Configuration Params**. Define the following parameter names and values:
      - o **guestinfo.ignition.config.data**: Paste the contents of the base64-encoded compute Ignition config file for this machine type.



- **guestinfo.ignition.config.data.encoding**: Specify **base64**.
  - **disk.EnableUUID**: Specify **TRUE**.
- h. In the **Virtual Hardware** panel of the **Customize hardware** tab, modify the specified values as required. Ensure that the amount of RAM, CPU, and disk storage meets the minimum requirements for the machine type. Also, make sure to select the correct network under **Add network adapter** if there are multiple networks available.
  - i. Complete the configuration and power on the VM.
2. Continue to create more compute machines for your cluster.

### 17.6.17. Disk partitioning

In most cases, data partitions are originally created by installing RHCOS, rather than by installing another operating system. In such cases, the OpenShift Container Platform installer should be allowed to configure your disk partitions.

However, there are two cases where you might want to intervene to override the default partitioning when installing an OpenShift Container Platform node:

- **Create separate partitions**: For greenfield installations on an empty disk, you might want to add separate storage to a partition. This is officially supported for making **/var** or a subdirectory of **/var**, such as **/var/lib/etcd**, a separate partition, but not both.



#### IMPORTANT

For disk sizes larger than 100GB, and especially disk sizes larger than 1TB, create a separate **/var** partition. See "Creating a separate **/var** partition" and this [Red Hat Knowledgebase article](#) for more information.



#### IMPORTANT

Kubernetes supports only two file system partitions. If you add more than one partition to the original configuration, Kubernetes cannot monitor all of them.

- **Retain existing partitions**: For a brownfield installation where you are reinstalling OpenShift Container Platform on an existing node and want to retain data partitions installed from your previous operating system, there are both boot arguments and options to **coreos-installer** that allow you to retain existing data partitions.

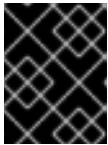
### Creating a separate **/var** partition

In general, disk partitioning for OpenShift Container Platform should be left to the installer. However, there are cases where you might want to create separate partitions in a part of the filesystem that you expect to grow.

OpenShift Container Platform supports the addition of a single partition to attach storage to either the **/var** partition or a subdirectory of **/var**. For example:

- **/var/lib/containers**: Holds container-related content that can grow as more images and containers are added to a system.
- **/var/lib/etcd**: Holds data that you might want to keep separate for purposes such as performance optimization of etcd storage.

- **/var**: Holds data that you might want to keep separate for purposes such as auditing.



## IMPORTANT

For disk sizes larger than 100GB, and especially larger than 1TB, create a separate **/var** partition.

Storing the contents of a **/var** directory separately makes it easier to grow storage for those areas as needed and reinstall OpenShift Container Platform at a later date and keep that data intact. With this method, you will not have to pull all your containers again, nor will you have to copy massive log files when you update systems.

Because **/var** must be in place before a fresh installation of Red Hat Enterprise Linux CoreOS (RHCOS), the following procedure sets up the separate **/var** partition by creating a machine config manifest that is inserted during the **openshift-install** preparation phases of an OpenShift Container Platform installation.

### Procedure

1. Create a directory to hold the OpenShift Container Platform installation files:

```
$ mkdir $HOME/clusterconfig
```

2. Run **openshift-install** to create a set of files in the **manifest** and **openshift** subdirectories. Answer the system questions as you are prompted:

```
$ openshift-install create manifests --dir $HOME/clusterconfig
? SSH Public Key ...
$ ls $HOME/clusterconfig/openshift/
99_kubeadmin-password-secret.yaml
99_openshift-cluster-api_master-machines-0.yaml
99_openshift-cluster-api_master-machines-1.yaml
99_openshift-cluster-api_master-machines-2.yaml
...
```

3. Create a Butane config that configures the additional partition. For example, name the file **`$HOME/clusterconfig/98-var-partition.bu`**, change the disk device name to the name of the storage device on the **worker** systems, and set the storage size as appropriate. This example places the **/var** directory on a separate partition:

```
variant: openshift
version: 4.9.0
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 98-var-partition
storage:
  disks:
    - device: /dev/<device_name> 1
    partitions:
      - label: var
        start_mib: <partition_start_offset> 2
        size_mib: <partition_size> 3
  filesystems:
```

```
- device: /dev/disk/by-partlabel/var
  path: /var
  format: xfs
  mount_options: [defaults, prjquota] 4
  with_mount_unit: true
```

- 1 The storage device name of the disk that you want to partition.
- 2 When adding a data partition to the boot disk, a minimum value of 25000 mebibytes is recommended. The root file system is automatically resized to fill all available space up to the specified offset. If no value is specified, or if the specified value is smaller than the recommended minimum, the resulting root file system will be too small, and future reinstalls of RHCOS might overwrite the beginning of the data partition.
- 3 The size of the data partition in mebibytes.
- 4 The **prjquota** mount option must be enabled for filesystems used for container storage.



#### NOTE

When creating a separate **/var** partition, you cannot use different instance types for worker nodes, if the different instance types do not have the same device name.

4. Create a manifest from the Butane config and save it to the **clusterconfig/openshift** directory. For example, run the following command:

```
$ butane $HOME/clusterconfig/98-var-partition.bu -o $HOME/clusterconfig/openshift/98-var-partition.yaml
```

5. Run **openshift-install** again to create Ignition configs from a set of files in the **manifest** and **openshift** subdirectories:

```
$ openshift-install create ignition-configs --dir $HOME/clusterconfig
$ ls $HOME/clusterconfig/
auth bootstrap.ign master.ign metadata.json worker.ign
```

Now you can use the Ignition config files as input to the vSphere installation procedures to install Red Hat Enterprise Linux CoreOS (RHCOS) systems.

### 17.6.18. Updating the bootloader using bootupd

To update the bootloader by using **bootupd**, you must either install **bootupd** on RHCOS machines manually or provide a machine config with the enabled **systemd** unit. Unlike **grubby** or other bootloader tools, **bootupd** does not manage kernel space configuration such as passing kernel arguments.

After you have installed **bootupd**, you can manage it remotely from the OpenShift Container Platform cluster.



## NOTE

It is recommended that you use **bootupd** only on bare metal or virtualized hypervisor installations, such as for protection against the BootHole vulnerability.

### Manual install method

You can manually install **bootupd** by using the **bootctl** command-line tool.

1. Inspect the system status:

```
# bootupctl status
```

#### Example output

```
Component EFI
Installed: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
Update: At latest version
```

2. RHCOS images created without **bootupd** installed on them require an explicit adoption phase. If the system status is **Adoptable**, perform the adoption:

```
# bootupctl adopt-and-update
```

#### Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

3. If an update is available, apply the update so that the changes take effect on the next reboot:

```
# bootupctl update
```

#### Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

### Machine config method

Another way to enable **bootupd** is by providing a machine config.

- Provide a machine config file with the enabled **systemd** unit, as shown in the following example:

#### Example output

```
variant: rhcos
version: 1.1.0
systemd:
units:
- name: custom-bootupd-auto.service
enabled: true
contents: |
[Unit]
Description=Bootupd automatic update
```

```
[Service]
ExecStart=/usr/bin/bootupctl update
RemainAfterExit=yes
```

```
[Install]
WantedBy=multi-user.target
```

### 17.6.19. Waiting for the bootstrap process to complete

The OpenShift Container Platform bootstrap process begins after the cluster nodes first boot into the persistent RHCOS environment that has been installed to disk. The configuration information provided through the Ignition config files is used to initialize the bootstrap process and install OpenShift Container Platform on the machines. You must wait for the bootstrap process to complete.

#### Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have obtained the installation program and generated the Ignition config files for your cluster.
- You installed RHCOS on your cluster machines and provided the Ignition config files that the OpenShift Container Platform installation program generated.
- Your machines have direct internet access or have an HTTP or HTTPS proxy available.

#### Procedure

1. Monitor the bootstrap process:

```
$ ./openshift-install --dir <installation_directory> wait-for bootstrap-complete \ 1
--log-level=info 2
```

- 1 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

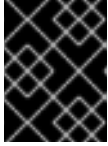
- 2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

#### Example output

```
INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...
INFO API v1.22.1 up
INFO Waiting up to 30m0s for bootstrapping to complete...
INFO It is now safe to remove the bootstrap resources
```

The command succeeds when the Kubernetes API server signals that it has been bootstrapped on the control plane machines.

2. After bootstrap process is complete, remove the bootstrap machine from the load balancer.



## IMPORTANT

You must remove the bootstrap machine from the load balancer at this point. You can also remove or reformat the bootstrap machine itself.

### 17.6.20. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

#### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

#### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

#### Example output

```
system:admin
```

### 17.6.21. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

#### Prerequisites

- You added machines to your cluster.

#### Procedure

1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

#### Example output

NAME	STATUS	ROLES	AGE	VERSION
master-0	Ready	master	63m	v1.22.1
master-1	Ready	master	63m	v1.22.1
master-2	Ready	master	64m	v1.22.1

The output lists all of the machines that you created.



#### NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

- Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

#### Example output

NAME	AGE	REQUESTOR	CONDITION
csr-8b2br	15m	system:serviceaccount:openshift-machine-config-operator:node-bootstrapper	Pending
csr-8vnps	15m	system:serviceaccount:openshift-machine-config-operator:node-bootstrapper	Pending
...			

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

- If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:



#### NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.

**NOTE**

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrap** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{"\n"}{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```

**NOTE**

Some Operators might not become available until some CSRs are approved.

- Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

**Example output**

```
NAME      AGE   REQUESTOR                                     CONDITION
csr-bfd72 5m26s system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv 5m26s system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

- If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** **<csr\_name>** is the name of a CSR from the list of current CSRs.



- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{\n"}\n{{end}}' | xargs oc adm certificate approve
```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

### Example output

```
NAME      STATUS  ROLES  AGE  VERSION
master-0  Ready   master 73m  v1.22.1
master-1  Ready   master 73m  v1.22.1
master-2  Ready   master 74m  v1.22.1
worker-0  Ready   worker 11m  v1.22.1
worker-1  Ready   worker 11m  v1.22.1
```



### NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

### Additional information

- For more information on CSRs, see [Certificate Signing Requests](#).

#### 17.6.21.1. Initial Operator configuration

After the control plane initializes, you must immediately configure some Operators so that they all become available.

### Prerequisites

- Your control plane has initialized.

### Procedure

1. Watch the cluster components come online:

```
$ watch -n5 oc get clusteroperators
```

### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
authentication	4.9.0	True	False	False	19m
baremetal	4.9.0	True	False	False	37m
cloud-credential	4.9.0	True	False	False	40m
cluster-autoscaler	4.9.0	True	False	False	37m
config-operator	4.9.0	True	False	False	38m

console	4.9.0	True	False	False	26m
csi-snapshot-controller	4.9.0	True	False	False	37m
dns	4.9.0	True	False	False	37m
etcd	4.9.0	True	False	False	36m
image-registry	4.9.0	True	False	False	31m
ingress	4.9.0	True	False	False	30m
insights	4.9.0	True	False	False	31m
kube-apiserver	4.9.0	True	False	False	26m
kube-controller-manager	4.9.0	True	False	False	36m
kube-scheduler	4.9.0	True	False	False	36m
kube-storage-version-migrator	4.9.0	True	False	False	37m
machine-api	4.9.0	True	False	False	29m
machine-approver	4.9.0	True	False	False	37m
machine-config	4.9.0	True	False	False	36m
marketplace	4.9.0	True	False	False	37m
monitoring	4.9.0	True	False	False	29m
network	4.9.0	True	False	False	38m
node-tuning	4.9.0	True	False	False	37m
openshift-apiserver	4.9.0	True	False	False	32m
openshift-controller-manager	4.9.0	True	False	False	30m
openshift-samples	4.9.0	True	False	False	32m
operator-lifecycle-manager	4.9.0	True	False	False	37m
operator-lifecycle-manager-catalog	4.9.0	True	False	False	37m
operator-lifecycle-manager-packageserver	4.9.0	True	False	False	32m
service-ca	4.9.0	True	False	False	38m
storage	4.9.0	True	False	False	37m

2. Configure the Operators that are not available.

### 17.6.21.2. Image registry removed during installation

On platforms that do not provide shareable object storage, the OpenShift Image Registry Operator bootstraps itself as **Removed**. This allows **openshift-installer** to complete installations on these platform types.

After installation, you must edit the Image Registry Operator configuration to switch the **managementState** from **Removed** to **Managed**.



#### NOTE

The Prometheus console provides an **ImageRegistryRemoved** alert, for example:

"Image Registry has been removed. **ImageStreamTags**, **BuildConfigs** and **DeploymentConfigs** which reference **ImageStreamTags** may not work as expected. Please configure storage and update the config to **Managed** state by editing `configs.imageregistry.operator.openshift.io`."

### 17.6.21.3. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

### 17.6.21.3.1. Configuring block registry storage for VMware vSphere

To allow the image registry to use block storage types such as vSphere Virtual Machine Disk (VMDK) during upgrades as a cluster administrator, you can use the **Recreate** rollout strategy.



#### IMPORTANT

Block storage volumes are supported but not recommended for use with image registry on production clusters. An installation where the registry is configured on block storage is not highly available because the registry cannot have more than one replica.

#### Procedure

1. To set the image registry storage as a block storage type, patch the registry so that it uses the **Recreate** rollout strategy and runs with only **1** replica:

```
$ oc patch config.imageregistry.operator.openshift.io/cluster --type=merge -p '{"spec": {"rolloutStrategy": "Recreate", "replicas": 1}}'
```

2. Provision the PV for the block storage device, and create a PVC for that volume. The requested block volume uses the ReadWriteOnce (RWO) access mode.
  - a. Create a **pvc.yaml** file with the following contents to define a VMware vSphere **PersistentVolumeClaim** object:

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: image-registry-storage 1
  namespace: openshift-image-registry 2
spec:
  accessModes:
    - ReadWriteOnce 3
  resources:
    requests:
      storage: 100Gi 4
```

- 1 A unique name that represents the **PersistentVolumeClaim** object.
- 2 The namespace for the **PersistentVolumeClaim** object, which is **openshift-image-registry**.
- 3 The access mode of the persistent volume claim. With **ReadWriteOnce**, the volume can be mounted with read and write permissions by a single node.
- 4 The size of the persistent volume claim.

- b. Create the **PersistentVolumeClaim** object from the file:

```
$ oc create -f pvc.yaml -n openshift-image-registry
```

3. Edit the registry configuration so that it references the correct PVC:

```
$ oc edit config.imageregistry.operator.openshift.io -o yaml
```

### Example output

```
storage:
  pvc:
    claim: 1
```

- 1 Creating a custom PVC allows you to leave the **claim** field blank for the default automatic creation of an **image-registry-storage** PVC.

For instructions about configuring registry storage so that it references the correct PVC, see [Configuring the registry for vSphere](#).

## 17.6.22. Completing installation on user-provisioned infrastructure

After you complete the Operator configuration, you can finish installing the cluster on infrastructure that you provide.

### Prerequisites

- Your control plane has initialized.
- You have completed the initial Operator configuration.

### Procedure

1. Confirm that all the cluster components are online with the following command:

```
$ watch -n5 oc get clusteroperators
```

### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
authentication	4.9.0	True	False	False	19m
baremetal	4.9.0	True	False	False	37m
cloud-credential	4.9.0	True	False	False	40m
cluster-autoscaler	4.9.0	True	False	False	37m
config-operator	4.9.0	True	False	False	38m
console	4.9.0	True	False	False	26m
csi-snapshot-controller	4.9.0	True	False	False	37m
dns	4.9.0	True	False	False	37m
etcd	4.9.0	True	False	False	36m
image-registry	4.9.0	True	False	False	31m
ingress	4.9.0	True	False	False	30m

insights	4.9.0	True	False	False	31m
kube-apiserver	4.9.0	True	False	False	26m
kube-controller-manager	4.9.0	True	False	False	36m
kube-scheduler	4.9.0	True	False	False	36m
kube-storage-version-migrator	4.9.0	True	False	False	37m
machine-api	4.9.0	True	False	False	29m
machine-approver	4.9.0	True	False	False	37m
machine-config	4.9.0	True	False	False	36m
marketplace	4.9.0	True	False	False	37m
monitoring	4.9.0	True	False	False	29m
network	4.9.0	True	False	False	38m
node-tuning	4.9.0	True	False	False	37m
openshift-apiserver	4.9.0	True	False	False	32m
openshift-controller-manager	4.9.0	True	False	False	30m
openshift-samples	4.9.0	True	False	False	32m
operator-lifecycle-manager	4.9.0	True	False	False	37m
operator-lifecycle-manager-catalog	4.9.0	True	False	False	37m
operator-lifecycle-manager-packageserver	4.9.0	True	False	False	32m
service-ca	4.9.0	True	False	False	38m
storage	4.9.0	True	False	False	37m

Alternatively, the following command notifies you when all of the clusters are available. It also retrieves and displays credentials:

```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

### Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

The command succeeds when the Cluster Version Operator finishes deploying the OpenShift Container Platform cluster from Kubernetes API server.

### IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Confirm that the Kubernetes API server is communicating with the pods.

a. To view a list of all pods, use the following command:

```
$ oc get pods --all-namespaces
```

#### Example output

```

NAMESPACE           NAME                                     READY  STATUS
RESTARTS  AGE
openshift-apiserver-operator  openshift-apiserver-operator-85cb746d55-zqhs8  1/1
Running   1    9m
openshift-apiserver          apiserver-67b9g                                1/1  Running  0
3m
openshift-apiserver          apiserver-ljcmx                                1/1  Running  0
1m
openshift-apiserver          apiserver-z25h4                                1/1  Running  0
2m
openshift-authentication-operator  authentication-operator-69d5d8bf84-vh2n8    1/1
Running   0    5m
...

```

b. View the logs for a pod that is listed in the output of the previous command by using the following command:

```
$ oc logs <pod_name> -n <namespace> 1
```

**1** Specify the pod name and namespace, as shown in the output of the previous command.

If the pod logs display, the Kubernetes API server can communicate with the cluster machines.

3. For an installation with Fibre Channel Protocol (FCP), additional steps are required to enable multipathing. Do not enable multipathing during installation. See "Enabling multipathing with kernel arguments on RHCOS" in the *Post-installation machine configuration tasks* documentation for more information.

You can add extra compute machines after the cluster installation is completed by following [Adding compute machines to vSphere](#).

### 17.6.23. Backing up VMware vSphere volumes

OpenShift Container Platform provisions new volumes as independent persistent disks to freely attach and detach the volume on any node in the cluster. As a consequence, it is not possible to back up volumes that use snapshots, or to restore volumes from snapshots. See [Snapshot Limitations](#) for more information.

#### Procedure

To create a backup of persistent volumes:

1. Stop the application that is using the persistent volume.

2. Clone the persistent volume.
3. Restart the application.
4. Create a backup of the cloned volume.
5. Delete the cloned volume.

### 17.6.24. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

#### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

### 17.6.25. Next steps

- [Customize your cluster](#).
- If necessary, you can [opt out of remote health reporting](#) .
- [Set up your registry and configure registry storage](#) .
- Optional: [View the events from the vSphere Problem Detector Operator](#) to determine if the cluster has permission or storage configuration issues.

## 17.7. INSTALLING A CLUSTER ON VSPHERE IN A RESTRICTED NETWORK

In OpenShift Container Platform 4.9, you can install a cluster on VMware vSphere infrastructure in a restricted network by creating an internal mirror of the installation release content.



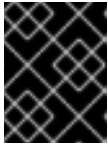
#### NOTE

OpenShift Container Platform supports deploying a cluster to a single VMware vCenter only. Deploying a cluster with machines/machine sets on multiple vCenters is not supported.

### 17.7.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).

- You [created a registry on your mirror host](#) and obtained the **imageContentSources** data for your version of OpenShift Container Platform.



### IMPORTANT

Because the installation media is on the mirror host, you can use that computer to complete all installation steps.

- You provisioned [persistent storage](#) for your cluster. To deploy a private image registry, your storage must provide the ReadWriteMany access mode.
- The OpenShift Container Platform installer requires access to port 443 on the vCenter and ESXi hosts. You verified that port 443 is accessible.
- If you use a firewall, you confirmed with the administrator that port 443 is accessible. Control plane nodes must be able to reach vCenter and ESXi hosts on port 443 for the installation to succeed.
- If you use a firewall and plan to use the Telemetry service, you [configured the firewall to allow the sites](#) that your cluster requires access to.



### NOTE

If you are configuring a proxy, be sure to also review this site list.

## 17.7.2. About installations in restricted networks

In OpenShift Container Platform 4.9, you can perform an installation that does not require an active connection to the internet to obtain software components. Restricted network installations can be completed using installer-provisioned infrastructure or user-provisioned infrastructure, depending on the cloud platform to which you are installing the cluster.

If you choose to perform a restricted network installation on a cloud platform, you still require access to its cloud APIs. Some cloud functions, like Amazon Web Service's Route 53 DNS and IAM services, require internet access. Depending on your network, you might require less internet access for an installation on bare metal hardware or on VMware vSphere.

To complete a restricted network installation, you must create a registry that mirrors the contents of the OpenShift Container Platform registry and contains the installation media. You can create this registry on a mirror host, which can access both the internet and your closed network, or by using other methods that meet your restrictions.

### 17.7.2.1. Additional limits

Clusters in restricted networks have the following additional limitations and restrictions:

- The **ClusterVersion** status includes an **Unable to retrieve available updates** error.
- By default, you cannot use the contents of the Developer Catalog because you cannot access the required image stream tags.

## 17.7.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to obtain the images that are necessary to install your cluster.



You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



### IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

#### 17.7.4. VMware vSphere infrastructure requirements

You must install the OpenShift Container Platform cluster on a VMware vSphere version 6 or 7 instance that meets the requirements for the components that you use.

**Table 17.63. Version requirements for vSphere virtual environments**

Virtual environment product	Required version
VM hardware version	13 or later
vSphere ESXi hosts	6.5 or later
vCenter host	6.5 or later



### IMPORTANT

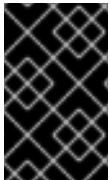
Installing a cluster on VMware vSphere version 6.7U2 or earlier and virtual hardware version 13 is now deprecated. These versions are still fully supported, but support will be removed in a future version of OpenShift Container Platform. Hardware version 15 is now the default for vSphere virtual machines in OpenShift Container Platform. To update the hardware version for your vSphere nodes, see the "Updating hardware on nodes running in vSphere" article.

**Table 17.64. Minimum supported vSphere version for VMware components**

Component	Minimum supported versions	Description
-----------	----------------------------	-------------

Component	Minimum supported versions	Description
Hypervisor	vSphere 6.5 and later with HW version 13	This version is the minimum version that Red Hat Enterprise Linux CoreOS (RHCOS) supports. See the <a href="#">Red Hat Enterprise Linux 8 supported hypervisors list</a> .
Storage with in-tree drivers	vSphere 6.5 and later	This plugin creates vSphere storage by using the in-tree storage drivers for vSphere included in OpenShift Container Platform.
Optional: Networking (NSX-T)	vSphere 6.5U3 or vSphere 6.7U2 and later	vSphere 6.5U3 or vSphere 6.7U2+ are required for OpenShift Container Platform. For more information about the compatibility of NSX and OpenShift Container Platform, see the Release Notes section of VMware's <a href="#">NSX container plugin documentation</a> .

If you use a vSphere version 6.5 instance, consider upgrading to 6.7U3 or 7.0 before you install OpenShift Container Platform.



### IMPORTANT

You must ensure that the time on your ESXi hosts is synchronized before you install OpenShift Container Platform. See [Edit Time Configuration for a Host](#) in the VMware documentation.

## 17.7.5. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate.

Review the following details about the required network ports.

**Table 17.65. Ports used for all-machine to all-machine communications**

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	<b>1936</b>	Metrics
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> and the Cluster Version Operator on port <b>9099</b> .

Protocol	Port	Description
	<b>10250-10259</b>	The default ports that Kubernetes reserves
	<b>10256</b>	openshift-sdn
UDP	<b>4789</b>	virtual extensible LAN (VXLAN)
	<b>6081</b>	Geneve
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> .
	<b>500</b>	IPsec IKE packets
	<b>4500</b>	IPsec NAT-T packets
TCP/UDP	<b>30000-32767</b>	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 17.66. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	<b>6443</b>	Kubernetes API

Table 17.67. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	<b>2379-2380</b>	etcd server and peer ports

#### Additional resources

- To update the hardware version for your vSphere nodes, see [Updating hardware on nodes running in vSphere](#).

#### 17.7.6. vCenter requirements

Before you install an OpenShift Container Platform cluster on your vCenter that uses infrastructure that the installer provisions, you must prepare your environment.

#### Required vCenter account privileges

To install an OpenShift Container Platform cluster in a vCenter, the installation program requires access to an account with privileges to read and create the required resources. Using an account that has global administrative privileges is the simplest way to access all of the necessary permissions.

If you cannot use an account with global administrative privileges, you must create roles to grant the privileges necessary for OpenShift Container Platform cluster installation. While most of the privileges are always required, some are required only if you plan for the installation program to provision a folder to contain the OpenShift Container Platform cluster on your vCenter instance, which is the default behavior. You must create or amend vSphere roles for the specified objects to grant the required privileges.

An additional role is required if the installation program is to create a vSphere virtual machine folder.

#### Example 17.16. Roles and privileges required for installation in vSphere API

vSphere object for role	When required	Required privileges in vSphere API
vSphere vCenter	Always	<b>Cns.Searchable</b> <b>InventoryService.Tagging.AttachTag</b> <b>InventoryService.Tagging.CreateCategory</b> <b>InventoryService.Tagging.CreateTag</b> <b>InventoryService.Tagging.DeleteCategory</b> <b>InventoryService.Tagging.DeleteTag</b> <b>InventoryService.Tagging.EditCategory</b> <b>InventoryService.Tagging.EditTag</b> <b>Sessions.ValidateSession</b> <b>StorageProfile.Update</b> <b>StorageProfile.View</b>
vSphere vCenter Cluster	Always	<b>Host.Config.StorageResource.AssignVMToPool</b> <b>VApp.AssignResourcePool</b> <b>VApp.Import</b> <b>VirtualMachine.Config.AddNewDisk</b>
vSphere Datastore	Always	<b>Datastore.AllocateSpace</b> <b>Datastore.Browse</b> <b>Datastore.FileManagement</b> <b>InventoryService.Tagging.ObjectAttachable</b>
vSphere Port Group	Always	<b>Network.Assign</b>
Virtual Machine Folder	Always	<b>InventoryService.Tagging.ObjectAttachable</b>

vSphere object for role	When required	Resource.AssignVMToPool Required privileges in vSphere API
		<b>VirtualMachine.Config.AddExistingDisk</b> <b>VirtualMachine.Config.AddNewDisk</b> <b>VirtualMachine.Config.AddRemoveDevice</b> <b>VirtualMachine.Config.AdvancedConfig</b> <b>VirtualMachine.Config.Annotation</b> <b>VirtualMachine.Config.CPUCount</b> <b>VirtualMachine.Config.DiskExtend</b> <b>VirtualMachine.Config.DiskLease</b> <b>VirtualMachine.Config.EditDevice</b> <b>VirtualMachine.Config.Memory</b> <b>VirtualMachine.Config.RemoveDisk</b> <b>VirtualMachine.Config.Rename</b> <b>VirtualMachine.Config.ResetGuestInfo</b> <b>VirtualMachine.Config.Resource</b> <b>VirtualMachine.Config.Settings</b> <b>VirtualMachine.Config.UpgradeVirtualHardware</b> <b>VirtualMachine.Interact.GuestControl</b> <b>VirtualMachine.Interact.PowerOff</b> <b>VirtualMachine.Interact.PowerOn</b> <b>VirtualMachine.Interact.Reset</b> <b>VirtualMachine.Inventory.Create</b> <b>VirtualMachine.Inventory.CreateFromExisting</b> <b>VirtualMachine.Inventory.Delete</b> <b>VirtualMachine.Provisioning.Clone</b> <b>VirtualMachine.Provisioning.MarkAsTemplate</b> <b>VirtualMachine.Provisioning.DeployTemplate</b>
vSphere vCenter Datacenter		<b>InventoryService.Tagging.O</b>

vSphere object for role	If the installation program creates the virtual machine folder When required	ObjectAttachable Required privileges in vSphere API Resource.AssignVMToPool VApp.Import
		VirtualMachine.Config.AddExistingDisk VirtualMachine.Config.AddNewDisk VirtualMachine.Config.AddRemoveDevice VirtualMachine.Config.AdvancedConfig VirtualMachine.Config.Annotation VirtualMachine.Config.CPUCount VirtualMachine.Config.DiskExtend VirtualMachine.Config.DiskLease VirtualMachine.Config.EditDevice VirtualMachine.Config.Memory VirtualMachine.Config.RemoveDisk VirtualMachine.Config.Rename VirtualMachine.Config.ResetGuestInfo VirtualMachine.Config.Resource VirtualMachine.Config.Settings VirtualMachine.Config.UpgradeVirtualHardware VirtualMachine.Interact.GuestControl VirtualMachine.Interact.PowerOff VirtualMachine.Interact.PowerOn VirtualMachine.Interact.Reset VirtualMachine.Inventory.Create VirtualMachine.Inventory.CreateFromExisting VirtualMachine.Inventory.Delete VirtualMachine.Provisioning.Clone VirtualMachine.Provisioning.DeployTemplate VirtualMachine.Provisioning

vSphere object for role	When required	Required privileges in vSphere API
		g.MarkAsTemplate Folder.Create Folder.Delete

Example 17.17. Roles and privileges required for installation in vCenter graphical user interface (GUI)

vSphere object for role	When required	Required privileges in vCenter GUI
vSphere vCenter	Always	<b>Cns.Searchable</b> <b>"vSphere Tagging"."Assign or Unassign vSphere Tag"</b> <b>"vSphere Tagging"."Create vSphere Tag Category"</b> <b>"vSphere Tagging"."Create vSphere Tag"</b> <b>vSphere Tagging"."Delete vSphere Tag Category"</b> <b>"vSphere Tagging"."Delete vSphere Tag"</b> <b>"vSphere Tagging"."Edit vSphere Tag Category"</b> <b>"vSphere Tagging"."Edit vSphere Tag"</b> <b>Sessions."Validate session"</b> <b>"Profile-driven storage"."Profile-driven storage update"</b> <b>"Profile-driven storage"."Profile-driven storage view"</b>
vSphere vCenter Cluster	If VMs will be created in the cluster root	<b>Host.Configuration."Storage partition configuration"</b> <b>Resource."Assign virtual machine to resource pool"</b> <b>VApp."Assign resource pool"</b> <b>VApp.Import</b> <b>"Virtual machine"."Change Configuration"."Add new disk"</b>

vSphere object for role	When required	Required privileges in vCenter GUI
vSphere vCenter Resource Pool	If an existing resource pool is provided	<b>Host.Configuration."Storage partition configuration"</b> <b>Resource."Assign virtual machine to resource pool"</b> <b>VApp."Assign resource pool"</b> <b>VApp.Import</b> <b>"Virtual machine"."Change Configuration"."Add new disk"</b>
vSphere Datastore	Always	<b>Datastore."Allocate space"</b> <b>Datastore."Browse datastore"</b> <b>Datastore."Low level file operations"</b> <b>"vSphere Tagging"."Assign or Unassign vSphere Tag on Object"</b>
vSphere Port Group	Always	<b>Network."Assign network"</b>
Virtual Machine Folder	Always	<b>"vSphere Tagging"."Assign or Unassign vSphere Tag on Object"</b> <b>Resource."Assign virtual machine to resource pool"</b> <b>VApp.Import</b> <b>"Virtual machine"."Change Configuration"."Add existing disk"</b> <b>"Virtual machine"."Change Configuration"."Add new disk"</b> <b>"Virtual machine"."Change Configuration"."Add or remove device"</b> <b>"Virtual machine"."Change Configuration"."Advanced configuration"</b> <b>"Virtual machine"."Change Configuration"."Set annotation"</b> <b>"Virtual machine"."Change Configuration"."Change CPU count"</b> <b>"Virtual machine"."Change Configuration"."Extend virtual disk"</b> <b>"Virtual machine"."Change Configuration"."Acquire</b>



vSphere object for role	When required	Required privileges in vCenter GUI
		<p>disk lease"</p> <p>Virtual machine : Change Configuration". "Modify device settings"</p> <p>"Virtual machine". "Change Configuration". "Change Memory"</p> <p>"Virtual machine". "Change Configuration". "Remove disk"</p> <p>"Virtual machine". "Change Configuration". Rename</p> <p>"Virtual machine". "Change Configuration". "Reset guest information"</p> <p>"Virtual machine". "Change Configuration". "Change resource"</p> <p>"Virtual machine". "Change Configuration". "Change Settings"</p> <p>"Virtual machine". "Change Configuration". "Upgrade virtual machine compatibility"</p> <p>"Virtual machine". Interaction. "Guest operating system management by VIX API"</p> <p>"Virtual machine". Interaction. "Power off"</p> <p>"Virtual machine". Interaction. "Power on"</p> <p>"Virtual machine". Interaction. Reset</p> <p>"Virtual machine". "Edit Inventory". "Create new"</p> <p>"Virtual machine". "Edit Inventory". "Create from existing"</p> <p>"Virtual machine". "Edit Inventory". "Remove"</p> <p>"Virtual machine". Provisioning. "Clone virtual machine"</p> <p>"Virtual machine". Provisioning. "Mark as template"</p> <p>"Virtual machine". Provisioning. "Deploy template"</p>
vSphere vCenter Datacenter		"vSphere Tagging". "Assign or Unassign vSphere Tag

vSphere object for role	If the installation program creates the virtual machine folder <b>When required</b>	<b>on Object"</b> Required privileges in vCenter GUI Resource: Assign Virtual machine to resource pool"
		VApp.Import "Virtual machine"."Change Configuration"."Add existing disk" "Virtual machine"."Change Configuration"."Add new disk" "Virtual machine"."Change Configuration"."Add or remove device" "Virtual machine"."Change Configuration"."Advanced configuration" "Virtual machine"."Change Configuration"."Set annotation" "Virtual machine"."Change Configuration"."Change CPU count" "Virtual machine"."Change Configuration"."Extend virtual disk" "Virtual machine"."Change Configuration"."Acquire disk lease" "Virtual machine"."Change Configuration"."Modify device settings" "Virtual machine"."Change Configuration"."Change Memory" "Virtual machine"."Change Configuration"."Remove disk" "Virtual machine"."Change Configuration".Rename "Virtual machine"."Change Configuration"."Reset guest information" "Virtual machine"."Change Configuration"."Change resource" "Virtual machine"."Change Configuration"."Change Settings" "Virtual machine"."Change Configuration"."Upgrade virtual machine compatibility" "Virtual machine".Interaction."Guest operating system management by VIX API"

vSphere object for role	When required	Required privileges in vCenter GUI
		"Virtual machine".Interaction."Power on" "Virtual machine".Interaction.Reset "Virtual machine"."Edit Inventory"."Create new" "Virtual machine"."Edit Inventory"."Create from existing" "Virtual machine"."Edit Inventory"."Remove" "Virtual machine".Provisioning."Clone virtual machine" "Virtual machine".Provisioning."Deploy template" "Virtual machine".Provisioning."Mark as template" Folder."Create folder" Folder."Delete folder"

Additionally, the user requires some **ReadOnly** permissions, and some of the roles require permission to propagate the permissions to child objects. These settings vary depending on whether or not you install the cluster into an existing folder.

#### Example 17.18. Required permissions and propagation settings

vSphere object	Folder type	Propagate to children	Permissions required
vSphere vCenter	Always	False	Listed required privileges
vSphere vCenter Datacenter	Existing folder	False	<b>ReadOnly</b> permission
	Installation program creates the folder	True	Listed required privileges
vSphere vCenter Cluster	Always	True	Listed required privileges
vSphere vCenter Datastore	Always	False	Listed required privileges
vSphere Switch	Always	False	<b>ReadOnly</b> permission

vSphere object	Folder type	Propagate to children	Permissions required
vSphere Port Group	Always	False	Listed required privileges
vSphere vCenter Virtual Machine Folder	Existing folder	True	Listed required privileges

For more information about creating an account with only the required privileges, see [vSphere Permissions and User Management Tasks](#) in the vSphere documentation.

### Using OpenShift Container Platform with vMotion

If you intend on using vMotion in your vSphere environment, consider the following before installing a OpenShift Container Platform cluster.

- OpenShift Container Platform generally supports compute-only vMotion. Using Storage vMotion can cause issues and is not supported.  
To help ensure the uptime of your compute and control plane nodes, it is recommended that you follow the VMware best practices for vMotion. It is also recommended to use VMware anti-affinity rules to improve the availability of OpenShift Container Platform during maintenance or hardware issues.

For more information about vMotion and anti-affinity rules, see the VMware vSphere documentation for [vMotion networking requirements](#) and [VM anti-affinity rules](#).

- If you are using vSphere volumes in your pods, migrating a VM across datastores either manually or through Storage vMotion causes, invalid references within OpenShift Container Platform persistent volume (PV) objects. These references prevent affected pods from starting up and can result in data loss.
- Similarly, OpenShift Container Platform does not support selective migration of VMDKs across datastores, using datastore clusters for VM provisioning or for dynamic or static provisioning of PVs, or using a datastore that is part of a datastore cluster for dynamic or static provisioning of PVs.

### Cluster resources

When you deploy an OpenShift Container Platform cluster that uses installer-provisioned infrastructure, the installation program must be able to create several resources in your vCenter instance.

A standard OpenShift Container Platform installation creates the following vCenter resources:

- 1 Folder
- 1 Tag category
- 1 Tag
- Virtual machines:
  - 1 template
  - 1 temporary bootstrap node
  - 3 control plane nodes

- 3 compute machines

Although these resources use 856 GB of storage, the bootstrap node is destroyed during the cluster installation process. A minimum of 800 GB of storage is required to use a standard cluster.

If you deploy more compute machines, the OpenShift Container Platform cluster will use more storage.

### Cluster limits

Available resources vary between clusters. The number of possible clusters within a vCenter is limited primarily by available storage space and any limitations on the number of required resources. Be sure to consider both limitations to the vCenter resources that the cluster creates and the resources that you require to deploy a cluster, such as IP addresses and networks.

### Networking requirements

You must use DHCP for the network and ensure that the DHCP server is configured to provide persistent IP addresses to the cluster machines. You must configure the default gateway to use the DHCP server. All nodes must be in the same VLAN. You cannot scale the cluster using a second VLAN as a Day 2 operation. The VM in your restricted network must have access to vCenter so that it can provision and manage nodes, persistent volume claims (PVCs), and other resources. Additionally, you must create the following networking resources before you install the OpenShift Container Platform cluster:



#### NOTE

It is recommended that each OpenShift Container Platform node in the cluster must have access to a Network Time Protocol (NTP) server that is discoverable via DHCP. Installation is possible without an NTP server. However, asynchronous server clocks will cause errors, which NTP server prevents.

### Required IP Addresses

An installer-provisioned vSphere installation requires two static IP addresses:

- The **API** address is used to access the cluster API.
- The **Ingress** address is used for cluster ingress traffic.

You must provide these IP addresses to the installation program when you install the OpenShift Container Platform cluster.

### DNS records

You must create DNS records for two static IP addresses in the appropriate DNS server for the vCenter instance that hosts your OpenShift Container Platform cluster. In each record, **<cluster\_name>** is the cluster name and **<base\_domain>** is the cluster base domain that you specify when you install the cluster. A complete DNS record takes the form: **<component>.<cluster\_name>.<base\_domain>..**

**Table 17.68. Required DNS records**

Component	Record	Description
-----------	--------	-------------

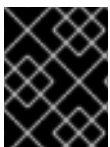
Component	Record	Description
API VIP	<b>api.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	This DNS A/AAAA or CNAME record must point to the load balancer for the control plane machines. This record must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
Ingress VIP	<b>*.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A wildcard DNS A/AAAA or CNAME record that points to the load balancer that targets the machines that run the Ingress router pods, which are the worker nodes by default. This record must be resolvable by both clients external to the cluster and from all the nodes within the cluster.

### 17.7.7. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.



#### IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



#### NOTE

You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

#### Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.



#### NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

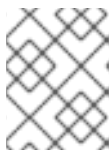
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.



#### NOTE

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

#### Example output

```
Agent pid 31874
```



#### NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1 Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

## Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

## Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

## 17.7.8. Adding vCenter root CA certificates to your system trust

Because the installation program requires access to your vCenter's API, you must add your vCenter's trusted root CA certificates to your system trust before you install an OpenShift Container Platform cluster.

### Procedure

1. From the vCenter home page, download the vCenter's root CA certificates. Click **Download trusted root CA certificates** in the vSphere Web Services SDK section. The **<vCenter>/certs/download.zip** file downloads.
2. Extract the compressed file that contains the vCenter root CA certificates. The contents of the compressed file resemble the following file structure:

```
certs
├── lin
│   ├── 108f4d17.0
│   ├── 108f4d17.r1
│   ├── 7e757f6a.0
│   ├── 8e4f8471.0
│   └── 8e4f8471.r0
├── mac
│   ├── 108f4d17.0
│   ├── 108f4d17.r1
│   ├── 7e757f6a.0
│   ├── 8e4f8471.0
│   └── 8e4f8471.r0
└── win
    ├── 108f4d17.0.crt
    ├── 108f4d17.r1.crl
    ├── 7e757f6a.0.crt
    ├── 8e4f8471.0.crt
    └── 8e4f8471.r0.crl
```

3 directories, 15 files

3. Add the files for your operating system to the system trust. For example, on a Fedora operating system, run the following command:

```
# cp certs/lin/* /etc/pki/ca-trust/source/anchors
```

4. Update your system trust. For example, on a Fedora operating system, run the following command:



```
# update-ca-trust extract
```

### 17.7.9. Creating the RHCOS image for restricted network installations

Download the Red Hat Enterprise Linux CoreOS (RHCOS) image to install OpenShift Container Platform on a restricted network VMware vSphere environment.

#### Prerequisites

- Obtain the OpenShift Container Platform installation program. For a restricted network installation, the program is on your mirror registry host.

#### Procedure

1. Log in to the Red Hat Customer Portal's [Product Downloads page](#).
2. Under **Version**, select the most recent release of OpenShift Container Platform 4.9 for RHEL 8.



#### IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image versions that match your OpenShift Container Platform version if they are available.

3. Download the **Red Hat Enterprise Linux CoreOS (RHCOS) - vSphere** image.
4. Upload the image you downloaded to a location that is accessible from the bastion server.

The image is now available for a restricted installation. Note the image name or location for use in OpenShift Container Platform deployment.

### 17.7.10. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on VMware vSphere.

#### Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster. For a restricted network installation, these files are on your mirror host.
- Have the **imageContentSources** values that were generated during mirror registry creation.
- Obtain the contents of the certificate for your mirror registry.
- Retrieve a Red Hat Enterprise Linux CoreOS (RHCOS) image and upload it to an accessible location.
- Obtain service principal permissions at the subscription level.

#### Procedure

1. Create the **install-config.yaml** file.

- a. Change to the directory that contains the installation program and run the following command:

```
$. /openshift-install create install-config --dir <installation_directory> 1
```

- 1** For **<installation\_directory>**, specify the directory name to store the files that the installation program creates.



### IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

- b. At the prompts, provide the configuration details for your cloud:
  - i. Optional: Select an SSH key to use to access your cluster machines.



### NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

- ii. Select **vsphere** as the platform to target.
- iii. Specify the name of your vCenter instance.
- iv. Specify the user name and password for the vCenter account that has the required permissions to create the cluster.  
The installation program connects to your vCenter instance.
- v. Select the datacenter in your vCenter instance to connect to.
- vi. Select the default vCenter datastore to use.
- vii. Select the vCenter cluster to install the OpenShift Container Platform cluster in. The installation program uses the root resource pool of the vSphere cluster as the default resource pool.
- viii. Select the network in the vCenter instance that contains the virtual IP addresses and DNS records that you configured.
- ix. Enter the virtual IP address that you configured for control plane API access.
- x. Enter the virtual IP address that you configured for cluster ingress.
- xi. Enter the base domain. This base domain must be the same one that you used in the DNS records that you configured.

- xii. Enter a descriptive name for your cluster. The cluster name must be the same one that you used in the DNS records that you configured.
  - xiii. Paste the [pull secret from the Red Hat OpenShift Cluster Manager](#) .
2. In the **install-config.yaml** file, set the value of **platform.vsphere.clusterOSImage** to the image location or name. For example:

```
platform:
  vsphere:
    clusterOSImage: http://mirror.example.com/images/rhcos-43.81.201912131630.0-vmware.x86_64.ova?sha256=ffebbd68e8a1f2a245ca19522c16c86f67f9ac8e4e0c1f0a812b068b16f7265d
```

3. Edit the **install-config.yaml** file to provide the additional information that is required for an installation in a restricted network.
  - a. Update the **pullSecret** value to contain the authentication information for your registry:

```
pullSecret: '{"auths":{"<mirror_host_name>:5000":{"auth": "<credentials>","email": "you@example.com"}}}'
```

For **<mirror\_host\_name>**, specify the registry domain name that you specified in the certificate for your mirror registry, and for **<credentials>**, specify the base64-encoded user name and password for your mirror registry.

- b. Add the **additionalTrustBundle** parameter and value.

```
additionalTrustBundle: |
  -----BEGIN CERTIFICATE-----
  /-----END CERTIFICATE-----
```

The value must be the contents of the certificate file that you used for your mirror registry, which can be an existing, trusted certificate authority or the self-signed certificate that you generated for the mirror registry.

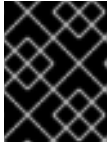
- c. Add the image content resources, which look like this excerpt:

```
imageContentSources:
- mirrors:
  - <mirror_host_name>:5000/<repo_name>/release
    source: quay.io/openshift-release-dev/ocp-release
- mirrors:
  - <mirror_host_name>:5000/<repo_name>/release
    source: registry.redhat.io/ocp/release
```

To complete these values, use the **imageContentSources** that you recorded during mirror registry creation.

4. Make any other modifications to the **install-config.yaml** file that you require. You can find more information about the available parameters in the **Installation configuration parameters** section.

5. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



### IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

#### 17.7.10.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.



### NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.



### IMPORTANT

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

#### 17.7.10.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 17.69. Required parameters

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;</b> . <b>&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .

Parameter	Description	Values
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}</b> . <b>{{.baseDomain}}</b> .	String of lowercase letters and hyphens (-), such as <b>dev</b> .
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws, baremetal, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } }</pre>


### 17.7.10.1.2. Network configuration parameters


You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

**Table 17.70. Network parameters**

Parameter	Description	Values
-----------	-------------	--------

Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	Object  <b>NOTE</b> You cannot modify parameters specified by the <b>networking</b> object after installation.
<b>networking.networkType</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .
<b>networking.clusterNetwork</b>	The IP address blocks for pods.  The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b> .  If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example:  <pre>networking:   clusterNetwork:     - cidr: 10.128.0.0/14       hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	Required if you use <b>networking.clusterNetwork</b> . An IP address block.  An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b> .
<b>networking.clusterNetwork.hostPrefix</b>	The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b> . A <b>hostPrefix</b> value of <b>23</b> provides 510 ( $2^{(32 - 23)} - 2$ ) pod IP addresses.	A subnet prefix.  The default value is <b>23</b> .


Parameter	Description	Values
<b>networking.serviceNetwork</b>	<p>The IP address block for services. The default value is <b>172.30.0.0/16</b>.</p> <p>The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.</p>	<p>An array with an IP address block in CIDR format. For example:</p> <pre>networking:   serviceNetwork:     - 172.30.0.0/16</pre>
<b>networking.machineNetwork</b>	<p>The IP address blocks for machines.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   machineNetwork:     - cidr: 10.0.0.0/16</pre>
<b>networking.machineNetwork.cidr</b>	<p>Required if you use <b>networking.machineNetwork</b>. An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b>.</p>	<p>An IP network block in CIDR notation.</p> <p>For example, <b>10.0.0.0/16</b>.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p> </div> </div>

### 17.7.10.1.3. Optional configuration parameters


Optional installation configuration parameters are described in the following table:



Table 17.71. Optional parameters

Parameter	Description	Values
<b>additionalTrustBundle</b>	<p>A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.</p>	String
<b>compute</b>	<p>The configuration for the machines that comprise the compute nodes.</p>	Array of <b>MachinePool</b> objects.


Parameter	Description	Values
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String
<b>compute.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b>
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String



Parameter	Description	Values
<b>controlPlane.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platform</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>controlPlane.replicas</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.

Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.</p> <p> <b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators reference content</i>.</p> <p> <b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p>	<b>Mint, Passthrough, Manual</b> or an empty string ("").

Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start;"> <div style="width: 40px; height: 40px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 40px; height: 40px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<b>Internal</b> or <b>External</b> . The default value is <b>External</b> .  Setting this field to <b>Internal</b> is not supported on non-cloud platforms.

Parameter	Description	Values
<b>sshKey</b>	<p>The SSH key or keys to authenticate access your cluster machines.</p>  <p><b>NOTE</b></p> <p>For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.</p>	<p>One or more keys. For example:</p> <pre>sshKey:   &lt;key1&gt;   &lt;key2&gt;   &lt;key3&gt;</pre>

#### 17.7.10.1.4. Additional VMware vSphere configuration parameters

Additional VMware vSphere configuration parameters are described in the following table:

Table 17.72. Additional VMware vSphere cluster parameters

Parameter	Description	Values
<b>platform.vsphere.vcenter</b>	The fully-qualified hostname or IP address of the vCenter server.	String
<b>platform.vsphere.username</b>	The user name to use to connect to the vCenter instance with. This user must have at least the roles and privileges that are required for <a href="#">static or dynamic persistent volume provisioning</a> in vSphere.	String
<b>platform.vsphere.password</b>	The password for the vCenter user name.	String
<b>platform.vsphere.datacenter</b>	The name of the datacenter to use in the vCenter instance.	String
<b>platform.vsphere.defaultDatastore</b>	The name of the default datastore to use for provisioning volumes.	String

Parameter	Description	Values
<b>platform.vsphere.folder</b>	<i>Optional.</i> The absolute path of an existing folder where the installation program creates the virtual machines. If you do not provide this value, the installation program creates a folder that is named with the infrastructure ID in the datacenter virtual machine folder.	String, for example, <code>/&lt;datacenter_name&gt;/vm/&lt;folder_name&gt;/&lt;subfolder_name&gt;</code> .
<b>platform.vsphere.network</b>	The network in the vCenter instance that contains the virtual IP addresses and DNS records that you configured.	String
<b>platform.vsphere.cluster</b>	The vCenter cluster to install the OpenShift Container Platform cluster in.	String
<b>platform.vsphere.apiVIP</b>	The virtual IP (VIP) address that you configured for control plane API access.	An IP address, for example <b>128.0.0.1</b> .
<b>platform.vsphere.ingressVIP</b>	The virtual IP (VIP) address that you configured for cluster ingress.	An IP address, for example <b>128.0.0.1</b> .

#### 17.7.10.1.5. Optional VMware vSphere machine pool configuration parameters

Optional VMware vSphere machine pool configuration parameters are described in the following table:

Table 17.73. Optional VMware vSphere machine pool parameters

Parameter	Description	Values
<b>platform.vsphere.clusterOSImage</b>	The location from which the installer downloads the RHCOS image. You must set this parameter to perform an installation in a restricted network.	An HTTP or HTTPS URL, optionally with a SHA-256 checksum. For example, <code>https://mirror.openshift.com/images/rhcos-&lt;version&gt;-vmware.&lt;architecture&gt;.ova</code> .
<b>platform.vsphere.osDisk.diskSizeGB</b>	The size of the disk in gigabytes.	Integer
<b>platform.vsphere.cpus</b>	The total number of virtual processor cores to assign a virtual machine. The value of <b>platform.vsphere.cpus</b> must be a multiple of <b>platform.vsphere.coresPerSocket</b> value.	Integer

Parameter	Description	Values
<b>platform.vsphere.coresPerSocket</b>	The number of cores per socket in a virtual machine. The number of virtual sockets on the virtual machine is <b>platform.vsphere.cpus/platform.vsphere.coresPerSocket</b> . The default value for control plane nodes and worker nodes is <b>4</b> and <b>2</b> , respectively.	Integer
<b>platform.vsphere.memoryMB</b>	The size of a virtual machine's memory in megabytes.	Integer

### 17.7.10.2. Sample install-config.yaml file for an installer-provisioned VMware vSphere cluster

You can customize the install-config.yaml file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```

apiVersion: v1
baseDomain: example.com 1
compute: 2
- hyperthreading: Enabled 3
  name: worker
  replicas: 3
  platform:
    vsphere: 4
      cpus: 2
      coresPerSocket: 2
      memoryMB: 8192
      osDisk:
        diskSizeGB: 120
controlPlane: 5
  hyperthreading: Enabled 6
  name: master
  replicas: 3
  platform:
    vsphere: 7
      cpus: 4
      coresPerSocket: 2
      memoryMB: 16384
      osDisk:
        diskSizeGB: 120
metadata:
  name: cluster 8
platform:
  vsphere:
    vcenter: your.vcenter.server
    username: username
    password: password
    datacenter: datacenter

```



- 12 Provide the contents of the certificate file that you used for your mirror registry.
- 13 Provide the **imageContentSources** section from the output of the command to mirror the repository.

### 17.7.10.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

#### Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



#### NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

#### Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

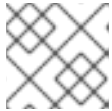
```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
  additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
  ...
```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3



A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with `.` to match subdomains only. For

- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.



#### NOTE

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



#### NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

### 17.7.11. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



#### IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

#### Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

#### Procedure

1. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
--log-level=info 2
```

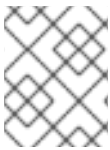
- 1 For **<installation\_directory>**, specify the location of your customized **./install-config.yaml** file.

- 2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

When the cluster deployment completes, directions for accessing your cluster, including a link to its web console and credentials for the **kubeadmin** user, display in your terminal.

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Ee6gm-ymBZj-Wt5AL"
INFO Time elapsed: 36m22s
```

+



#### NOTE

The cluster access and credential information also outputs to **<installation\_directory>/openshift\_install.log** when an installation succeeds.

+



#### IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

+



#### IMPORTANT

You must not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

### 17.7.12. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



## IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

### Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

```
$ tar xvf <file>
```

5. Place the **oc** binary in a directory that is on your **PATH**.  
To check your **PATH**, execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

## Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your **PATH**.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### 17.7.13. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

#### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

#### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

#### Example output

```
system:admin
```

### 17.7.14. Disabling the default OperatorHub sources

Operator catalogs that source content provided by Red Hat and community projects are configured for OperatorHub by default during an OpenShift Container Platform installation. In a restricted network environment, you must disable the default catalogs as a cluster administrator.

#### Procedure

- Disable the sources for the default catalogs by adding **disableAllDefaultSources: true** to the **OperatorHub** object:

```
$ oc patch OperatorHub cluster --type json \
  -p '[{"op": "add", "path": "/spec/disableAllDefaultSources", "value": true}]'
```

#### TIP

Alternatively, you can use the web console to manage catalog sources. From the **Administration** → **Cluster Settings** → **Configuration** → **OperatorHub** page, click the **Sources** tab, where you can create, delete, disable, and enable individual sources.

### 17.7.15. Creating registry storage

After you install the cluster, you must create storage for the Registry Operator.

#### 17.7.15.1. Image registry removed during installation

On platforms that do not provide shareable object storage, the OpenShift Image Registry Operator bootstraps itself as **Removed**. This allows **openshift-installer** to complete installations on these platform types.

After installation, you must edit the Image Registry Operator configuration to switch the **managementState** from **Removed** to **Managed**.



#### NOTE

The Prometheus console provides an **ImageRegistryRemoved** alert, for example:

"Image Registry has been removed. **ImageStreamTags**, **BuildConfigs** and **DeploymentConfigs** which reference **ImageStreamTags** may not work as expected. Please configure storage and update the config to **Managed** state by editing `configs.imageregistry.operator.openshift.io`."

#### 17.7.15.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

### 17.7.15.2.1. Configuring registry storage for VMware vSphere

As a cluster administrator, following installation you must configure your registry to use storage.

#### Prerequisites

- Cluster administrator permissions.
- A cluster on VMware vSphere.
- Persistent storage provisioned for your cluster, such as Red Hat OpenShift Container Storage.



#### IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have "100Gi" capacity.



#### IMPORTANT

Testing shows issues with using the NFS server on RHEL as storage backend for core services. This includes the OpenShift Container Registry and Quay, Prometheus for monitoring storage, and Elasticsearch for logging storage. Therefore, using RHEL NFS to back PVs used by core services is not recommended.

Other NFS implementations on the marketplace might not have these issues. Contact the individual NFS implementation vendor for more information on any testing that was possibly completed against these OpenShift Container Platform core components.

#### Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.



#### NOTE

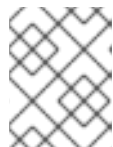
When using shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

#### Example output

```
No resources found in openshift-image-registry namespace
```

**NOTE**

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

**Example output**

```
storage:
  pvc:
    claim: 1
```

- 1** Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** persistent volume claim (PVC). The PVC is generated based on the default storage class. However, be aware that the default storage class might provide ReadWriteOnce (RWO) volumes, such as a RADOS Block Device (RBD), which can cause issues when replicating to more than one replica.

4. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

**Example output**

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED
image-registry	4.7	True	False	6h50m

### 17.7.16. Steal clock accounting

By default, the installation program provisions the cluster's virtual machines without enabling the steal clock accounting parameter (**stealclock.enabled**). Enabling steal clock accounting can help with troubleshooting cluster issues. After the cluster is deployed, use the vSphere Client to enable this parameter on each of the virtual machines.

For more information, see this [Red Hat knowledge base article](#).

### 17.7.17. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

#### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

### 17.7.18. Next steps

- [Customize your cluster.](#)
- If necessary, you can [opt out of remote health reporting](#) .
- [Set up your registry and configure registry storage](#) .

## 17.8. INSTALLING A CLUSTER ON VSPHERE IN A RESTRICTED NETWORK WITH USER-PROVISIONED INFRASTRUCTURE

In OpenShift Container Platform version 4.9, you can install a cluster on VMware vSphere infrastructure that you provision in a restricted network.



### NOTE

OpenShift Container Platform supports deploying a cluster to a single VMware vCenter only. Deploying a cluster with machines/machine sets on multiple vCenters is not supported.

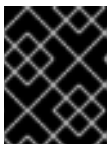


### IMPORTANT

The steps for performing a user-provisioned infrastructure installation are provided as an example only. Installing a cluster with infrastructure you provide requires knowledge of the vSphere platform and the installation process of OpenShift Container Platform. Use the user-provisioned infrastructure installation instructions as a guide; you are free to create the required resources through other methods.

### 17.8.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You [created a registry on your mirror host](#) and obtained the **imageContentSources** data for your version of OpenShift Container Platform.



### IMPORTANT

Because the installation media is on the mirror host, you can use that computer to complete all installation steps.

- You provisioned [persistent storage](#) for your cluster. To deploy a private image registry, your storage must provide **ReadWriteMany** access modes.
- Completing the installation requires that you upload the Red Hat Enterprise Linux CoreOS (RHCOS) OVA on vSphere hosts. The machine from which you complete this process requires access to port 443 on the vCenter and ESXi hosts. You verified that port 443 is accessible.



- If you use a firewall, you confirmed with the administrator that port 443 is accessible. Control plane nodes must be able to reach vCenter and ESXi hosts on port 443 for the installation to succeed.
- If you use a firewall and plan to use the Telemetry service, you [configured the firewall to allow the sites](#) that your cluster requires access to.



### NOTE

Be sure to also review this site list if you are configuring a proxy.

## 17.8.2. About installations in restricted networks

In OpenShift Container Platform 4.9, you can perform an installation that does not require an active connection to the internet to obtain software components. Restricted network installations can be completed using installer-provisioned infrastructure or user-provisioned infrastructure, depending on the cloud platform to which you are installing the cluster.

If you choose to perform a restricted network installation on a cloud platform, you still require access to its cloud APIs. Some cloud functions, like Amazon Web Service's Route 53 DNS and IAM services, require internet access. Depending on your network, you might require less internet access for an installation on bare metal hardware or on VMware vSphere.

To complete a restricted network installation, you must create a registry that mirrors the contents of the OpenShift Container Platform registry and contains the installation media. You can create this registry on a mirror host, which can access both the internet and your closed network, or by using other methods that meet your restrictions.



### IMPORTANT

Because of the complexity of the configuration for user-provisioned installations, consider completing a standard user-provisioned infrastructure installation before you attempt a restricted network installation using user-provisioned infrastructure. Completing this test installation might make it easier to isolate and troubleshoot any issues that might arise during your installation in a restricted network.

### 17.8.2.1. Additional limits

Clusters in restricted networks have the following additional limitations and restrictions:

- The **ClusterVersion** status includes an **Unable to retrieve available updates** error.
- By default, you cannot use the contents of the Developer Catalog because you cannot access the required image stream tags.

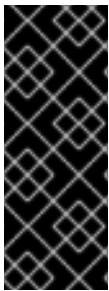
## 17.8.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to obtain the images that are necessary to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.

- Access [Quay.io](https://quay.io) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



### IMPORTANT

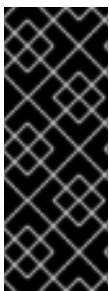
If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

## 17.8.4. VMware vSphere infrastructure requirements

You must install the OpenShift Container Platform cluster on a VMware vSphere version 6 or 7 instance that meets the requirements for the components that you use.

**Table 17.74. Version requirements for vSphere virtual environments**

Virtual environment product	Required version
VM hardware version	13 or later
vSphere ESXi hosts	6.5 or later
vCenter host	6.5 or later



### IMPORTANT

Installing a cluster on VMware vSphere version 6.7U2 or earlier and virtual hardware version 13 is now deprecated. These versions are still fully supported, but support will be removed in a future version of OpenShift Container Platform. Hardware version 15 is now the default for vSphere virtual machines in OpenShift Container Platform. To update the hardware version for your vSphere nodes, see the "Updating hardware on nodes running in vSphere" article.

**Table 17.75. Minimum supported vSphere version for VMware components**

Component	Minimum supported versions	Description
Hypervisor	vSphere 6.5 and later with HW version 13	This version is the minimum version that Red Hat Enterprise Linux CoreOS (RHCOS) supports. See the <a href="#">Red Hat Enterprise Linux 8 supported hypervisors list</a> .

Component	Minimum supported versions	Description
Storage with in-tree drivers	vSphere 6.5 and later	This plugin creates vSphere storage by using the in-tree storage drivers for vSphere included in OpenShift Container Platform.
Optional: Networking (NSX-T)	vSphere 6.5U3 or vSphere 6.7U2 and later	vSphere 6.5U3 or vSphere 6.7U2+ are required for OpenShift Container Platform. For more information about the compatibility of NSX and OpenShift Container Platform, see the Release Notes section of VMware's <a href="#">NSX container plugin documentation</a> .

If you use a vSphere version 6.5 instance, consider upgrading to 6.7U3 or 7.0 before you install OpenShift Container Platform.



### IMPORTANT

You must ensure that the time on your ESXi hosts is synchronized before you install OpenShift Container Platform. See [Edit Time Configuration for a Host](#) in the VMware documentation.

#### Additional resources

- To update the hardware version for your vSphere nodes, see [Updating hardware on nodes running in vSphere](#).

### 17.8.5. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

#### 17.8.5.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

**Table 17.76. Minimum required hosts**

Hosts	Description
-------	-------------

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.

**IMPORTANT**

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 7.9, or RHEL 8.4.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See [Red Hat Enterprise Linux technology capabilities and limits](#) .

**IMPORTANT**

All virtual machines must reside in the same datastore and in the same folder as the installer.

### 17.8.5.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

**Table 17.77. Minimum resource requirements**

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 7.9, or RHEL 8.4 [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio:  $(\text{threads per core} \times \text{cores}) \times \text{sockets} = \text{vCPUs}$ .
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.

### 17.8.5.3. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

### 17.8.5.4. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.

It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.



#### NOTE

If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

### 17.8.5.4.1. Setting the cluster node hostnames through DHCP

On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

### 17.8.5.4.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.



#### IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

Table 17.78. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	<b>1936</b>	Metrics
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> and the Cluster Version Operator on port <b>9099</b> .
	<b>10250-10259</b>	The default ports that Kubernetes reserves
	<b>10256</b>	openshift-sdn
UDP	<b>4789</b>	VXLAN and Geneve
	<b>6081</b>	VXLAN and Geneve
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> .
	<b>500</b>	IPsec IKE packets
	<b>4500</b>	IPsec NAT-T packets

Protocol	Port	Description
TCP/UDP	<b>30000-32767</b>	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 17.79. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	<b>6443</b>	Kubernetes API

Table 17.80. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	<b>2379-2380</b>	etcd server and peer ports

### Ethernet adaptor hardware address requirements

When provisioning VMs for the cluster, the ethernet interfaces configured for each VM must use a MAC address from the VMware Organizationally Unique Identifier (OUI) allocation ranges:

- **00:05:69:00:00:00 to 00:05:69:FF:FF:FF**
- **00:0c:29:00:00:00 to 00:0c:29:FF:FF:FF**
- **00:1c:14:00:00:00 to 00:1c:14:FF:FF:FF**
- **00:50:56:00:00:00 to 00:50:56:FF:FF:FF**

If a MAC address outside the VMware OUI is used, the cluster installation will not succeed.

### NTP configuration for user-provisioned infrastructure

OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service*.

If a DHCP server provides NTP server information, the chrony time service on the Red Hat Enterprise Linux CoreOS (RHCOS) machines read the information and can sync the clock with the NTP servers.

### Additional resources

- [Configuring chrony time service](#)

### 17.8.5.5. User-provisioned DNS requirements

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API

- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines

Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.




#### NOTE

It is recommended to use a DHCP server to provide the hostnames to each cluster node. See the *DHCP recommendations for user-provisioned infrastructure* section for more information.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, **<cluster\_name>** is the cluster name and **<base\_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster\_name>.<base\_domain>..**

Table 17.81. Required DNS records

Component	Record	Description
Kubernetes API	<b>api.&lt;cluster_name&gt;.&lt;base_domain&gt;..</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
	<b>api-int.&lt;cluster_name&gt;.&lt;base_domain&gt;..</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster.
		 <p><b>IMPORTANT</b></p> <p>The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.</p>



Component	Record	Description
Routes	<b>*.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.  For example, <b>console-openshift-console.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;</b> is used as a wildcard route to the OpenShift Container Platform console.
Bootstrap machine	<b>bootstrap.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.
Control plane machines	<b>&lt;master&gt;&lt;n&gt;.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.
Compute machines	<b>&lt;worker&gt;&lt;n&gt;.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.



## NOTE

In OpenShift Container Platform 4.4 and later, you do not need to specify etcd host and SRV records in your DNS configuration.

## TIP

You can use the **dig** command to verify name and reverse name resolution. See the section on *Validating DNS resolution for user-provisioned infrastructure* for detailed validation steps.

### 17.8.5.5.1. Example DNS configuration for user-provisioned clusters

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is **ocp4** and the base domain is **example.com**.

#### Example DNS A record configuration for a user-provisioned cluster

The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

## Example 17.19. Sample DNS zone database

```

$TTL 1W
@ IN SOA ns1.example.com. root (
    2019070700 ; serial
    3H ; refresh (3 hours)
    30M ; retry (30 minutes)
    2W ; expiry (2 weeks)
    1W ) ; minimum (1 week)
IN NS ns1.example.com.
IN MX 10 smtp.example.com.
;
;
ns1.example.com. IN A 192.168.1.5
smtp.example.com. IN A 192.168.1.5
;
helper.example.com. IN A 192.168.1.5
helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com. IN A 192.168.1.5 1
api-int.ocp4.example.com. IN A 192.168.1.5 2
;
*.apps.ocp4.example.com. IN A 192.168.1.5 3
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 4
;
master0.ocp4.example.com. IN A 192.168.1.97 5
master1.ocp4.example.com. IN A 192.168.1.98 6
master2.ocp4.example.com. IN A 192.168.1.99 7
;
worker0.ocp4.example.com. IN A 192.168.1.11 8
worker1.ocp4.example.com. IN A 192.168.1.7 9
;
;EOF

```

- 1 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.
- 2 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.
- 3 Provides name resolution for the wildcard routes. The record refers to the IP address of the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

**NOTE**

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

- 4 Provides name resolution for the bootstrap machine.
- 5 6 7 Provides name resolution for the control plane machines.
- 8 9 Provides name resolution for the compute machines.

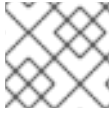
### Example DNS PTR record configuration for a user-provisioned cluster

The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

#### Example 17.20. Sample DNS zone database for reverse records

```
$TTL 1W
@ IN SOA ns1.example.com. root (
    2019070700 ; serial
    3H ; refresh (3 hours)
    30M ; retry (30 minutes)
    2W ; expiry (2 weeks)
    1W ) ; minimum (1 week)
IN NS ns1.example.com.
;
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. 2
;
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. 3
;
97.1.168.192.in-addr.arpa. IN PTR master0.ocp4.example.com. 4
98.1.168.192.in-addr.arpa. IN PTR master1.ocp4.example.com. 5
99.1.168.192.in-addr.arpa. IN PTR master2.ocp4.example.com. 6
;
11.1.168.192.in-addr.arpa. IN PTR worker0.ocp4.example.com. 7
7.1.168.192.in-addr.arpa. IN PTR worker1.ocp4.example.com. 8
;
;EOF
```

- 1 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.
- 2 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.
- 3 Provides reverse DNS resolution for the bootstrap machine.
- 4 5 6 Provides reverse DNS resolution for the control plane machines.
- 7 8 Provides reverse DNS resolution for the compute machines.

**NOTE**

A PTR record is not required for the OpenShift Container Platform application wildcard.

**17.8.5.6. Load balancing requirements for user-provisioned infrastructure**

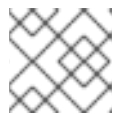
Before you install OpenShift Container Platform, you must provision the API and application ingress load balancing infrastructure. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

**NOTE**

If you want to deploy the API and application ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer.** Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:
  - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the API routes.
  - A stateless load balancing algorithm. The options vary based on the load balancer implementation.

**NOTE**

Session persistence is not required for the API load balancer to function properly.

Configure the following ports on both the front and back of the load balancers:

**Table 17.82. API load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
<b>6443</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the <b>/readyz</b> endpoint for the API server health check probe.	X	X	Kubernetes API server
<b>22623</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server

**NOTE**

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the **/readyz** endpoint to the removal of the API server instance from the pool. Within the time frame after **/readyz** returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application ingress load balancer.** Provides an ingress point for application traffic flowing in from outside the cluster. Configure the following conditions:
  - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the ingress routes.
  - A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

**TIP**

If the true IP address of the client can be seen by the application ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

Configure the following ports on both the front and back of the load balancers:

**Table 17.83. Application ingress load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
<b>443</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic
<b>80</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic
<b>1936</b>	The worker nodes that run the Ingress Controller pods, by default. You must configure the <b>/healthz/ready</b> endpoint for the ingress health check probe.	X	X	HTTP traffic

**NOTE**

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

**NOTE**

A working configuration for the Ingress router is required for an OpenShift Container Platform cluster. You must configure the Ingress router after the control plane initializes.

**17.8.5.6.1. Example load balancer configuration for user-provisioned clusters**

This section provides an example API and application ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an `/etc/haproxy/haproxy.cfg` configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing one load balancing solution over another.

**NOTE**

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

**Example 17.21. Sample API and application ingress load balancer configuration**

```

global
  log      127.0.0.1 local2
  pidfile  /var/run/haproxy.pid
  maxconn  4000
  daemon
defaults
  mode            http
  log             global
  option          dontlognull
  option http-server-close
  option          redispatch
  retries         3
  timeout http-request 10s
  timeout queue    1m
  timeout connect  10s
  timeout client   1m
  timeout server   1m
  timeout http-keep-alive 10s
  timeout check    10s
  maxconn         3000
frontend stats
  bind *:1936
  mode            http
  log             global
  maxconn 10
  stats enable
  stats hide-version
  stats refresh 30s
  stats show-node
  stats show-desc Stats for ocp4 cluster 1
  stats auth admin:ocp4
  stats uri /stats
listen api-server-6443 2

```

```

bind *:6443
mode tcp
server bootstrap bootstrap.ocp4.example.com:6443 check inter 1s backup 3
server master0 master0.ocp4.example.com:6443 check inter 1s
server master1 master1.ocp4.example.com:6443 check inter 1s
server master2 master2.ocp4.example.com:6443 check inter 1s
listen machine-config-server-22623 4
bind *:22623
mode tcp
server bootstrap bootstrap.ocp4.example.com:22623 check inter 1s backup 5
server master0 master0.ocp4.example.com:22623 check inter 1s
server master1 master1.ocp4.example.com:22623 check inter 1s
server master2 master2.ocp4.example.com:22623 check inter 1s
listen ingress-router-443 6
bind *:443
mode tcp
balance source
server worker0 worker0.ocp4.example.com:443 check inter 1s
server worker1 worker1.ocp4.example.com:443 check inter 1s
listen ingress-router-80 7
bind *:80
mode tcp
balance source
server worker0 worker0.ocp4.example.com:80 check inter 1s
server worker1 worker1.ocp4.example.com:80 check inter 1s

```

- 1** In the example, the cluster name is **ocp4**.
- 2** Port **6443** handles the Kubernetes API traffic and points to the control plane machines.
- 3** **5** The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.
- 4** Port **22623** handles the machine config server traffic and points to the control plane machines.
- 6** Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.
- 7** Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

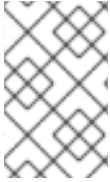


#### NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

#### TIP

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltupe** on the HAProxy node.

**NOTE**

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running **setsebool -P haproxy\_connect\_any=1**.

### 17.8.6. Preparing the user-provisioned infrastructure

Before you install OpenShift Container Platform on user-provisioned infrastructure, you must prepare the underlying infrastructure.

This section provides details about the high-level steps required to set up your cluster infrastructure in preparation for an OpenShift Container Platform installation. This includes configuring IP networking and network connectivity for your cluster nodes, enabling the required ports through your firewall, and setting up the required DNS and load balancing infrastructure.

After preparation, your cluster infrastructure must meet the requirements outlined in the *Requirements for a cluster with user-provisioned infrastructure* section.

#### Prerequisites

- You have reviewed the [OpenShift Container Platform 4.x Tested Integrations](#) page.
- You have reviewed the infrastructure requirements detailed in the *Requirements for a cluster with user-provisioned infrastructure* section.

#### Procedure

1. If you are using DHCP to provide the IP networking configuration to your cluster nodes, configure your DHCP service.
  - a. Add persistent IP addresses for the nodes to your DHCP server configuration. In your configuration, match the MAC address of the relevant network interface to the intended IP address for each node.
  - b. When you use DHCP to configure IP addressing for the cluster machines, the machines also obtain the DNS server information through DHCP. Define the persistent DNS server address that is used by the cluster nodes through your DHCP server configuration.

**NOTE**

If you are not using a DHCP service, you must provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

- c. Define the hostnames of your cluster nodes in your DHCP server configuration. See the *Setting the cluster node hostnames through DHCP* section for details about hostname considerations.



**NOTE**

If you are not using a DHCP service, the cluster nodes obtain their hostname through a reverse DNS lookup.

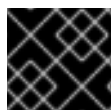
2. Ensure that your network infrastructure provides the required network connectivity between the cluster components. See the *Networking requirements for user-provisioned infrastructure* section for details about the requirements.
3. Configure your firewall to enable the ports required for the OpenShift Container Platform cluster components to communicate. See *Networking requirements for user-provisioned infrastructure* section for details about the ports that are required.
4. Setup the required DNS infrastructure for your cluster.
  - a. Configure DNS name resolution for the Kubernetes API, the application wildcard, the bootstrap machine, the control plane machines, and the compute machines.
  - b. Configure reverse DNS resolution for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.  
See the *User-provisioned DNS requirements* section for more information about the OpenShift Container Platform DNS requirements.
5. Validate your DNS configuration.
  - a. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses in the responses correspond to the correct components.
  - b. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names in the responses correspond to the correct components.  
See the *Validating DNS resolution for user-provisioned infrastructure* section for detailed DNS validation steps.
6. Provision the required API and application ingress load balancing infrastructure. See the *Load balancing requirements for user-provisioned infrastructure* section for more information about the requirements.

**NOTE**

Some load balancing solutions require the DNS name resolution for the cluster nodes to be in place before the load balancing is initialized.

### 17.8.7. Validating DNS resolution for user-provisioned infrastructure

You can validate your DNS configuration before installing OpenShift Container Platform on user-provisioned infrastructure.

**IMPORTANT**

The validation steps detailed in this section must succeed before you install your cluster.

#### Prerequisites

- You have configured the required DNS records for your user-provisioned infrastructure.

## Procedure

- From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses contained in the responses correspond to the correct components.
  - Perform a lookup against the Kubernetes API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api.<cluster_name>.<base_domain> 1
```

- Replace **<nameserver\_ip>** with the IP address of the nameserver, **<cluster\_name>** with your cluster name, and **<base\_domain>** with your base domain name.

### Example output

```
api.ocp4.example.com. 0 IN A 192.168.1.5
```

- Perform a lookup against the Kubernetes internal API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api-int.<cluster_name>.<base_domain>
```

### Example output

```
api-int.ocp4.example.com. 0 IN A 192.168.1.5
```

- Test an example **\*.apps.<cluster\_name>.<base\_domain>** DNS wildcard lookup. All of the application wildcard lookups must resolve to the IP address of the application ingress load balancer:

```
$ dig +noall +answer @<nameserver_ip> random.apps.<cluster_name>.<base_domain>
```

### Example output

```
random.apps.ocp4.example.com. 0 IN A 192.168.1.5
```



## NOTE

In the example outputs, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

You can replace **random** with another wildcard value. For example, you can query the route to the OpenShift Container Platform console:

```
$ dig +noall +answer @<nameserver_ip> console-openshift-console.apps.<cluster_name>.<base_domain>
```

**Example output**

```
console-openshift-console.apps.ocp4.example.com. 0 IN A 192.168.1.5
```

- d. Run a lookup against the bootstrap DNS record name. Check that the result points to the IP address of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> bootstrap.<cluster_name>.<base_domain>
```

**Example output**

```
bootstrap.ocp4.example.com. 0 IN A 192.168.1.96
```

- e. Use this method to perform lookups against the DNS record names for the control plane and compute nodes. Check that the results correspond to the IP addresses of each node.
2. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names contained in the responses correspond to the correct components.
    - a. Perform a reverse lookup against the IP address of the API load balancer. Check that the response includes the record names for the Kubernetes API and the Kubernetes internal API:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.5
```

**Example output**

```
5.1.168.192.in-addr.arpa. 0 IN PTR api-int.ocp4.example.com. 1  
5.1.168.192.in-addr.arpa. 0 IN PTR api.ocp4.example.com. 2
```

- 1** Provides the record name for the Kubernetes internal API.
- 2** Provides the record name for the Kubernetes API.

**NOTE**

A PTR record is not required for the OpenShift Container Platform application wildcard. No validation step is needed for reverse DNS resolution against the IP address of the application ingress load balancer.

- b. Perform a reverse lookup against the IP address of the bootstrap node. Check that the result points to the DNS record name of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.96
```

**Example output**

```
96.1.168.192.in-addr.arpa. 0 IN PTR bootstrap.ocp4.example.com.
```

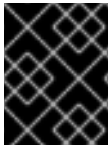
- c. Use this method to perform reverse lookups against the IP addresses for the control plane and compute nodes. Check that the results correspond to the DNS record names of each node.

### 17.8.8. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.



#### IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



#### NOTE

You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

#### Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.



#### NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the **./openshift-install gather** command.



#### NOTE

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

#### Example output

```
Agent pid 31874
```



#### NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1** Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

#### Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

#### Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program. If you install a cluster on infrastructure that you provision, you must provide the key to the installation program.

### 17.8.9. Manually creating the installation configuration file

For user-provisioned installations of OpenShift Container Platform, you manually generate your installation configuration file.

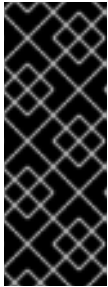
#### Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain the **imageContentSources** section from the output of the command to mirror the repository.
- Obtain the contents of the certificate for your mirror registry.

## Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```



### IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation\_directory>**.



### NOTE

You must name this configuration file **install-config.yaml**.

- Unless you use a registry that RHCOS trusts by default, such as **docker.io**, you must provide the contents of the certificate for your mirror repository in the **additionalTrustBundle** section. In most cases, you must provide the certificate for your mirror.
- You must include the **imageContentSources** section from the output of the command to mirror the repository.



### NOTE

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation\_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



control plane pool is used.

- 3 6** Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.



### IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Your machines must use at least 8 CPUs and 32 GB of RAM if you disable simultaneous multithreading.

- 4** You must set the value of the **replicas** parameter to **0**. This parameter controls the number of workers that the cluster creates and manages for you, which are functions that the cluster does not perform when you use user-provisioned infrastructure. You must manually deploy worker machines for the cluster to use before you finish installing OpenShift Container Platform.
- 7** The number of control plane machines that you add to the cluster. Because the cluster uses this values as the number of etcd endpoints in the cluster, the value must match the number of control plane machines that you deploy.
- 8** The cluster name that you specified in your DNS records.
- 9** The fully-qualified hostname or IP address of the vCenter server.
- 10** The name of the user for accessing the server. This user must have at least the roles and privileges that are required for [static or dynamic persistent volume provisioning](#) in vSphere.
- 11** The password associated with the vSphere user.
- 12** The vSphere datacenter.
- 13** The default vSphere datastore to use.
- 14** Optional: For installer-provisioned infrastructure, the absolute path of an existing folder where the installation program creates the virtual machines, for example, `/<datacenter_name>/vm/<folder_name>/<subfolder_name>`. If you do not provide this value, the installation program creates a top-level folder in the datacenter virtual machine folder that is named with the infrastructure ID. If you are providing the infrastructure for the cluster, omit this parameter.
- 15** Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.



### IMPORTANT

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

- 16** For **<local\_registry>**, specify the registry domain name, and optionally the port, that your mirror registry uses to serve content. For example **registry.example.com** or **registryv.example.com:5000**. For **<credentials>**, specify the base64-encoded user name and



password for your mirror registry.

- 17 The public portion of the default SSH key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).



#### NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

- 18 Provide the contents of the certificate file that you used for your mirror registry.
- 19 Provide the **imageContentSources** section from the output of the command to mirror the repository.

### 17.8.9.2. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

#### Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



#### NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

#### Procedure

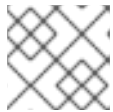
1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
  additionalTrustBundle: | 4
```

```
-----BEGIN CERTIFICATE-----
<MY_TRUSTED_CA_CERT>
-----END CERTIFICATE-----
```

...

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations. You must include vCenter's IP address and the IP range that you use for its machines.
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

**NOTE**

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

**NOTE**

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

### 17.8.10. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.



## IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

## Prerequisites

- You obtained the OpenShift Container Platform installation program. For a restricted network installation, these files are on your mirror host.
- You created the **install-config.yaml** installation configuration file.

## Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

- 1 For **<installation\_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

2. Remove the Kubernetes manifest files that define the control plane machines and compute machine sets:

```
$ rm -f openshift/99_openshift-cluster-api_master-machines-*.yaml openshift/99_openshift-cluster-api_worker-machineset-*.yaml
```

Because you create and manage these resources yourself, you do not have to initialize them.

- You can preserve the machine set files to create compute machines by using the machine API, but you must update references to them to match your environment.
3. Check that the **mastersSchedulable** parameter in the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:
    - a. Open the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** file.
    - b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.
    - c. Save and exit the file.

- To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> ❶
```

- For **<installation\_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation\_directory>/auth** directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

### 17.8.11. Configuring chrony time service

You must set the time server and related settings used by the chrony time service (**chronyd**) by modifying the contents of the **chrony.conf** file and passing those contents to your nodes as a machine config.

#### Procedure

- Create a Butane config including the contents of the **chrony.conf** file. For example, to configure chrony on worker nodes, create a **99-worker-chrony.bu** file.



#### NOTE

See "Creating machine configs with Butane" for information about Butane.

```
variant: openshift
version: 4.9.0
metadata:
  name: 99-worker-chrony ❶
  labels:
    machineconfiguration.openshift.io/role: worker ❷
storage:
  files:
  - path: /etc/chrony.conf
    mode: 0644 ❸
    overwrite: true
  contents:
    inline: |
      pool 0.rhel.pool.ntp.org iburst ❹
      driftfile /var/lib/chrony/drift
```

```
makestep 1.0 3
rtcsync
logdir /var/log/chrony
```

- 1 2 On control plane nodes, substitute **master** for **worker** in both of these locations.
  - 3 Specify an octal value mode for the **mode** field in the machine config file. After creating the file and applying the changes, the **mode** is converted to a decimal value. You can check the YAML file with the command **oc get mc <mc-name> -o yaml**.
  - 4 Specify any valid, reachable time source, such as the one provided by your DHCP server.
2. Use Butane to generate a **MachineConfig** object file, **99-worker-chrony.yaml**, containing the configuration to be delivered to the nodes:

```
$ butane 99-worker-chrony.bu -o 99-worker-chrony.yaml
```

3. Apply the configurations in one of two ways:
  - If the cluster is not running yet, after you generate manifest files, add the **MachineConfig** object file to the **<installation\_directory>/openshift** directory, and then continue to create the cluster.
  - If the cluster is already running, apply the file:

```
$ oc apply -f ./99-worker-chrony.yaml
```

### 17.8.12. Extracting the infrastructure name

The Ignition config files contain a unique cluster identifier that you can use to uniquely identify your cluster in VMware vSphere. If you plan to use the cluster identifier as the name of your virtual machine folder, you must extract it.

#### Prerequisites

- You obtained the OpenShift Container Platform installation program and the pull secret for your cluster.
- You generated the Ignition config files for your cluster.
- You installed the **jq** package.

#### Procedure

- To extract and view the infrastructure name from the Ignition config file metadata, run the following command:

```
$ jq -r .infraID <installation_directory>/metadata.json 1
```

- 1 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

#### Example output

openshift-vw9j6 **1**

- 1** The output of this command is your cluster name and a random string.

### 17.8.13. Installing RHCOS and starting the OpenShift Container Platform bootstrap process

To install OpenShift Container Platform on user-provisioned infrastructure on VMware vSphere, you must install Red Hat Enterprise Linux CoreOS (RHCOS) on vSphere hosts. When you install RHCOS, you must provide the Ignition config file that was generated by the OpenShift Container Platform installation program for the type of machine you are installing. If you have configured suitable networking, DNS, and load balancing infrastructure, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS machines have rebooted.

#### Prerequisites

- You have obtained the Ignition config files for your cluster.
- You have access to an HTTP server that you can access from your computer and that the machines that you create can access.
- You have created a [vSphere cluster](#).

#### Procedure

1. Upload the bootstrap Ignition config file, which is named **<installation\_directory>/bootstrap.ign**, that the installation program created to your HTTP server. Note the URL of this file.
2. Save the following secondary Ignition config file for your bootstrap node to your computer as **<installation\_directory>/merge-bootstrap.ign**:

```
{
  "ignition": {
    "config": {
      "merge": [
        {
          "source": "<bootstrap_ignition_config_url>", 1
          "verification": {}
        }
      ]
    },
    "timeouts": {},
    "version": "3.2.0"
  },
  "networkd": {},
  "passwd": {},
  "storage": {},
  "systemd": {}
}
```

- 1** Specify the URL of the bootstrap Ignition config file that you hosted.

When you create the virtual machine (VM) for the bootstrap machine, you use this Ignition config file.

3. Locate the following Ignition config files that the installation program created:
  - **<installation\_directory>/master.ign**
  - **<installation\_directory>/worker.ign**
  - **<installation\_directory>/merge-bootstrap.ign**
4. Convert the Ignition config files to Base64 encoding. Later in this procedure, you must add these files to the extra configuration parameter **guestinfo.ignition.config.data** in your VM. For example, if you use a Linux operating system, you can use the **base64** command to encode the files.

```
$ base64 -w0 <installation_directory>/master.ign > <installation_directory>/master.64
```

```
$ base64 -w0 <installation_directory>/worker.ign > <installation_directory>/worker.64
```

```
$ base64 -w0 <installation_directory>/merge-bootstrap.ign > <installation_directory>/merge-bootstrap.64
```



#### IMPORTANT

If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

5. Obtain the RHCOS OVA image. Images are available from the [RHCOS image mirror](#) page.



#### IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download an image with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image version that matches your OpenShift Container Platform version if it is available.

The filename contains the OpenShift Container Platform version number in the format **rhcos-vmware.<architecture>.ova**.

6. In the vSphere Client, create a folder in your datacenter to store your VMs.
  - a. Click the **VMs and Templates** view.
  - b. Right-click the name of your datacenter.
  - c. Click **New Folder → New VM and Template Folder**.
  - d. In the window that is displayed, enter the folder name. If you did not specify an existing folder in the **install-config.yaml** file, then create a folder with the same name as the infrastructure ID. You use this folder name so vCenter dynamically provisions storage in the appropriate location for its Workspace configuration.

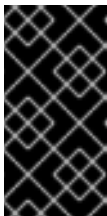
7. In the vSphere Client, create a template for the OVA image and then clone the template as needed.



#### NOTE

In the following steps, you create a template and then clone the template for all of your cluster machines. You then provide the location for the Ignition config file for that cloned machine type when you provision the VMs.

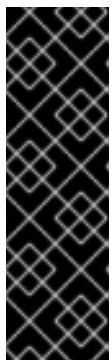
- a. From the **Hosts and Clusters** tab, right-click your cluster name and select **Deploy OVF Template**.
- b. On the **Select an OVF** tab, specify the name of the RHCOS OVA file that you downloaded.
- c. On the **Select a name and folder** tab, set a **Virtual machine name** for your template, such as **Template-RHCOS**. Click the name of your vSphere cluster and select the folder you created in the previous step.
- d. On the **Select a compute resource** tab, click the name of your vSphere cluster.
- e. On the **Select storage** tab, configure the storage options for your VM.
  - Select **Thin Provision** or **Thick Provision**, based on your storage preferences.
  - Select the datastore that you specified in your **install-config.yaml** file.
- f. On the **Select network** tab, specify the network that you configured for the cluster, if available.
- g. When creating the OVF template, do not specify values on the **Customize template** tab or configure the template any further.



#### IMPORTANT

Do not start the original VM template. The VM template must remain off and must be cloned for new RHCOS machines. Starting the VM template configures the VM template as a VM on the platform, which prevents it from being used as a template that machine sets can apply configurations to.

8. Optional: Update the configured virtual hardware version in the VM template, if necessary. Follow [Upgrading a virtual machine to the latest hardware version](#) in the VMware documentation for more information.



#### IMPORTANT

It is recommended that you update the hardware version of the VM template to version 15 before creating VMs from it, if necessary. Using hardware version 13 for your cluster nodes running on vSphere is now deprecated. If your imported template defaults to hardware version 13, you must ensure that your ESXi host is on 6.7U3 or later before upgrading the VM template to hardware version 15. If your vSphere version is less than 6.7U3, you can skip this upgrade step; however, a future version of OpenShift Container Platform is scheduled to remove support for hardware version 13 and vSphere versions less than 6.7U3.



9. After the template deploys, deploy a VM for a machine in the cluster.
  - a. Right-click the template name and click **Clone** → **Clone to Virtual Machine**
  - b. On the **Select a name and folder** tab, specify a name for the VM. You might include the machine type in the name, such as **control-plane-0** or **compute-1**.
  - c. On the **Select a name and folder** tab, select the name of the folder that you created for the cluster.
  - d. On the **Select a compute resource** tab, select the name of a host in your datacenter.
  - e. Optional: On the **Select storage** tab, customize the storage options.
  - f. On the **Select clone options**, select **Customize this virtual machine's hardware**
  - g. On the **Customize hardware** tab, click **VM Options** → **Advanced**.
    - Optional: Override default DHCP networking in vSphere. To enable static IP networking:

- i. Set your static IP configuration:

```
$ export IPCFG="ip=<ip>::<gateway>:<netmask>:<hostname>:<iface>:none
nameserver=svr1 [nameserver=svr2 [nameserver=svr3 [...]]]"
```

#### Example command

```
$ export IPCFG="ip=192.168.100.101::192.168.100.254:255.255.255.0::none
nameserver=8.8.8.8"
```

- ii. Set the **guestinfo.afterburn.initrd.network-kargs** property before booting a VM from an OVA in vSphere:

```
$ govc vm.change -vm "<vm_name>" -e "guestinfo.afterburn.initrd.network-
kargs=${IPCFG}"
```

- Optional: In the event of cluster performance issues, from the **Latency Sensitivity** list, select **High**. Ensure that your VM's CPU and memory reservation have the following values:
  - Memory reservation value must be equal to its configured memory size.
  - CPU reservation value must be at least the number of low latency virtual CPUs multiplied by the measured physical CPU speed.
- Click **Edit Configuration**, and on the **Configuration Parameters** window, search the list of available parameters for steal clock accounting (**stealclock.enable**). If it is available, set its value to **TRUE**. Enabling steal clock accounting can help with troubleshooting cluster issues.
- Click **Add Configuration Params**. Define the following parameter names and values:
  - **guestinfo.ignition.config.data**: Locate the base-64 encoded files that you created previously in this procedure, and paste the contents of the base64-encoded Ignition config file for this machine type.

- **guestinfo.ignition.config.data.encoding**: Specify **base64**.
  - **disk.EnableUUID**: Specify **TRUE**.
  - **stealclock.enable**: If this parameter was not defined, add it and specify **TRUE**.
- h. In the **Virtual Hardware** panel of the **Customize hardware** tab, modify the specified values as required. Ensure that the amount of RAM, CPU, and disk storage meets the minimum requirements for the machine type.
- i. Complete the configuration and power on the VM.
10. Create the rest of the machines for your cluster by following the preceding steps for each machine.



### IMPORTANT

You must create the bootstrap and control plane machines at this time. Because some pods are deployed on compute machines by default, also create at least two compute machines before you install the cluster.

## 17.8.14. Adding more compute machines to a cluster in vSphere

You can add more compute machines to a user-provisioned OpenShift Container Platform cluster on VMware vSphere.

### Prerequisites

- Obtain the base64-encoded Ignition file for your compute machines.
- You have access to the vSphere template that you created for your cluster.

### Procedure

1. After the template deploys, deploy a VM for a machine in the cluster.
  - a. Right-click the template's name and click **Clone** → **Clone to Virtual Machine**
  - b. On the **Select a name and folder** tab, specify a name for the VM. You might include the machine type in the name, such as **compute-1**.
  - c. On the **Select a name and folder** tab, select the name of the folder that you created for the cluster.
  - d. On the **Select a compute resource** tab, select the name of a host in your datacenter.
  - e. Optional: On the **Select storage** tab, customize the storage options.
  - f. On the **Select clone options**, select **Customize this virtual machine's hardware**
  - g. On the **Customize hardware** tab, click **VM Options** → **Advanced**.
    - From the **Latency Sensitivity** list, select **High**.
    - Click **Edit Configuration**, and on the **Configuration Parameters** window, click **Add Configuration Params**. Define the following parameter names and values:

- **guestinfo.ignition.config.data**: Paste the contents of the base64-encoded compute Ignition config file for this machine type.
  - **guestinfo.ignition.config.data.encoding**: Specify **base64**.
  - **disk.EnableUUID**: Specify **TRUE**.
- h. In the **Virtual Hardware** panel of the **Customize hardware** tab, modify the specified values as required. Ensure that the amount of RAM, CPU, and disk storage meets the minimum requirements for the machine type. Also, make sure to select the correct network under **Add network adapter** if there are multiple networks available.
- i. Complete the configuration and power on the VM.
2. Continue to create more compute machines for your cluster.

### 17.8.15. Disk partitioning

In most cases, data partitions are originally created by installing RHCOS, rather than by installing another operating system. In such cases, the OpenShift Container Platform installer should be allowed to configure your disk partitions.

However, there are two cases where you might want to intervene to override the default partitioning when installing an OpenShift Container Platform node:

- **Create separate partitions**: For greenfield installations on an empty disk, you might want to add separate storage to a partition. This is officially supported for making **/var** or a subdirectory of **/var**, such as **/var/lib/etcd**, a separate partition, but not both.



#### IMPORTANT

For disk sizes larger than 100GB, and especially disk sizes larger than 1TB, create a separate **/var** partition. See "Creating a separate **/var** partition" and this [Red Hat Knowledgebase article](#) for more information.



#### IMPORTANT

Kubernetes supports only two file system partitions. If you add more than one partition to the original configuration, Kubernetes cannot monitor all of them.

- **Retain existing partitions**: For a brownfield installation where you are reinstalling OpenShift Container Platform on an existing node and want to retain data partitions installed from your previous operating system, there are both boot arguments and options to **coreos-installer** that allow you to retain existing data partitions.

#### Creating a separate **/var** partition

In general, disk partitioning for OpenShift Container Platform should be left to the installer. However, there are cases where you might want to create separate partitions in a part of the filesystem that you expect to grow.

OpenShift Container Platform supports the addition of a single partition to attach storage to either the **/var** partition or a subdirectory of **/var**. For example:

- **/var/lib/containers**: Holds container-related content that can grow as more images and containers are added to a system.

- **/var/lib/etcd**: Holds data that you might want to keep separate for purposes such as performance optimization of etcd storage.
- **/var**: Holds data that you might want to keep separate for purposes such as auditing.



## IMPORTANT

For disk sizes larger than 100GB, and especially larger than 1TB, create a separate **/var** partition.

Storing the contents of a **/var** directory separately makes it easier to grow storage for those areas as needed and reinstall OpenShift Container Platform at a later date and keep that data intact. With this method, you will not have to pull all your containers again, nor will you have to copy massive log files when you update systems.

Because **/var** must be in place before a fresh installation of Red Hat Enterprise Linux CoreOS (RHCOS), the following procedure sets up the separate **/var** partition by creating a machine config manifest that is inserted during the **openshift-install** preparation phases of an OpenShift Container Platform installation.

## Procedure

1. Create a directory to hold the OpenShift Container Platform installation files:

```
$ mkdir $HOME/clusterconfig
```

2. Run **openshift-install** to create a set of files in the **manifest** and **openshift** subdirectories. Answer the system questions as you are prompted:

```
$ openshift-install create manifests --dir $HOME/clusterconfig
? SSH Public Key ...
$ ls $HOME/clusterconfig/openshift/
99_kubeadmin-password-secret.yaml
99_openshift-cluster-api_master-machines-0.yaml
99_openshift-cluster-api_master-machines-1.yaml
99_openshift-cluster-api_master-machines-2.yaml
...
```

3. Create a Butane config that configures the additional partition. For example, name the file **\$HOME/clusterconfig/98-var-partition.bu**, change the disk device name to the name of the storage device on the **worker** systems, and set the storage size as appropriate. This example places the **/var** directory on a separate partition:

```
variant: openshift
version: 4.9.0
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 98-var-partition
storage:
  disks:
    - device: /dev/<device_name> 1
  partitions:
    - label: var
```

```

start_mib: <partition_start_offset> 2
size_mib: <partition_size> 3
filesystems:
- device: /dev/disk/by-partlabel/var
  path: /var
  format: xfs
  mount_options: [defaults, prjquota] 4
  with_mount_unit: true

```

- 1 The storage device name of the disk that you want to partition.
- 2 When adding a data partition to the boot disk, a minimum value of 25000 mebibytes is recommended. The root file system is automatically resized to fill all available space up to the specified offset. If no value is specified, or if the specified value is smaller than the recommended minimum, the resulting root file system will be too small, and future reinstalls of RHCOS might overwrite the beginning of the data partition.
- 3 The size of the data partition in mebibytes.
- 4 The **prjquota** mount option must be enabled for filesystems used for container storage.



#### NOTE

When creating a separate **/var** partition, you cannot use different instance types for worker nodes, if the different instance types do not have the same device name.

4. Create a manifest from the Butane config and save it to the **clusterconfig/openshift** directory. For example, run the following command:

```
$ butane $HOME/clusterconfig/98-var-partition.bu -o $HOME/clusterconfig/openshift/98-var-partition.yaml
```

5. Run **openshift-install** again to create Ignition configs from a set of files in the **manifest** and **openshift** subdirectories:

```
$ openshift-install create ignition-configs --dir $HOME/clusterconfig
$ ls $HOME/clusterconfig/
auth bootstrap.ign master.ign metadata.json worker.ign
```

Now you can use the Ignition config files as input to the vSphere installation procedures to install Red Hat Enterprise Linux CoreOS (RHCOS) systems.

### 17.8.16. Updating the bootloader using bootupd

To update the bootloader by using **bootupd**, you must either install **bootupd** on RHCOS machines manually or provide a machine config with the enabled **systemd** unit. Unlike **grubby** or other bootloader tools, **bootupd** does not manage kernel space configuration such as passing kernel arguments.

After you have installed **bootupd**, you can manage it remotely from the OpenShift Container Platform cluster.



## NOTE

It is recommended that you use **bootupd** only on bare metal or virtualized hypervisor installations, such as for protection against the BootHole vulnerability.

## Manual install method

You can manually install **bootupd** by using the **bootctl** command-line tool.

1. Inspect the system status:

```
# bootupctl status
```

### Example output

```
Component EFI
Installed: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
Update: At latest version
```

2. RHCOS images created without **bootupd** installed on them require an explicit adoption phase. If the system status is **Adoptable**, perform the adoption:

```
# bootupctl adopt-and-update
```

### Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

3. If an update is available, apply the update so that the changes take effect on the next reboot:

```
# bootupctl update
```

### Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

## Machine config method

Another way to enable **bootupd** is by providing a machine config.

- Provide a machine config file with the enabled **systemd** unit, as shown in the following example:

### Example output

```
variant: rhcos
version: 1.1.0
systemd:
  units:
    - name: custom-bootupd-auto.service
      enabled: true
      contents: |
        [Unit]
        Description=Bootupd automatic update
```

```
[Service]
ExecStart=/usr/bin/bootupctl update
RemainAfterExit=yes
```

```
[Install]
WantedBy=multi-user.target
```

### 17.8.17. Waiting for the bootstrap process to complete

The OpenShift Container Platform bootstrap process begins after the cluster nodes first boot into the persistent RHCOS environment that has been installed to disk. The configuration information provided through the Ignition config files is used to initialize the bootstrap process and install OpenShift Container Platform on the machines. You must wait for the bootstrap process to complete.

#### Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have obtained the installation program and generated the Ignition config files for your cluster.
- You installed RHCOS on your cluster machines and provided the Ignition config files that the OpenShift Container Platform installation program generated.

#### Procedure

1. Monitor the bootstrap process:

```
$ ./openshift-install --dir <installation_directory> wait-for bootstrap-complete \ 1
--log-level=info 2
```

- 1 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

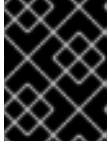
- 2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

#### Example output

```
INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...
INFO API v1.22.1 up
INFO Waiting up to 30m0s for bootstrapping to complete...
INFO It is now safe to remove the bootstrap resources
```

The command succeeds when the Kubernetes API server signals that it has been bootstrapped on the control plane machines.

2. After bootstrap process is complete, remove the bootstrap machine from the load balancer.



## IMPORTANT

You must remove the bootstrap machine from the load balancer at this point. You can also remove or reformat the bootstrap machine itself.

### 17.8.18. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

#### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

#### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

#### Example output

```
system:admin
```

### 17.8.19. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

#### Prerequisites

- You added machines to your cluster.

#### Procedure

1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

#### Example output



NAME	STATUS	ROLES	AGE	VERSION
master-0	Ready	master	63m	v1.22.1
master-1	Ready	master	63m	v1.22.1
master-2	Ready	master	64m	v1.22.1

The output lists all of the machines that you created.



#### NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

- Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

#### Example output

NAME	AGE	REQUESTOR	CONDITION
csr-8b2br	15m	system:serviceaccount:openshift-machine-config-operator:node-bootstrapper	Pending
csr-8vnps	15m	system:serviceaccount:openshift-machine-config-operator:node-bootstrapper	Pending
...			

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

- If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:



#### NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.

**NOTE**

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrap** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{\n"}\n{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```

**NOTE**

Some Operators might not become available until some CSRs are approved.

- Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

**Example output**

```
NAME      AGE   REQUESTOR                                     CONDITION
csr-bfd72 5m26s system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv 5m26s system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

- If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{\n"}\n{{end}}' | xargs oc adm certificate approve
```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

### Example output

```
NAME      STATUS  ROLES  AGE  VERSION
master-0  Ready   master 73m  v1.22.1
master-1  Ready   master 73m  v1.22.1
master-2  Ready   master 74m  v1.22.1
worker-0  Ready   worker 11m  v1.22.1
worker-1  Ready   worker 11m  v1.22.1
```



### NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

### Additional information

- For more information on CSRs, see [Certificate Signing Requests](#).

## 17.8.20. Initial Operator configuration

After the control plane initializes, you must immediately configure some Operators so that they all become available.

### Prerequisites

- Your control plane has initialized.

### Procedure

1. Watch the cluster components come online:

```
$ watch -n5 oc get clusteroperators
```

### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
authentication	4.9.0	True	False	False	19m
baremetal	4.9.0	True	False	False	37m
cloud-credential	4.9.0	True	False	False	40m
cluster-autoscaler	4.9.0	True	False	False	37m
config-operator	4.9.0	True	False	False	38m

console	4.9.0	True	False	False	26m
csi-snapshot-controller	4.9.0	True	False	False	37m
dns	4.9.0	True	False	False	37m
etcd	4.9.0	True	False	False	36m
image-registry	4.9.0	True	False	False	31m
ingress	4.9.0	True	False	False	30m
insights	4.9.0	True	False	False	31m
kube-apiserver	4.9.0	True	False	False	26m
kube-controller-manager	4.9.0	True	False	False	36m
kube-scheduler	4.9.0	True	False	False	36m
kube-storage-version-migrator	4.9.0	True	False	False	37m
machine-api	4.9.0	True	False	False	29m
machine-approver	4.9.0	True	False	False	37m
machine-config	4.9.0	True	False	False	36m
marketplace	4.9.0	True	False	False	37m
monitoring	4.9.0	True	False	False	29m
network	4.9.0	True	False	False	38m
node-tuning	4.9.0	True	False	False	37m
openshift-apiserver	4.9.0	True	False	False	32m
openshift-controller-manager	4.9.0	True	False	False	30m
openshift-samples	4.9.0	True	False	False	32m
operator-lifecycle-manager	4.9.0	True	False	False	37m
operator-lifecycle-manager-catalog	4.9.0	True	False	False	37m
operator-lifecycle-manager-packageserver	4.9.0	True	False	False	32m
service-ca	4.9.0	True	False	False	38m
storage	4.9.0	True	False	False	37m

2. Configure the Operators that are not available.

### 17.8.20.1. Disabling the default OperatorHub sources

Operator catalogs that source content provided by Red Hat and community projects are configured for OperatorHub by default during an OpenShift Container Platform installation. In a restricted network environment, you must disable the default catalogs as a cluster administrator.

#### Procedure

- Disable the sources for the default catalogs by adding **disableAllDefaultSources: true** to the **OperatorHub** object:

```
$ oc patch OperatorHub cluster --type json \
  -p [{"op": "add", "path": "/spec/disableAllDefaultSources", "value": true}]
```

#### TIP

Alternatively, you can use the web console to manage catalog sources. From the **Administration** → **Cluster Settings** → **Configuration** → **OperatorHub** page, click the **Sources** tab, where you can create, delete, disable, and enable individual sources.

### 17.8.20.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

### 17.8.20.2.1. Configuring registry storage for VMware vSphere

As a cluster administrator, following installation you must configure your registry to use storage.

#### Prerequisites

- Cluster administrator permissions.
- A cluster on VMware vSphere.
- Persistent storage provisioned for your cluster, such as Red Hat OpenShift Container Storage.



#### IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have "100Gi" capacity.



#### IMPORTANT

Testing shows issues with using the NFS server on RHEL as storage backend for core services. This includes the OpenShift Container Registry and Quay, Prometheus for monitoring storage, and Elasticsearch for logging storage. Therefore, using RHEL NFS to back PVs used by core services is not recommended.

Other NFS implementations on the marketplace might not have these issues. Contact the individual NFS implementation vendor for more information on any testing that was possibly completed against these OpenShift Container Platform core components.

#### Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.



#### NOTE

When using shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

### Example output

```
No resources found in openshift-image-registry namespace
```



#### NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

### Example output

```
storage:
  pvc:
    claim: 1
```

- 1 Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** persistent volume claim (PVC). The PVC is generated based on the default storage class. However, be aware that the default storage class might provide ReadWriteOnce (RWO) volumes, such as a RADOS Block Device (RBD), which can cause issues when replicating to more than one replica.

4. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED
image-registry	4.7	True	False	False

#### 17.8.20.2.2. Configuring storage for the image registry in non-production clusters

You must configure storage for the Image Registry Operator. For non-production clusters, you can set the image registry to an empty directory. If you do so, all images are lost if you restart the registry.

#### Procedure

- To set the image registry storage to an empty directory:

```
$ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec": {"storage":{"emptyDir":{}}}'
```

**WARNING**

Configure this option for only non-production clusters.

If you run this command before the Image Registry Operator initializes its components, the **oc patch** command fails with the following error:

```
Error from server (NotFound): configs.imageregistry.operator.openshift.io "cluster" not found
```

Wait a few minutes and run the command again.

**17.8.20.2.3. Configuring block registry storage for VMware vSphere**

To allow the image registry to use block storage types such as vSphere Virtual Machine Disk (VMDK) during upgrades as a cluster administrator, you can use the **Recreate** rollout strategy.

**IMPORTANT**

Block storage volumes are supported but not recommended for use with image registry on production clusters. An installation where the registry is configured on block storage is not highly available because the registry cannot have more than one replica.

**Procedure**

1. To set the image registry storage as a block storage type, patch the registry so that it uses the **Recreate** rollout strategy and runs with only **1** replica:

```
$ oc patch config.imageregistry.operator.openshift.io/cluster --type=merge -p '{"spec": {"rolloutStrategy": "Recreate", "replicas": 1}}'
```

2. Provision the PV for the block storage device, and create a PVC for that volume. The requested block volume uses the ReadWriteOnce (RWO) access mode.

- a. Create a **pvc.yaml** file with the following contents to define a VMware vSphere **PersistentVolumeClaim** object:

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: image-registry-storage 1
  namespace: openshift-image-registry 2
spec:
  accessModes:
  - ReadWriteOnce 3
  resources:
    requests:
      storage: 100Gi 4
```

- 1 A unique name that represents the **PersistentVolumeClaim** object.

- 2 The namespace for the **PersistentVolumeClaim** object, which is **openshift-image-registry**.
- 3 The access mode of the persistent volume claim. With **ReadWriteOnce**, the volume can be mounted with read and write permissions by a single node.
- 4 The size of the persistent volume claim.

b. Create the **PersistentVolumeClaim** object from the file:

```
$ oc create -f pvc.yaml -n openshift-image-registry
```

3. Edit the registry configuration so that it references the correct PVC:

```
$ oc edit config.imageregistry.operator.openshift.io -o yaml
```

### Example output

```
storage:
  pvc:
    claim: 1
```

- 1 Creating a custom PVC allows you to leave the **claim** field blank for the default automatic creation of an **image-registry-storage** PVC.

For instructions about configuring registry storage so that it references the correct PVC, see [Configuring the registry for vSphere](#).

## 17.8.21. Completing installation on user-provisioned infrastructure

After you complete the Operator configuration, you can finish installing the cluster on infrastructure that you provide.

### Prerequisites

- Your control plane has initialized.
- You have completed the initial Operator configuration.

### Procedure

1. Confirm that all the cluster components are online with the following command:

```
$ watch -n5 oc get clusteroperators
```

### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED
authentication	4.9.0	True	False	False 19m
baremetal	4.9.0	True	False	False 37m



cloud-credential	4.9.0	True	False	False	40m
cluster-autoscaler	4.9.0	True	False	False	37m
config-operator	4.9.0	True	False	False	38m
console	4.9.0	True	False	False	26m
csi-snapshot-controller	4.9.0	True	False	False	37m
dns	4.9.0	True	False	False	37m
etcd	4.9.0	True	False	False	36m
image-registry	4.9.0	True	False	False	31m
ingress	4.9.0	True	False	False	30m
insights	4.9.0	True	False	False	31m
kube-apiserver	4.9.0	True	False	False	26m
kube-controller-manager	4.9.0	True	False	False	36m
kube-scheduler	4.9.0	True	False	False	36m
kube-storage-version-migrator	4.9.0	True	False	False	37m
machine-api	4.9.0	True	False	False	29m
machine-approver	4.9.0	True	False	False	37m
machine-config	4.9.0	True	False	False	36m
marketplace	4.9.0	True	False	False	37m
monitoring	4.9.0	True	False	False	29m
network	4.9.0	True	False	False	38m
node-tuning	4.9.0	True	False	False	37m
openshift-apiserver	4.9.0	True	False	False	32m
openshift-controller-manager	4.9.0	True	False	False	30m
openshift-samples	4.9.0	True	False	False	32m
operator-lifecycle-manager	4.9.0	True	False	False	37m
operator-lifecycle-manager-catalog	4.9.0	True	False	False	37m
operator-lifecycle-manager-packageserver	4.9.0	True	False	False	32m
service-ca	4.9.0	True	False	False	38m
storage	4.9.0	True	False	False	37m

Alternatively, the following command notifies you when all of the clusters are available. It also retrieves and displays credentials:

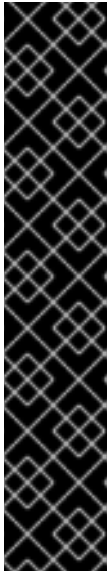
```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

### Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

The command succeeds when the Cluster Version Operator finishes deploying the OpenShift Container Platform cluster from Kubernetes API server.



## IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Confirm that the Kubernetes API server is communicating with the pods.

a. To view a list of all pods, use the following command:

```
$ oc get pods --all-namespaces
```

### Example output

```

NAMESPACE           NAME                                     READY  STATUS
RESTARTS  AGE
openshift-apiserver-operator  openshift-apiserver-operator-85cb746d55-zqhs8  1/1
Running   1    9m
openshift-apiserver          apiserver-67b9g                                1/1  Running  0
3m
openshift-apiserver          apiserver-ljcmx                                1/1  Running  0
1m
openshift-apiserver          apiserver-z25h4                                1/1  Running  0
2m
openshift-authentication-operator  authentication-operator-69d5d8bf84-vh2n8  1/1
Running   0    5m
...

```

b. View the logs for a pod that is listed in the output of the previous command by using the following command:

```
$ oc logs <pod_name> -n <namespace> ❶
```

- ❶ Specify the pod name and namespace, as shown in the output of the previous command.

If the pod logs display, the Kubernetes API server can communicate with the cluster machines.

3. For an installation with Fibre Channel Protocol (FCP), additional steps are required to enable multipathing. Do not enable multipathing during installation. See "Enabling multipathing with kernel arguments on RHCOS" in the *Post-installation machine configuration tasks* documentation for more information.

4. Register your cluster on the [Cluster registration](#) page.

You can add extra compute machines after the cluster installation is completed by following [Adding compute machines to vSphere](#).

### 17.8.22. Backing up VMware vSphere volumes

OpenShift Container Platform provisions new volumes as independent persistent disks to freely attach and detach the volume on any node in the cluster. As a consequence, it is not possible to back up volumes that use snapshots, or to restore volumes from snapshots. See [Snapshot Limitations](#) for more information.

#### Procedure

To create a backup of persistent volumes:

1. Stop the application that is using the persistent volume.
2. Clone the persistent volume.
3. Restart the application.
4. Create a backup of the cloned volume.
5. Delete the cloned volume.

### 17.8.23. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

#### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

### 17.8.24. Next steps

- [Customize your cluster](#).
- If the mirror registry that you used to install your cluster has a trusted CA, add it to the cluster by [configuring additional trust stores](#).
- If necessary, you can [opt out of remote health reporting](#).
- Optional: [View the events from the vSphere Problem Detector Operator](#) to determine if the cluster has permission or storage configuration issues.

## 17.9. UNINSTALLING A CLUSTER ON VSPHERE THAT USES INSTALLER-PROVISIONED INFRASTRUCTURE

You can remove a cluster that you deployed in your VMware vSphere instance by using installer-provisioned infrastructure.

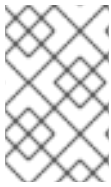


#### NOTE

When you run the **openshift-install destroy cluster** command to uninstall OpenShift Container Platform, vSphere volumes are not automatically deleted. The cluster administrator must manually find the vSphere volumes and delete them.

### 17.9.1. Removing a cluster that uses installer-provisioned infrastructure

You can remove a cluster that uses installer-provisioned infrastructure from your cloud.



#### NOTE

After uninstallation, check your cloud provider for any resources not removed properly, especially with User Provisioned Infrastructure (UPI) clusters. There might be resources that the installer did not create or that the installer is unable to access.

#### Prerequisites

- Have a copy of the installation program that you used to deploy the cluster.
- Have the files that the installation program generated when you created your cluster.

#### Procedure

1. From the directory that contains the installation program on the computer that you used to install the cluster, run the following command:

```
$. /openshift-install destroy cluster \  
--dir <installation_directory> --log-level info 1 2
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.
- 2** To view different details, specify **warn**, **debug**, or **error** instead of **info**.



#### NOTE

You must specify the directory that contains the cluster definition files for your cluster. The installation program requires the **metadata.json** file in this directory to delete the cluster.

2. Optional: Delete the **<installation\_directory>** directory and the OpenShift Container Platform installation program.

## 17.10. USING THE VSPHERE PROBLEM DETECTOR OPERATOR

### 17.10.1. About the vSphere Problem Detector Operator

The vSphere Problem Detector Operator checks clusters that are deployed on vSphere for common installation and misconfiguration issues that are related to storage.

The Operator runs in the **openshift-cluster-storage-operator** namespace and is started by the Cluster Storage Operator when the Cluster Storage Operator detects that the cluster is deployed on vSphere. The vSphere Problem Detector Operator communicates with the vSphere vCenter Server to determine the virtual machines in the cluster, the default datastore, and other information about the vSphere vCenter Server configuration. The Operator uses the credentials from the Cloud Credential Operator to connect to vSphere.

The Operator runs the checks according to the following schedule:

- The checks run every 8 hours.
- If any check fails, the Operator runs the checks again in intervals of 1 minute, 2 minutes, 4, 8, and so on. The Operator doubles the interval up to a maximum interval of 8 hours.
- When all checks pass, the schedule returns to an 8 hour interval.

The Operator increases the frequency of the checks after a failure so that the Operator can report success quickly after the failure condition is remedied. You can run the Operator manually for immediate troubleshooting information.

### 17.10.2. Running the vSphere Problem Detector Operator checks

You can override the schedule for running the vSphere Problem Detector Operator checks and run the checks immediately.

The vSphere Problem Detector Operator automatically runs the checks every 8 hours. However, when the Operator starts, it runs the checks immediately. The Operator is started by the Cluster Storage Operator when the Cluster Storage Operator starts and determines that the cluster is running on vSphere. To run the checks immediately, you can scale the vSphere Problem Detector Operator to **0** and back to **1** so that it restarts the vSphere Problem Detector Operator.

#### Prerequisites

- Access to the cluster as a user with the **cluster-admin** role.

#### Procedure

1. Scale the Operator to **0**:

```
$ oc scale deployment/vsphere-problem-detector-operator --replicas=0 \
-n openshift-cluster-storage-operator
```

If the deployment does not scale to zero immediately, you can run the following command to wait for the pods to exit:

```
$ oc wait pods -l name=vsphere-problem-detector-operator \
--for=delete --timeout=5m -n openshift-cluster-storage-operator
```

2. Scale the Operator back to **1**:

```
$ oc scale deployment/vsphere-problem-detector-operator --replicas=1 \
-n openshift-cluster-storage-operator
```

3. Delete the old leader lock to speed up the new leader election for the Cluster Storage Operator:

```
$ oc delete -n openshift-cluster-storage-operator \
  cm vsphere-problem-detector-lock
```

### Verification

- View the events or logs that are generated by the vSphere Problem Detector Operator. Confirm that the events or logs have recent timestamps.

### 17.10.3. Viewing the events from the vSphere Problem Detector Operator

After the vSphere Problem Detector Operator runs and performs the configuration checks, it creates events that can be viewed from the command line or from the OpenShift Container Platform web console.

#### Procedure

- To view the events by using the command line, run the following command:

```
$ oc get event -n openshift-cluster-storage-operator \
  --sort-by={.metadata.creationTimestamp}
```

#### Example output

```
16m Normal Started pod/vsphere-problem-detector-operator-xxxxx Started
container vsphere-problem-detector
16m Normal Created pod/vsphere-problem-detector-operator-xxxxx Created
container vsphere-problem-detector
16m Normal LeaderElection configmap/vsphere-problem-detector-lock vsphere-
problem-detector-operator-xxxxx became leader
```

- To view the events by using the OpenShift Container Platform web console, navigate to **Home** → **Events** and select **openshift-cluster-storage-operator** from the **Project** menu.

### 17.10.4. Viewing the logs from the vSphere Problem Detector Operator

After the vSphere Problem Detector Operator runs and performs the configuration checks, it creates log records that can be viewed from the command line or from the OpenShift Container Platform web console.

#### Procedure

- To view the logs by using the command line, run the following command:

```
$ oc logs deployment/vsphere-problem-detector-operator \
  -n openshift-cluster-storage-operator
```

#### Example output

```
I0108 08:32:28.445696 1 operator.go:209] ClusterInfo passed
I0108 08:32:28.451029 1 datastore.go:57] CheckStorageClasses checked 1 storage
```

```
classes, 0 problems found
```

```
I0108 08:32:28.451047 1 operator.go:209] CheckStorageClasses passed
```

```
I0108 08:32:28.452160 1 operator.go:209] CheckDefaultDatastore passed
```

```
I0108 08:32:28.480648 1 operator.go:271] CheckNodeDiskUUID:<host_name> passed
```

```
I0108 08:32:28.480685 1 operator.go:271] CheckNodeProviderID:<host_name> passed
```

- To view the Operator logs with the OpenShift Container Platform web console, perform the following steps:
  - a. Navigate to **Workloads** → **Pods**.
  - b. Select **openshift-cluster-storage-operator** from the **Projects** menu.
  - c. Click the link for the **vsphere-problem-detector-operator** pod.
  - d. Click the **Logs** tab on the **Pod details** page to view the logs.

### 17.10.5. Configuration checks run by the vSphere Problem Detector Operator

The following tables identify the configuration checks that the vSphere Problem Detector Operator runs. Some checks verify the configuration of the cluster. Other checks verify the configuration of each node in the cluster.

**Table 17.84. Cluster configuration checks**

Name	Description
<b>CheckDefaultDatastore</b>	<p>Verifies that the default datastore name in the vSphere configuration is short enough for use with dynamic provisioning.</p> <p>If this check fails, you can expect the following:</p> <ul style="list-style-type: none"> <li>• <b>systemd</b> logs errors to the journal such as <b>Failed to set up mount unit: Invalid argument</b>.</li> <li>• <b>systemd</b> does not unmount volumes if the virtual machine is shut down or rebooted without draining all the pods from the node.</li> </ul> <p>If this check fails, reconfigure vSphere with a shorter name for the default datastore.</p>
<b>CheckFolderPermissions</b>	<p>Verifies the permission to list volumes in the default datastore. This permission is required to create volumes. The Operator verifies the permission by listing the <code>/</code> and <code>/kubevols</code> directories. The root directory must exist. It is acceptable if the <code>/kubevols</code> directory does not exist when the check runs. The <code>/kubevols</code> directory is created when the datastore is used with dynamic provisioning if the directory does not already exist.</p> <p>If this check fails, review the required permissions for the vCenter account that was specified during the OpenShift Container Platform installation.</p>

Name	Description
<b>CheckStorageClasses</b>	Verifies the following: <ul style="list-style-type: none"> <li>• The fully qualified path to each persistent volume that is provisioned by this storage class is less than 255 characters.</li> <li>• If a storage class uses a storage policy, the storage class must use one policy only and that policy must be defined.</li> </ul>
<b>CheckTaskPermissions</b>	Verifies the permission to list recent tasks and datastores.
<b>ClusterInfo</b>	Collects the cluster version and UUID from vSphere vCenter.

Table 17.85. Node configuration checks

Name	Description
<b>CheckNodeDiskUUID</b>	Verifies that all the vSphere virtual machines are configured with <b>disk.enableUUID=TRUE</b> .  If this check fails, see the <a href="#">How to check 'disk.EnableUUID' parameter from VM in vSphere</a> Red Hat Knowledgebase solution.
<b>CheckNodeProviderID</b>	Verifies that all nodes are configured with the <b>ProviderID</b> from vSphere vCenter. This check fails when the output from the following command does not include a provider ID for each node.  <pre>\$ oc get nodes -o custom-columns=NAME:.metadata.name,PROVIDER_ID:.spec.providerID,UUID:.status.nodeInfo.systemUUID</pre> If this check fails, refer to the vSphere product documentation for information about setting the provider ID for each node in the cluster.
<b>CollectNodeESXiVersion</b>	Reports the version of the ESXi hosts that run nodes.
<b>CollectNodeHWVersion</b>	Reports the virtual machine hardware version for a node.

### 17.10.6. About the storage class configuration check

The names for persistent volumes that use vSphere storage are related to the datastore name and cluster ID.

When a persistent volume is created, **systemd** creates a mount unit for the persistent volume. The **systemd** process has a 255 character limit for the length of the fully qualified path to the VDMK file that is used for the persistent volume.



The fully qualified path is based on the naming conventions for **systemd** and vSphere. The naming conventions use the following pattern:

```
/var/lib/kubelet/plugins/kubernetes.io/vsphere-volume/mounts/ [<datastore>] 00000000-0000-0000-0000-000000000000/<cluster_id>-dynamic-pvc-00000000-0000-0000-0000-000000000000.vmdk
```

- The naming conventions require 205 characters of the 255 character limit.
- The datastore name and the cluster ID are determined from the deployment.
- The datastore name and cluster ID are substituted into the preceding pattern. Then the path is processed with the **systemd-escape** command to escape special characters. For example, a hyphen character uses four characters after it is escaped. The escaped value is **\x2d**.
- After processing with **systemd-escape** to ensure that **systemd** can access the fully qualified path to the VDMK file, the length of the path must be less than 255 characters.

### 17.10.7. Metrics for the vSphere Problem Detector Operator

The vSphere Problem Detector Operator exposes the following metrics for use by the OpenShift Container Platform monitoring stack.

**Table 17.86. Metrics exposed by the vSphere Problem Detector Operator**

Name	Description
<b>vsphere_cluster_check_total</b>	Cumulative number of cluster-level checks that the vSphere Problem Detector Operator performed. This count includes both successes and failures.
<b>vsphere_cluster_check_errors</b>	Number of failed cluster-level checks that the vSphere Problem Detector Operator performed. For example, a value of <b>1</b> indicates that one cluster-level check failed.
<b>vsphere_esxi_version_total</b>	Number of ESXi hosts with a specific version. Be aware that if a host runs more than one node, the host is counted only once.
<b>vsphere_node_check_total</b>	Cumulative number of node-level checks that the vSphere Problem Detector Operator performed. This count includes both successes and failures.
<b>vsphere_node_check_errors</b>	Number of failed node-level checks that the vSphere Problem Detector Operator performed. For example, a value of <b>1</b> indicates that one node-level check failed.
<b>vsphere_node_hw_version_total</b>	Number of vSphere nodes with a specific hardware version.
<b>vsphere_vcenter_info</b>	Information about the vSphere vCenter Server.

### 17.10.8. Additional resources

- [Monitoring overview](#)

## CHAPTER 18. INSTALLING ON VMC

### 18.1. PREPARING TO INSTALL ON VMC

#### 18.1.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- If you use a firewall and plan to use Telemetry, you [configured the firewall to allow the sites](#) required by your cluster.

#### 18.1.2. Choosing a method to install OpenShift Container Platform on VMC

You can install OpenShift Container Platform on VMC by using installer-provisioned or user-provisioned infrastructure. The default installation type uses installer-provisioned infrastructure, where the installation program provisions the underlying infrastructure for the cluster. You can also install OpenShift Container Platform on infrastructure that you provide. If you do not use infrastructure that the installation program provisions, you must manage and maintain the cluster resources yourself.

See the [Installation process](#) for more information about installer-provisioned and user-provisioned installation processes.



#### IMPORTANT

The steps for performing a user-provisioned infrastructure installation are provided as an example only. Installing a cluster with infrastructure you provide requires knowledge of the VMC platform and the installation process of OpenShift Container Platform. Use the user-provisioned infrastructure installation instructions as a guide; you are free to create the required resources through other methods.

##### 18.1.2.1. Installer-provisioned infrastructure installation of OpenShift Container Platform on VMC

Installer-provisioned infrastructure allows the installation program to pre-configure and automate the provisioning of resources required by OpenShift Container Platform.

- [Installing a cluster on VMC](#) You can install OpenShift Container Platform on VMC by using installer-provisioned infrastructure installation with no customization.
- [Installing a cluster on VMC with customizations](#) You can install OpenShift Container Platform on VMC by using installer-provisioned infrastructure installation with the default customization options.
- [Installing a cluster on VMC with network customizations](#) You can install OpenShift Container Platform on installer-provisioned VMC infrastructure, with network customizations. You can customize your OpenShift Container Platform network configuration during installation, so that your cluster can coexist with your existing IP address allocations and adhere to your network requirements.
- [Installing a cluster on VMC in a restricted network](#) You can install a cluster on VMC

infrastructure in a restricted network by creating an internal mirror of the installation release content. You can use this method to deploy OpenShift Container Platform on an internal network that is not visible to the internet.

### 18.1.2.2. User-provisioned infrastructure installation of OpenShift Container Platform on VMC

User-provisioned infrastructure requires the user to provision all resources required by OpenShift Container Platform.

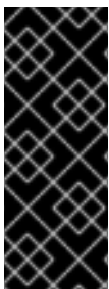
- **Installing a cluster on VMC with user-provisioned infrastructure** You can install OpenShift Container Platform on VMC infrastructure that you provision.
- **Installing a cluster on VMC with user-provisioned infrastructure and network customizations:** You can install OpenShift Container Platform on VMC infrastructure that you provision with customized network configuration options.
- **Installing a cluster on VMC in a restricted network with user-provisioned infrastructure** OpenShift Container Platform can be installed on VMC infrastructure that you provision in a restricted network.

### 18.1.3. VMware vSphere infrastructure requirements

You must install the OpenShift Container Platform cluster on a VMware vSphere version 6 or 7 instance that meets the requirements for the components that you use.

**Table 18.1. Version requirements for vSphere virtual environments**

Virtual environment product	Required version
VM hardware version	13 or later
vSphere ESXi hosts	6.5 or later
vCenter host	6.5 or later



#### IMPORTANT

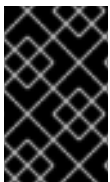
Installing a cluster on VMware vSphere version 6.7U2 or earlier and virtual hardware version 13 is now deprecated. These versions are still fully supported, but support will be removed in a future version of OpenShift Container Platform. Hardware version 15 is now the default for vSphere virtual machines in OpenShift Container Platform. To update the hardware version for your vSphere nodes, see the "Updating hardware on nodes running in vSphere" article.

**Table 18.2. Minimum supported vSphere version for VMware components**

Component	Minimum supported versions	Description
-----------	----------------------------	-------------

Component	Minimum supported versions	Description
Hypervisor	vSphere 6.5 and later with HW version 13	This version is the minimum version that Red Hat Enterprise Linux CoreOS (RHCOS) supports. See the <a href="#">Red Hat Enterprise Linux 8 supported hypervisors list</a> .
Storage with in-tree drivers	vSphere 6.5 and later	This plugin creates vSphere storage by using the in-tree storage drivers for vSphere included in OpenShift Container Platform.

If you use a vSphere version 6.5 instance, consider upgrading to 6.7U3 or 7.0 before you install OpenShift Container Platform.



### IMPORTANT

You must ensure that the time on your ESXi hosts is synchronized before you install OpenShift Container Platform. See [Edit Time Configuration for a Host](#) in the VMware documentation.

## 18.1.4. Uninstalling an installer-provisioned infrastructure installation of OpenShift Container Platform on VMC

- [Uninstalling a cluster on VMC that uses installer-provisioned infrastructure](#) You can remove a cluster that you deployed on VMC infrastructure that used installer-provisioned infrastructure.

## 18.2. INSTALLING A CLUSTER ON VMC

In OpenShift Container Platform version 4.9, you can install a cluster on VMware vSphere by deploying it to [VMware Cloud \(VMC\) on AWS](#).

Once you have configured your VMC environment for OpenShift Container Platform deployment, you use the OpenShift Container Platform installation program from the bastion management host, co-located in the VMC environment. The installation program and control plane automates the process of deploying and managing the resources needed for the OpenShift Container Platform cluster.

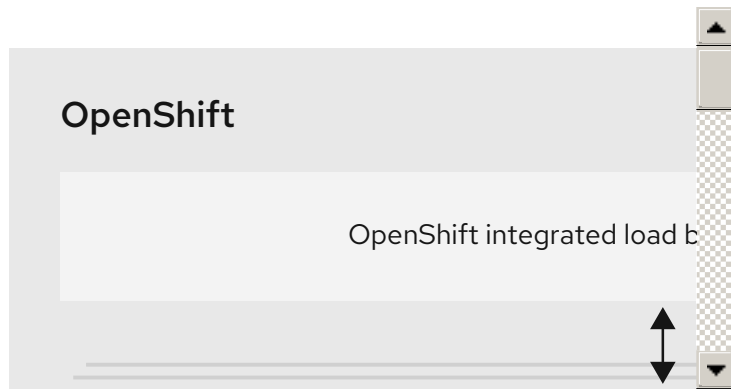


### NOTE

OpenShift Container Platform supports deploying a cluster to a single VMware vCenter only. Deploying a cluster with machines/machine sets on multiple vCenters is not supported.

### 18.2.1. Setting up VMC for vSphere

You can install OpenShift Container Platform on VMware Cloud (VMC) on AWS hosted vSphere clusters to enable applications to be deployed and managed both on-premise and off-premise, across the hybrid cloud.



You must configure several options in your VMC environment prior to installing OpenShift Container Platform on VMware vSphere. Ensure your VMC environment has the following prerequisites:

- Create a non-exclusive, DHCP-enabled, NSX-T network segment and subnet. Other virtual machines (VMs) can be hosted on the subnet, but at least eight IP addresses must be available for the OpenShift Container Platform deployment.
- Allocate two IP addresses, outside the DHCP range, and configure them with reverse DNS records.
  - A DNS record for **api.<cluster\_name>.<base\_domain>** pointing to the allocated IP address.
  - A DNS record for **\*.apps.<cluster\_name>.<base\_domain>** pointing to the allocated IP address.
- Configure the following firewall rules:
  - An ANY:ANY firewall rule between the OpenShift Container Platform compute network and the internet. This is used by nodes and applications to download container images.
  - An ANY:ANY firewall rule between the installation host and the software-defined data center (SDDC) management network on port 443. This allows you to upload the Red Hat Enterprise Linux CoreOS (RHCOS) OVA during deployment.
  - An HTTPS firewall rule between the OpenShift Container Platform compute network and vCenter. This connection allows OpenShift Container Platform to communicate with vCenter for provisioning and managing nodes, persistent volume claims (PVCs), and other resources.
- You must have the following information to deploy OpenShift Container Platform:
  - The OpenShift Container Platform cluster name, such as **vmc-prod-1**.
  - The base DNS name, such as **companyname.com**.
  - If not using the default, the pod network CIDR and services network CIDR must be identified, which are set by default to **10.128.0.0/14** and **172.30.0.0/16**, respectively. These CIDRs are used for pod-to-pod and pod-to-service communication and are not accessible externally; however, they must not overlap with existing subnets in your organization.
  - The following vCenter information:

- vCenter hostname, username, and password
- Datacenter name, such as **SDDC-Datacenter**
- Cluster name, such as **Cluster-1**
- Network name
- Datastore name, such as **WorkloadDatastore**

**NOTE**

It is recommended to move your vSphere cluster to the VMC **Compute-ResourcePool** resource pool after your cluster installation is finished.

- A Linux-based host deployed to VMC as a bastion.
  - The bastion host can be Red Hat Enterprise Linux (RHEL) or any another Linux-based host; it must have internet connectivity and the ability to upload an OVA to the ESXi hosts.
  - Download and install the OpenShift CLI tools to the bastion host.
    - The **openshift-install** installation program
    - The OpenShift CLI (**oc**) tool

**NOTE**

You cannot use the VMware NSX Container Plugin for Kubernetes (NCP), and NSX is not used as the OpenShift SDN. The version of NSX currently available with VMC is incompatible with the version of NCP certified with OpenShift Container Platform.

However, the NSX DHCP service is used for virtual machine IP management with the full-stack automated OpenShift Container Platform deployment and with nodes provisioned, either manually or automatically, by the Machine API integration with vSphere. Additionally, NSX firewall rules are created to enable access with the OpenShift Container Platform cluster and between the bastion host and the VMC vSphere hosts.

**18.2.1.1. VMC Sizer tool**

VMware Cloud on AWS is built on top of AWS bare metal infrastructure; this is the same bare metal infrastructure which runs AWS native services. When a VMware cloud on AWS software-defined data center (SDDC) is deployed, you consume these physical server nodes and run the VMware ESXi hypervisor in a single tenant fashion. This means the physical infrastructure is not accessible to anyone else using VMC. It is important to consider how many physical hosts you will need to host your virtual infrastructure.

To determine this, VMware provides the [VMC on AWS Sizer](#). With this tool, you can define the resources you intend to host on VMC:

- Types of workloads
- Total number of virtual machines
- Specification information such as:

- Storage requirements
- vCPUs
- vRAM
- Overcommit ratios

With these details, the sizer tool can generate a report, based on VMware best practices, and recommend your cluster configuration and the number of hosts you will need.

### 18.2.2. vSphere prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You provisioned [block registry storage](#). For more information on persistent storage, see [Understanding persistent storage](#).
- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.



#### NOTE

Be sure to also review this site list if you are configuring a proxy.

### 18.2.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



#### IMPORTANT

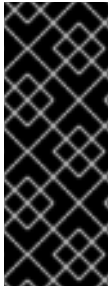
If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

### 18.2.4. VMware vSphere infrastructure requirements

You must install the OpenShift Container Platform cluster on a VMware vSphere version 6 or 7 instance that meets the requirements for the components that you use.

**Table 18.3. Version requirements for vSphere virtual environments**

Virtual environment product	Required version
VM hardware version	13 or later
vSphere ESXi hosts	6.5 or later
vCenter host	6.5 or later

**IMPORTANT**

Installing a cluster on VMware vSphere version 6.7U2 or earlier and virtual hardware version 13 is now deprecated. These versions are still fully supported, but support will be removed in a future version of OpenShift Container Platform. Hardware version 15 is now the default for vSphere virtual machines in OpenShift Container Platform. To update the hardware version for your vSphere nodes, see the "Updating hardware on nodes running in vSphere" article.

**Table 18.4. Minimum supported vSphere version for VMware components**

Component	Minimum supported versions	Description
Hypervisor	vSphere 6.5 and later with HW version 13	This version is the minimum version that Red Hat Enterprise Linux CoreOS (RHCOS) supports. See the <a href="#">Red Hat Enterprise Linux 8 supported hypervisors list</a> .
Storage with in-tree drivers	vSphere 6.5 and later	This plugin creates vSphere storage by using the in-tree storage drivers for vSphere included in OpenShift Container Platform.

If you use a vSphere version 6.5 instance, consider upgrading to 6.7U3 or 7.0 before you install OpenShift Container Platform.

**IMPORTANT**

You must ensure that the time on your ESXi hosts is synchronized before you install OpenShift Container Platform. See [Edit Time Configuration for a Host](#) in the VMware documentation.

**18.2.5. Network connectivity requirements**

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate.

Review the following details about the required network ports.



Table 18.5. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	<b>1936</b>	Metrics
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> and the Cluster Version Operator on port <b>9099</b> .
	<b>10250-10259</b>	The default ports that Kubernetes reserves
	<b>10256</b>	openshift-sdn
UDP	<b>4789</b>	virtual extensible LAN (VXLAN)
	<b>6081</b>	Geneve
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> .
	<b>500</b>	IPsec IKE packets
	<b>4500</b>	IPsec NAT-T packets
TCP/UDP	<b>30000-32767</b>	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 18.6. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	<b>6443</b>	Kubernetes API

Table 18.7. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	<b>2379-2380</b>	etcd server and peer ports

### Additional resources

- To update the hardware version for your vSphere nodes, see [Updating hardware on nodes running in vSphere](#).

## 18.2.6. vCenter requirements

Before you install an OpenShift Container Platform cluster on your vCenter that uses infrastructure that the installer provisions, you must prepare your environment.

### Required vCenter account privileges

To install an OpenShift Container Platform cluster in a vCenter, the installation program requires access to an account with privileges to read and create the required resources. Using an account that has global administrative privileges is the simplest way to access all of the necessary permissions.

If you cannot use an account with global administrative privileges, you must create roles to grant the privileges necessary for OpenShift Container Platform cluster installation. While most of the privileges are always required, some are required only if you plan for the installation program to provision a folder to contain the OpenShift Container Platform cluster on your vCenter instance, which is the default behavior. You must create or amend vSphere roles for the specified objects to grant the required privileges.

An additional role is required if the installation program is to create a vSphere virtual machine folder.

**Example 18.1. Roles and privileges required for installation in vSphere API**

vSphere object for role	When required	Required privileges in vSphere API
vSphere vCenter	Always	<b>Cns.Searchable</b> <b>InventoryService.Tagging.AttachTag</b> <b>InventoryService.Tagging.CreateCategory</b> <b>InventoryService.Tagging.CreateTag</b> <b>InventoryService.Tagging.DeleteCategory</b> <b>InventoryService.Tagging.DeleteTag</b> <b>InventoryService.Tagging.EditCategory</b> <b>InventoryService.Tagging.EditTag</b> <b>Sessions.ValidateSession</b> <b>StorageProfile.Update</b> <b>StorageProfile.View</b>
vSphere vCenter Cluster	Always	<b>Host.Config.StorageResource.AssignVMToPool</b> <b>VApp.AssignResourcePool</b> <b>VApp.Import</b> <b>VirtualMachine.Config.AddNewDisk</b>

vSphere object for role	When required	Required privileges in vSphere API
vSphere Datastore	Always	<b>Datastore.AllocateSpace</b> <b>Datastore.Browse</b> <b>Datastore.FileManagement</b> <b>InventoryService.Tagging.ObjectAttachable</b>
vSphere Port Group	Always	<b>Network.Assign</b>
Virtual Machine Folder	Always	<b>InventoryService.Tagging.ObjectAttachable</b> <b>Resource.AssignVMToPool</b> <b>VApp.Import</b> <b>VirtualMachine.Config.AddExistingDisk</b> <b>VirtualMachine.Config.AddNewDisk</b> <b>VirtualMachine.Config.AddRemoveDevice</b> <b>VirtualMachine.Config.AdvancedConfig</b> <b>VirtualMachine.Config.Annotation</b> <b>VirtualMachine.Config.CPUCount</b> <b>VirtualMachine.Config.DiskExtend</b> <b>VirtualMachine.Config.DiskLease</b> <b>VirtualMachine.Config.EditDevice</b> <b>VirtualMachine.Config.Memory</b> <b>VirtualMachine.Config.RemoveDisk</b> <b>VirtualMachine.Config.Rename</b> <b>VirtualMachine.Config.ResetGuestInfo</b> <b>VirtualMachine.Config.Resource</b> <b>VirtualMachine.Config.Settings</b> <b>VirtualMachine.Config.UpgradeVirtualHardware</b> <b>VirtualMachine.Interact.GuestControl</b> <b>VirtualMachine.Interact.PowerOff</b> <b>VirtualMachine.Interact.PowerOn</b> <b>VirtualMachine.Interact.Res</b>

vSphere object for role	When required	Required privileges in vSphere API
		<b>VirtualMachine.Inventory.CreateFromExisting</b> <b>VirtualMachine.Inventory.Delete</b> <b>VirtualMachine.Provisioning.Clone</b> <b>VirtualMachine.Provisioning.MarkAsTemplate</b> <b>VirtualMachine.Provisioning.DeployTemplate</b>
vSphere vCenter Datacenter	If the installation program creates the virtual machine folder	<b>InventoryService.Tagging.ObjectAttachable</b> <b>Resource.AssignVMToPool</b> <b>VApp.Import</b> <b>VirtualMachine.Config.AddExistingDisk</b> <b>VirtualMachine.Config.AddNewDisk</b> <b>VirtualMachine.Config.AddRemoveDevice</b> <b>VirtualMachine.Config.AdvancedConfig</b> <b>VirtualMachine.Config.Annotation</b> <b>VirtualMachine.Config.CPUCount</b> <b>VirtualMachine.Config.DiskExtend</b> <b>VirtualMachine.Config.DiskLease</b> <b>VirtualMachine.Config.EditDevice</b> <b>VirtualMachine.Config.Memory</b> <b>VirtualMachine.Config.RemoveDisk</b> <b>VirtualMachine.Config.Rename</b> <b>VirtualMachine.Config.ResetGuestInfo</b> <b>VirtualMachine.Config.Resource</b> <b>VirtualMachine.Config.Settings</b> <b>VirtualMachine.Config.UpgradeVirtualHardware</b> <b>VirtualMachine.Interact.GuestControl</b> <b>VirtualMachine.Interact.PowerOff</b>

vSphere object for role	When required	Required privileges in vSphere API
		<b>VirtualMachine.Interact.PowerOff</b> <b>VirtualMachine.Interact.Reset</b> <b>VirtualMachine.Inventory.Create</b> <b>VirtualMachine.Inventory.CreateFromExisting</b> <b>VirtualMachine.Inventory.Delete</b> <b>VirtualMachine.Provisioning.Clone</b> <b>VirtualMachine.Provisioning.DeployTemplate</b> <b>VirtualMachine.Provisioning.MarkAsTemplate</b> <b>Folder.Create</b> <b>Folder.Delete</b>

Example 18.2. Roles and privileges required for installation in vCenter graphical user interface (GUI)

vSphere object for role	When required	Required privileges in vCenter GUI
vSphere vCenter	Always	<b>Cns.Searchable</b> <b>"vSphere Tagging"."Assign or Unassign vSphere Tag"</b> <b>"vSphere Tagging"."Create vSphere Tag Category"</b> <b>"vSphere Tagging"."Create vSphere Tag"</b> <b>vSphere Tagging"."Delete vSphere Tag Category"</b> <b>"vSphere Tagging"."Delete vSphere Tag"</b> <b>"vSphere Tagging"."Edit vSphere Tag Category"</b> <b>"vSphere Tagging"."Edit vSphere Tag"</b> <b>Sessions."Validate session"</b> <b>"Profile-driven storage"."Profile-driven storage update"</b> <b>"Profile-driven storage"."Profile-driven storage view"</b>

vSphere object for role	When required	Required privileges in vCenter GUI
vSphere vCenter Cluster	If VMs will be created in the cluster root	<b>Host.Configuration."Storage partition configuration"</b> <b>Resource."Assign virtual machine to resource pool"</b> <b>VApp."Assign resource pool"</b> <b>VApp.Import</b> <b>"Virtual machine"."Change Configuration"."Add new disk"</b>
vSphere vCenter Resource Pool	If an existing resource pool is provided	<b>Host.Configuration."Storage partition configuration"</b> <b>Resource."Assign virtual machine to resource pool"</b> <b>VApp."Assign resource pool"</b> <b>VApp.Import</b> <b>"Virtual machine"."Change Configuration"."Add new disk"</b>
vSphere Datastore	Always	<b>Datastore."Allocate space"</b> <b>Datastore."Browse datastore"</b> <b>Datastore."Low level file operations"</b> <b>"vSphere Tagging"."Assign or Unassign vSphere Tag on Object"</b>
vSphere Port Group	Always	<b>Network."Assign network"</b>
Virtual Machine Folder	Always	<b>"vSphere Tagging"."Assign or Unassign vSphere Tag on Object"</b> <b>Resource."Assign virtual machine to resource pool"</b> <b>VApp.Import</b> <b>"Virtual machine"."Change Configuration"."Add existing disk"</b> <b>"Virtual machine"."Change Configuration"."Add new disk"</b> <b>"Virtual machine"."Change Configuration"."Add or remove device"</b> <b>"Virtual machine"."Change Configuration"."Advanced configuration"</b>

vSphere object for role	When required	"Virtual machine"."Change Configuration".Set annotation"
		<p>"Virtual machine"."Change Configuration"."Change CPU count"</p> <p>"Virtual machine"."Change Configuration"."Extend virtual disk"</p> <p>"Virtual machine"."Change Configuration"."Acquire disk lease"</p> <p>"Virtual machine"."Change Configuration"."Modify device settings"</p> <p>"Virtual machine"."Change Configuration"."Change Memory"</p> <p>"Virtual machine"."Change Configuration"."Remove disk"</p> <p>"Virtual machine"."Change Configuration".Rename</p> <p>"Virtual machine"."Change Configuration"."Reset guest information"</p> <p>"Virtual machine"."Change Configuration"."Change resource"</p> <p>"Virtual machine"."Change Configuration"."Change Settings"</p> <p>"Virtual machine"."Change Configuration"."Upgrade virtual machine compatibility"</p> <p>"Virtual machine".Interaction."Guest operating system management by VIX API"</p> <p>"Virtual machine".Interaction."Power off"</p> <p>"Virtual machine".Interaction."Power on"</p> <p>"Virtual machine".Interaction.Reset</p> <p>"Virtual machine"."Edit Inventory"."Create new"</p> <p>"Virtual machine"."Edit Inventory"."Create from existing"</p> <p>"Virtual machine"."Edit Inventory"."Remove"</p> <p>"Virtual</p>

vSphere object for role	When required	Required privileges in vCenter GUI
		<b>machine".Provisioning."Clone virtual machine"</b> <b>machine".Provisioning."Mark as template"</b> <b>"Virtual machine".Provisioning."Deploy template"</b>
vSphere vCenter Datacenter	If the installation program creates the virtual machine folder	<b>"vSphere Tagging". "Assign or Unassign vSphere Tag on Object"</b> <b>Resource."Assign virtual machine to resource pool"</b> <b>VApp.Import</b> <b>"Virtual machine". "Change Configuration". "Add existing disk"</b> <b>"Virtual machine". "Change Configuration". "Add new disk"</b> <b>"Virtual machine". "Change Configuration". "Add or remove device"</b> <b>"Virtual machine". "Change Configuration". "Advanced configuration"</b> <b>"Virtual machine". "Change Configuration". "Set annotation"</b> <b>"Virtual machine". "Change Configuration". "Change CPU count"</b> <b>"Virtual machine". "Change Configuration". "Extend virtual disk"</b> <b>"Virtual machine". "Change Configuration". "Acquire disk lease"</b> <b>"Virtual machine". "Change Configuration". "Modify device settings"</b> <b>"Virtual machine". "Change Configuration". "Change Memory"</b> <b>"Virtual machine". "Change Configuration". "Remove disk"</b> <b>"Virtual machine". "Change Configuration". Rename</b> <b>"Virtual machine". "Change Configuration". "Reset guest information"</b> <b>"Virtual machine". "Change Configuration". "Change resource"</b>



vSphere object for role	When required	"Virtual machine". "Change Configuration". "Change Settings"
		"Virtual machine". "Change Configuration". "Upgrade virtual machine compatibility" "Virtual machine". Interaction. "Guest operating system management by VIX API" "Virtual machine". Interaction. "Power off" "Virtual machine". Interaction. "Power on" "Virtual machine". Interaction. "Reset" "Virtual machine". "Edit Inventory". "Create new" "Virtual machine". "Edit Inventory". "Create from existing" "Virtual machine". "Edit Inventory". "Remove" "Virtual machine". Provisioning. "Clone virtual machine" "Virtual machine". Provisioning. "Deploy template" "Virtual machine". Provisioning. "Mark as template" Folder. "Create folder" Folder. "Delete folder"

Additionally, the user requires some **ReadOnly** permissions, and some of the roles require permission to propagate the permissions to child objects. These settings vary depending on whether or not you install the cluster into an existing folder.

### Example 18.3. Required permissions and propagation settings

vSphere object	Folder type	Propagate to children	Permissions required
vSphere vCenter	Always	False	Listed required privileges
vSphere vCenter Datacenter	Existing folder	False	<b>ReadOnly</b> permission

vSphere object	Folder type	Propagate to children	Permissions required
	Installation program creates the folder	True	Listed required privileges
vSphere vCenter Cluster	Always	True	Listed required privileges
vSphere vCenter Datastore	Always	False	Listed required privileges
vSphere Switch	Always	False	<b>ReadOnly</b> permission
vSphere Port Group	Always	False	Listed required privileges
vSphere vCenter Virtual Machine Folder	Existing folder	True	Listed required privileges

For more information about creating an account with only the required privileges, see [vSphere Permissions and User Management Tasks](#) in the vSphere documentation.

### Using OpenShift Container Platform with vMotion

If you intend on using vMotion in your vSphere environment, consider the following before installing a OpenShift Container Platform cluster.

- OpenShift Container Platform generally supports compute-only vMotion. Using Storage vMotion can cause issues and is not supported.  
To help ensure the uptime of your compute and control plane nodes, it is recommended that you follow the VMware best practices for vMotion. It is also recommended to use VMware anti-affinity rules to improve the availability of OpenShift Container Platform during maintenance or hardware issues.

For more information about vMotion and anti-affinity rules, see the VMware vSphere documentation for [vMotion networking requirements](#) and [VM anti-affinity rules](#).

- If you are using vSphere volumes in your pods, migrating a VM across datastores either manually or through Storage vMotion causes, invalid references within OpenShift Container Platform persistent volume (PV) objects. These references prevent affected pods from starting up and can result in data loss.
- Similarly, OpenShift Container Platform does not support selective migration of VMDKs across datastores, using datastore clusters for VM provisioning or for dynamic or static provisioning of PVs, or using a datastore that is part of a datastore cluster for dynamic or static provisioning of PVs.

### Cluster resources

When you deploy an OpenShift Container Platform cluster that uses installer-provisioned infrastructure, the installation program must be able to create several resources in your vCenter instance.

A standard OpenShift Container Platform installation creates the following vCenter resources:

- 1 Folder
- 1 Tag category
- 1 Tag
- Virtual machines:
  - 1 template
  - 1 temporary bootstrap node
  - 3 control plane nodes
  - 3 compute machines

Although these resources use 856 GB of storage, the bootstrap node is destroyed during the cluster installation process. A minimum of 800 GB of storage is required to use a standard cluster.

If you deploy more compute machines, the OpenShift Container Platform cluster will use more storage.

### Cluster limits

Available resources vary between clusters. The number of possible clusters within a vCenter is limited primarily by available storage space and any limitations on the number of required resources. Be sure to consider both limitations to the vCenter resources that the cluster creates and the resources that you require to deploy a cluster, such as IP addresses and networks.

### Networking requirements

You must use DHCP for the network and ensure that the DHCP server is configured to provide persistent IP addresses to the cluster machines. You must configure the default gateway to use the DHCP server. All nodes must be in the same VLAN. You cannot scale the cluster using a second VLAN as a Day 2 operation. Additionally, you must create the following networking resources before you install the OpenShift Container Platform cluster:



### NOTE

It is recommended that each OpenShift Container Platform node in the cluster must have access to a Network Time Protocol (NTP) server that is discoverable via DHCP. Installation is possible without an NTP server. However, asynchronous server clocks will cause errors, which NTP server prevents.

### Required IP Addresses

An installer-provisioned vSphere installation requires two static IP addresses:

- The **API** address is used to access the cluster API.
- The **Ingress** address is used for cluster ingress traffic.

You must provide these IP addresses to the installation program when you install the OpenShift Container Platform cluster.

### DNS records

You must create DNS records for two static IP addresses in the appropriate DNS server for the vCenter instance that hosts your OpenShift Container Platform cluster. In each record, **<cluster\_name>** is the cluster name and **<base\_domain>** is the cluster base domain that you specify when you install the

cluster. A complete DNS record takes the form: **<component>.<cluster\_name>.<base\_domain>.**

**Table 18.8. Required DNS records**

Component	Record	Description
API VIP	<b>api.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	This DNS A/AAAA or CNAME record must point to the load balancer for the control plane machines. This record must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
Ingress VIP	<b>*.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A wildcard DNS A/AAAA or CNAME record that points to the load balancer that targets the machines that run the Ingress router pods, which are the worker nodes by default. This record must be resolvable by both clients external to the cluster and from all the nodes within the cluster.

### 18.2.7. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

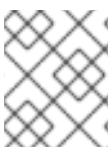
After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.



#### IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



#### NOTE

You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

#### Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.



#### NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

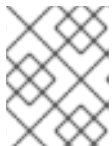
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.



#### NOTE

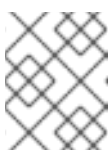
On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

#### Example output

```
Agent pid 31874
```



#### NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1 Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

### Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

### Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

## 18.2.8. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

### Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space

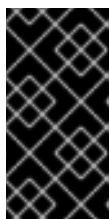
### Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



#### IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



#### IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#) . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform

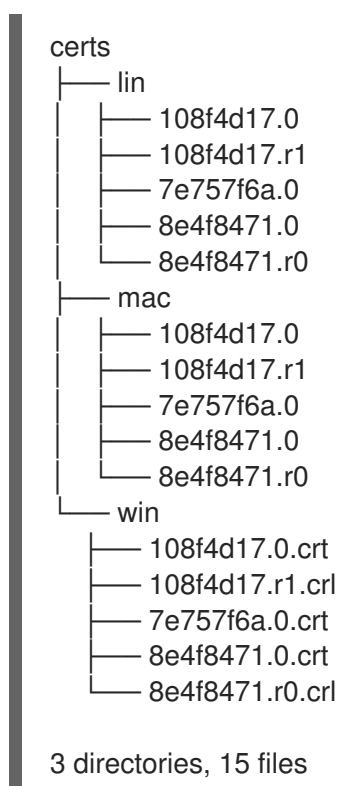
components.

### 18.2.9. Adding vCenter root CA certificates to your system trust

Because the installation program requires access to your vCenter's API, you must add your vCenter's trusted root CA certificates to your system trust before you install an OpenShift Container Platform cluster.

#### Procedure

1. From the vCenter home page, download the vCenter's root CA certificates. Click **Download trusted root CA certificates** in the vSphere Web Services SDK section. The **<vCenter>/certs/download.zip** file downloads.
2. Extract the compressed file that contains the vCenter root CA certificates. The contents of the compressed file resemble the following file structure:



3. Add the files for your operating system to the system trust. For example, on a Fedora operating system, run the following command:

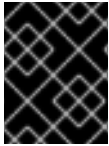
```
# cp certs/lin/* /etc/pki/ca-trust/source/anchors
```

4. Update your system trust. For example, on a Fedora operating system, run the following command:

```
# update-ca-trust extract
```

### 18.2.10. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.

**IMPORTANT**

You can run the **create cluster** command of the installation program only once, during initial installation.

**Prerequisites**

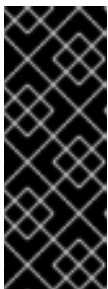
- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

**Procedure**

1. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
--log-level=info 2
```

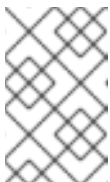
- 1** For **<installation\_directory>**, specify the directory name to store the files that the installation program creates.
- 2** To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

**IMPORTANT**

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

Provide values at the prompts:

- a. Optional: Select an SSH key to use to access your cluster machines.

**NOTE**

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

- b. Select **vsphere** as the platform to target.
- c. Specify the name of your vCenter instance.
- d. Specify the user name and password for the vCenter account that has the required permissions to create the cluster.  
The installation program connects to your vCenter instance.
- e. Select the datacenter in your vCenter instance to connect to.



- f. Select the default vCenter datastore to use.



#### NOTE

Datastore and cluster names cannot exceed 60 characters; therefore, ensure the combined string length does not exceed the 60 character limit.

- g. Select the vCenter cluster to install the OpenShift Container Platform cluster in. The installation program uses the root resource pool of the vSphere cluster as the default resource pool.
- h. Select the network in the vCenter instance that contains the virtual IP addresses and DNS records that you configured.
- i. Enter the virtual IP address that you configured for control plane API access.
- j. Enter the virtual IP address that you configured for cluster ingress.
- k. Enter the base domain. This base domain must be the same one that you used in the DNS records that you configured.
- l. Enter a descriptive name for your cluster. The cluster name must be the same one that you used in the DNS records that you configured.



#### NOTE

Datastore and cluster names cannot exceed 60 characters; therefore, ensure the combined string length does not exceed the 60 character limit.

- m. Paste the [pull secret from the Red Hat OpenShift Cluster Manager](#) .



#### IMPORTANT

Use the **openshift-install** command from the bastion hosted in the VMC environment.



#### NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

When the cluster deployment completes, directions for accessing your cluster, including a link to its web console and credentials for the **kubeadmin** user, display in your terminal.

#### Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
```

INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Ee6gm-ymBZj-Wt5AL"  
 INFO Time elapsed: 36m22s



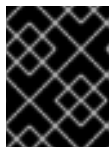
#### NOTE

The cluster access and credential information also outputs to `<installation_directory>/openshift_install.log` when an installation succeeds.



#### IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

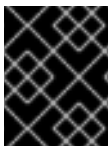


#### IMPORTANT

You must not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

### 18.2.11. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



#### IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

#### Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

```
$ tar xvf <file>
```

5. Place the **oc** binary in a directory that is on your **PATH**.  
To check your **PATH**, execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

### Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

## 18.2.12. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

### Example output

```
system:admin
```

## 18.2.13. Creating registry storage

After you install the cluster, you must create storage for the registry Operator.

### 18.2.13.1. Image registry removed during installation

On platforms that do not provide shareable object storage, the OpenShift Image Registry Operator bootstraps itself as **Removed**. This allows **openshift-installer** to complete installations on these platform types.

After installation, you must edit the Image Registry Operator configuration to switch the **managementState** from **Removed** to **Managed**.



## NOTE

The Prometheus console provides an **ImageRegistryRemoved** alert, for example:

"Image Registry has been removed. **ImageStreamTags**, **BuildConfigs** and **DeploymentConfigs** which reference **ImageStreamTags** may not work as expected. Please configure storage and update the config to **Managed** state by editing `configs.imageregistry.operator.openshift.io`."

### 18.2.13.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

#### 18.2.13.2.1. Configuring registry storage for VMware vSphere

As a cluster administrator, following installation you must configure your registry to use storage.

#### Prerequisites

- Cluster administrator permissions.
- A cluster on VMware vSphere.
- Persistent storage provisioned for your cluster, such as Red Hat OpenShift Container Storage.



## IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have "100Gi" capacity.



## IMPORTANT

Testing shows issues with using the NFS server on RHEL as storage backend for core services. This includes the OpenShift Container Registry and Quay, Prometheus for monitoring storage, and Elasticsearch for logging storage. Therefore, using RHEL NFS to back PVs used by core services is not recommended.

Other NFS implementations on the marketplace might not have these issues. Contact the individual NFS implementation vendor for more information on any testing that was possibly completed against these OpenShift Container Platform core components.

## Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.



### NOTE

When using shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

### Example output

```
No resources found in openshift-image-registry namespace
```



### NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

### Example output

```
storage:
  pvc:
    claim: 1
```

- 1** Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** persistent volume claim (PVC). The PVC is generated based on the default storage class. However, be aware that the default storage class might provide ReadWriteOnce (RWO) volumes, such as a RADOS Block Device (RBD), which can cause issues when replicating to more than one replica.

4. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED
image-registry	4.7	True	False	False

## 18.2.13.2.2. Configuring block registry storage for VMware vSphere

To allow the image registry to use block storage types such as vSphere Virtual Machine Disk (VMDK) during upgrades as a cluster administrator, you can use the **Recreate** rollout strategy.



## IMPORTANT

Block storage volumes are supported but not recommended for use with image registry on production clusters. An installation where the registry is configured on block storage is not highly available because the registry cannot have more than one replica.

## Procedure

1. To set the image registry storage as a block storage type, patch the registry so that it uses the **Recreate** rollout strategy and runs with only **1** replica:

```
$ oc patch config.imageregistry.operator.openshift.io/cluster --type=merge -p '{"spec": {"rolloutStrategy": "Recreate", "replicas": 1}}'
```

2. Provision the PV for the block storage device, and create a PVC for that volume. The requested block volume uses the ReadWriteOnce (RWO) access mode.
  - a. Create a **pvc.yaml** file with the following contents to define a VMware vSphere **PersistentVolumeClaim** object:

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: image-registry-storage 1
  namespace: openshift-image-registry 2
spec:
  accessModes:
  - ReadWriteOnce 3
  resources:
    requests:
      storage: 100Gi 4
```

- 1 A unique name that represents the **PersistentVolumeClaim** object.
- 2 The namespace for the **PersistentVolumeClaim** object, which is **openshift-image-registry**.
- 3 The access mode of the persistent volume claim. With **ReadWriteOnce**, the volume can be mounted with read and write permissions by a single node.
- 4 The size of the persistent volume claim.

- b. Create the **PersistentVolumeClaim** object from the file:

```
$ oc create -f pvc.yaml -n openshift-image-registry
```

3. Edit the registry configuration so that it references the correct PVC:

```
$ oc edit config.imageregistry.operator.openshift.io -o yaml
```

## Example output

```
storage:
  pvc:
    claim: 1
```

- 1 Creating a custom PVC allows you to leave the **claim** field blank for the default automatic creation of an **image-registry-storage** PVC.

For instructions about configuring registry storage so that it references the correct PVC, see [Configuring the registry for vSphere](#).

### 18.2.14. Backing up VMware vSphere volumes

OpenShift Container Platform provisions new volumes as independent persistent disks to freely attach and detach the volume on any node in the cluster. As a consequence, it is not possible to back up volumes that use snapshots, or to restore volumes from snapshots. See [Snapshot Limitations](#) for more information.

#### Procedure

To create a backup of persistent volumes:

1. Stop the application that is using the persistent volume.
2. Clone the persistent volume.
3. Restart the application.
4. Create a backup of the cloned volume.
5. Delete the cloned volume.

### 18.2.15. Steal clock accounting

By default, the installation program provisions the cluster's virtual machines without enabling the steal clock accounting parameter (**stealclock.enabled**). Enabling steal clock accounting can help with troubleshooting cluster issues. After the cluster is deployed, use the vSphere Client to enable this parameter on each of the virtual machines.

For more information, see this [Red Hat knowledge base article](#).

### 18.2.16. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

#### Additional resources



- See [About remote health monitoring](#) for more information about the Telemetry service

### 18.2.17. Next steps

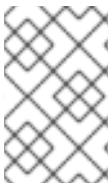
- [Customize your cluster.](#)
- If necessary, you can [opt out of remote health reporting](#) .
- [Set up your registry and configure registry storage](#) .
- Optional: [View the events from the vSphere Problem Detector Operator](#) to determine if the cluster has permission or storage configuration issues.

## 18.3. INSTALLING A CLUSTER ON VMC WITH CUSTOMIZATIONS

In OpenShift Container Platform version 4.9, you can install a cluster on your VMware vSphere instance using installer-provisioned infrastructure by deploying it to [VMware Cloud \(VMC\) on AWS](#) .

Once you configure your VMC environment for OpenShift Container Platform deployment, you use the OpenShift Container Platform installation program from the bastion management host, co-located in the VMC environment. The installation program and control plane automates the process of deploying and managing the resources needed for the OpenShift Container Platform cluster.

To customize the OpenShift Container Platform installation, you modify parameters in the **install-config.yaml** file before you install the cluster.

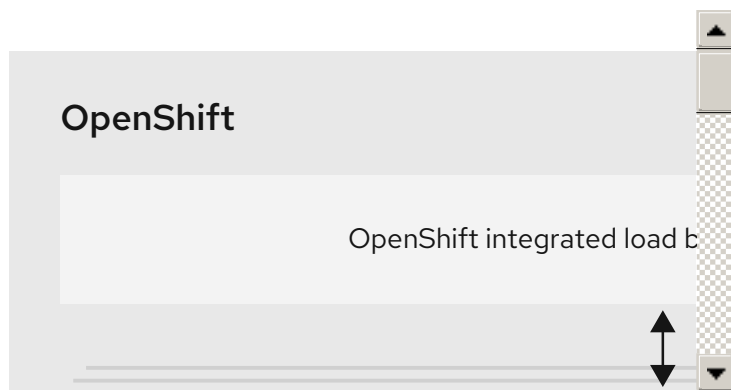


### NOTE

OpenShift Container Platform supports deploying a cluster to a single VMware vCenter only. Deploying a cluster with machines/machine sets on multiple vCenters is not supported.

### 18.3.1. Setting up VMC for vSphere

You can install OpenShift Container Platform on VMware Cloud (VMC) on AWS hosted vSphere clusters to enable applications to be deployed and managed both on-premise and off-premise, across the hybrid cloud.



You must configure several options in your VMC environment prior to installing OpenShift Container Platform on VMware vSphere. Ensure your VMC environment has the following prerequisites:

- Create a non-exclusive, DHCP-enabled, NSX-T network segment and subnet. Other virtual machines (VMs) can be hosted on the subnet, but at least eight IP addresses must be available for the OpenShift Container Platform deployment.
- Allocate two IP addresses, outside the DHCP range, and configure them with reverse DNS records.
  - A DNS record for **api.<cluster\_name>.<base\_domain>** pointing to the allocated IP address.
  - A DNS record for **\*.apps.<cluster\_name>.<base\_domain>** pointing to the allocated IP address.
- Configure the following firewall rules:
  - An ANY:ANY firewall rule between the OpenShift Container Platform compute network and the internet. This is used by nodes and applications to download container images.
  - An ANY:ANY firewall rule between the installation host and the software-defined data center (SDDC) management network on port 443. This allows you to upload the Red Hat Enterprise Linux CoreOS (RHCOS) OVA during deployment.
  - An HTTPS firewall rule between the OpenShift Container Platform compute network and vCenter. This connection allows OpenShift Container Platform to communicate with vCenter for provisioning and managing nodes, persistent volume claims (PVCs), and other resources.
- You must have the following information to deploy OpenShift Container Platform:
  - The OpenShift Container Platform cluster name, such as **vmc-prod-1**.
  - The base DNS name, such as **companyname.com**.
  - If not using the default, the pod network CIDR and services network CIDR must be identified, which are set by default to **10.128.0.0/14** and **172.30.0.0/16**, respectively. These CIDRs are used for pod-to-pod and pod-to-service communication and are not accessible externally; however, they must not overlap with existing subnets in your organization.
  - The following vCenter information:
    - vCenter hostname, username, and password
    - Datacenter name, such as **SDDC-Datacenter**
    - Cluster name, such as **Cluster-1**
    - Network name
    - Datastore name, such as **WorkloadDatastore**



#### NOTE

It is recommended to move your vSphere cluster to the VMC **Compute-ResourcePool** resource pool after your cluster installation is finished.

- A Linux-based host deployed to VMC as a bastion.

- The bastion host can be Red Hat Enterprise Linux (RHEL) or any another Linux-based host; it must have internet connectivity and the ability to upload an OVA to the ESXi hosts.
- Download and install the OpenShift CLI tools to the bastion host.
  - The **openshift-install** installation program
  - The OpenShift CLI (**oc**) tool



## NOTE

You cannot use the VMware NSX Container Plugin for Kubernetes (NCP), and NSX is not used as the OpenShift SDN. The version of NSX currently available with VMC is incompatible with the version of NCP certified with OpenShift Container Platform.

However, the NSX DHCP service is used for virtual machine IP management with the full-stack automated OpenShift Container Platform deployment and with nodes provisioned, either manually or automatically, by the Machine API integration with vSphere. Additionally, NSX firewall rules are created to enable access with the OpenShift Container Platform cluster and between the bastion host and the VMC vSphere hosts.

### 18.3.1.1. VMC Sizer tool

VMware Cloud on AWS is built on top of AWS bare metal infrastructure; this is the same bare metal infrastructure which runs AWS native services. When a VMware cloud on AWS software-defined data center (SDDC) is deployed, you consume these physical server nodes and run the VMware ESXi hypervisor in a single tenant fashion. This means the physical infrastructure is not accessible to anyone else using VMC. It is important to consider how many physical hosts you will need to host your virtual infrastructure.

To determine this, VMware provides the [VMC on AWS Sizer](#). With this tool, you can define the resources you intend to host on VMC:

- Types of workloads
- Total number of virtual machines
- Specification information such as:
  - Storage requirements
  - vCPUs
  - vRAM
  - Overcommit ratios

With these details, the sizer tool can generate a report, based on VMware best practices, and recommend your cluster configuration and the number of hosts you will need.

### 18.3.2. vSphere prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.

- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You provisioned [block registry storage](#). For more information on persistent storage, see [Understanding persistent storage](#).
- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.

**NOTE**

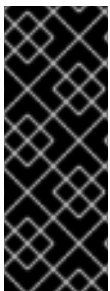
Be sure to also review this site list if you are configuring a proxy.

### 18.3.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.

**IMPORTANT**

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

### 18.3.4. VMware vSphere infrastructure requirements

You must install the OpenShift Container Platform cluster on a VMware vSphere version 6 or 7 instance that meets the requirements for the components that you use.

**Table 18.9. Version requirements for vSphere virtual environments**

Virtual environment product	Required version
VM hardware version	13 or later
vSphere ESXi hosts	6.5 or later
vCenter host	6.5 or later



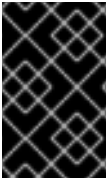
## IMPORTANT

Installing a cluster on VMware vSphere version 6.7U2 or earlier and virtual hardware version 13 is now deprecated. These versions are still fully supported, but support will be removed in a future version of OpenShift Container Platform. Hardware version 15 is now the default for vSphere virtual machines in OpenShift Container Platform. To update the hardware version for your vSphere nodes, see the "Updating hardware on nodes running in vSphere" article.

**Table 18.10. Minimum supported vSphere version for VMware components**

Component	Minimum supported versions	Description
Hypervisor	vSphere 6.5 and later with HW version 13	This version is the minimum version that Red Hat Enterprise Linux CoreOS (RHCOS) supports. See the <a href="#">Red Hat Enterprise Linux 8 supported hypervisors list</a> .
Storage with in-tree drivers	vSphere 6.5 and later	This plugin creates vSphere storage by using the in-tree storage drivers for vSphere included in OpenShift Container Platform.

If you use a vSphere version 6.5 instance, consider upgrading to 6.7U3 or 7.0 before you install OpenShift Container Platform.



## IMPORTANT

You must ensure that the time on your ESXi hosts is synchronized before you install OpenShift Container Platform. See [Edit Time Configuration for a Host](#) in the VMware documentation.

### 18.3.5. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate.

Review the following details about the required network ports.

**Table 18.11. Ports used for all-machine to all-machine communications**

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	<b>1936</b>	Metrics
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> and the Cluster Version Operator on port <b>9099</b> .

Protocol	Port	Description
	<b>10250-10259</b>	The default ports that Kubernetes reserves
	<b>10256</b>	openshift-sdn
UDP	<b>4789</b>	virtual extensible LAN (VXLAN)
	<b>6081</b>	Geneve
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> .
	<b>500</b>	IPsec IKE packets
	<b>4500</b>	IPsec NAT-T packets
TCP/UDP	<b>30000-32767</b>	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 18.12. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	<b>6443</b>	Kubernetes API

Table 18.13. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	<b>2379-2380</b>	etcd server and peer ports

#### Additional resources

- To update the hardware version for your vSphere nodes, see [Updating hardware on nodes running in vSphere](#).

### 18.3.6. vCenter requirements

Before you install an OpenShift Container Platform cluster on your vCenter that uses infrastructure that the installer provisions, you must prepare your environment.

#### Required vCenter account privileges

To install an OpenShift Container Platform cluster in a vCenter, the installation program requires access to an account with privileges to read and create the required resources. Using an account that has global administrative privileges is the simplest way to access all of the necessary permissions.

If you cannot use an account with global administrative privileges, you must create roles to grant the privileges necessary for OpenShift Container Platform cluster installation. While most of the privileges are always required, some are required only if you plan for the installation program to provision a folder to contain the OpenShift Container Platform cluster on your vCenter instance, which is the default behavior. You must create or amend vSphere roles for the specified objects to grant the required privileges.

An additional role is required if the installation program is to create a vSphere virtual machine folder.

#### Example 18.4. Roles and privileges required for installation in vSphere API

vSphere object for role	When required	Required privileges in vSphere API
vSphere vCenter	Always	<b>Cns.Searchable</b> <b>InventoryService.Tagging.AttachTag</b> <b>InventoryService.Tagging.CreateCategory</b> <b>InventoryService.Tagging.CreateTag</b> <b>InventoryService.Tagging.DeleteCategory</b> <b>InventoryService.Tagging.DeleteTag</b> <b>InventoryService.Tagging.EditCategory</b> <b>InventoryService.Tagging.EditTag</b> <b>Sessions.ValidateSession</b> <b>StorageProfile.Update</b> <b>StorageProfile.View</b>
vSphere vCenter Cluster	Always	<b>Host.Config.StorageResource.AssignVMToPool</b> <b>VApp.AssignResourcePool</b> <b>VApp.Import</b> <b>VirtualMachine.Config.AddNewDisk</b>
vSphere Datastore	Always	<b>Datastore.AllocateSpace</b> <b>Datastore.Browse</b> <b>Datastore.FileManagement</b> <b>InventoryService.Tagging.ObjectAttachable</b>
vSphere Port Group	Always	<b>Network.Assign</b>
Virtual Machine Folder	Always	<b>InventoryService.Tagging.ObjectAttachable</b>

vSphere object for role	When required	Resource.AssignVMToPool Required privileges in vSphere API
		ExistingDisk VirtualMachine.Config.AddNewDisk VirtualMachine.Config.AddRemoveDevice VirtualMachine.Config.AdvancedConfig VirtualMachine.Config.Annotation VirtualMachine.Config.CPUCount VirtualMachine.Config.DiskExtend VirtualMachine.Config.DiskLease VirtualMachine.Config.EditDevice VirtualMachine.Config.Memory VirtualMachine.Config.RemoveDisk VirtualMachine.Config.Rename VirtualMachine.Config.ResetGuestInfo VirtualMachine.Config.Resource VirtualMachine.Config.Settings VirtualMachine.Config.UpgradeVirtualHardware VirtualMachine.Interact.GuestControl VirtualMachine.Interact.PowerOff VirtualMachine.Interact.PowerOn VirtualMachine.Interact.Reset VirtualMachine.Inventory.Create VirtualMachine.Inventory.CreateFromExisting VirtualMachine.Inventory.Delete VirtualMachine.Provisioning.Clone VirtualMachine.Provisioning.MarkAsTemplate VirtualMachine.Provisioning.DeployTemplate
vSphere vCenter Datacenter		InventoryService.Tagging.O



vSphere object for role	If the installation program creates the virtual machine folder <b>When required</b>	<b>Object</b> Attachable Required privileges in vSphere Resource.AssignVMToPool VApp.Import
		VirtualMachine.Config.AddExistingDisk VirtualMachine.Config.AddNewDisk VirtualMachine.Config.AddRemoveDevice VirtualMachine.Config.AdvancedConfig VirtualMachine.Config.Annotation VirtualMachine.Config.CPUCount VirtualMachine.Config.DiskExtend VirtualMachine.Config.DiskLease VirtualMachine.Config.EditDevice VirtualMachine.Config.Memory VirtualMachine.Config.RemoveDisk VirtualMachine.Config.Rename VirtualMachine.Config.ResetGuestInfo VirtualMachine.Config.Resource VirtualMachine.Config.Settings VirtualMachine.Config.UpgradeVirtualHardware VirtualMachine.Interact.GuestControl VirtualMachine.Interact.PowerOff VirtualMachine.Interact.PowerOn VirtualMachine.Interact.Reset VirtualMachine.Inventory.Create VirtualMachine.Inventory.CreateFromExisting VirtualMachine.Inventory.Delete VirtualMachine.Provisioning.Clone VirtualMachine.Provisioning.DeployTemplate VirtualMachine.Provisioning

vSphere object for role	When required	Required privileges in vSphere API
		g.MarkAsTemplate Folder.Create Folder.Delete

Example 18.5. Roles and privileges required for installation in vCenter graphical user interface (GUI)

vSphere object for role	When required	Required privileges in vCenter GUI
vSphere vCenter	Always	<b>Cns.Searchable</b> "vSphere Tagging"."Assign or Unassign vSphere Tag" "vSphere Tagging"."Create vSphere Tag Category" "vSphere Tagging"."Create vSphere Tag" vSphere Tagging"."Delete vSphere Tag Category" "vSphere Tagging"."Delete vSphere Tag" "vSphere Tagging"."Edit vSphere Tag Category" "vSphere Tagging"."Edit vSphere Tag" Sessions."Validate session" "Profile-driven storage"."Profile-driven storage update" "Profile-driven storage"."Profile-driven storage view"
vSphere vCenter Cluster	If VMs will be created in the cluster root	<b>Host.Configuration."Storage partition configuration"</b> Resource."Assign virtual machine to resource pool" VApp."Assign resource pool" VApp.Import "Virtual machine"."Change Configuration"."Add new disk"

vSphere object for role	When required	Required privileges in vCenter GUI
vSphere vCenter Resource Pool	If an existing resource pool is provided	<b>Host.Configuration."Storage partition configuration"</b> <b>Resource."Assign virtual machine to resource pool"</b> <b>VApp."Assign resource pool"</b> <b>VApp.Import</b> <b>"Virtual machine"."Change Configuration"."Add new disk"</b>
vSphere Datastore	Always	<b>Datastore."Allocate space"</b> <b>Datastore."Browse datastore"</b> <b>Datastore."Low level file operations"</b> <b>"vSphere Tagging"."Assign or Unassign vSphere Tag on Object"</b>
vSphere Port Group	Always	<b>Network."Assign network"</b>
Virtual Machine Folder	Always	<b>"vSphere Tagging"."Assign or Unassign vSphere Tag on Object"</b> <b>Resource."Assign virtual machine to resource pool"</b> <b>VApp.Import</b> <b>"Virtual machine"."Change Configuration"."Add existing disk"</b> <b>"Virtual machine"."Change Configuration"."Add new disk"</b> <b>"Virtual machine"."Change Configuration"."Add or remove device"</b> <b>"Virtual machine"."Change Configuration"."Advanced configuration"</b> <b>"Virtual machine"."Change Configuration"."Set annotation"</b> <b>"Virtual machine"."Change Configuration"."Change CPU count"</b> <b>"Virtual machine"."Change Configuration"."Extend virtual disk"</b> <b>"Virtual machine"."Change Configuration"."Acquire</b>

vSphere object for role	When required	Required privileges in vCenter GUI
		<p>disk lease"</p> <p>Virtual machine : Change Configuration". "Modify device settings"</p> <p>"Virtual machine". "Change Configuration". "Change Memory"</p> <p>"Virtual machine". "Change Configuration". "Remove disk"</p> <p>"Virtual machine". "Change Configuration". Rename</p> <p>"Virtual machine". "Change Configuration". "Reset guest information"</p> <p>"Virtual machine". "Change Configuration". "Change resource"</p> <p>"Virtual machine". "Change Configuration". "Change Settings"</p> <p>"Virtual machine". "Change Configuration". "Upgrade virtual machine compatibility"</p> <p>"Virtual machine". Interaction. "Guest operating system management by VIX API"</p> <p>"Virtual machine". Interaction. "Power off"</p> <p>"Virtual machine". Interaction. "Power on"</p> <p>"Virtual machine". Interaction. Reset</p> <p>"Virtual machine". "Edit Inventory". "Create new"</p> <p>"Virtual machine". "Edit Inventory". "Create from existing"</p> <p>"Virtual machine". "Edit Inventory". "Remove"</p> <p>"Virtual machine". Provisioning. "Clone virtual machine"</p> <p>"Virtual machine". Provisioning. "Mark as template"</p> <p>"Virtual machine". Provisioning. "Deploy template"</p>
vSphere vCenter Datacenter		"vSphere Tagging". "Assign or Unassign vSphere Tag

vSphere object for role	If the installation program creates the virtual machine folder When required	on Object" Required privileges in vCenter GUI Resource: Assign virtual machine to resource pool"
		VApp.Import "Virtual machine"."Change Configuration"."Add existing disk" "Virtual machine"."Change Configuration"."Add new disk" "Virtual machine"."Change Configuration"."Add or remove device" "Virtual machine"."Change Configuration"."Advanced configuration" "Virtual machine"."Change Configuration"."Set annotation" "Virtual machine"."Change Configuration"."Change CPU count" "Virtual machine"."Change Configuration"."Extend virtual disk" "Virtual machine"."Change Configuration"."Acquire disk lease" "Virtual machine"."Change Configuration"."Modify device settings" "Virtual machine"."Change Configuration"."Change Memory" "Virtual machine"."Change Configuration"."Remove disk" "Virtual machine"."Change Configuration".Rename "Virtual machine"."Change Configuration"."Reset guest information" "Virtual machine"."Change Configuration"."Change resource" "Virtual machine"."Change Configuration"."Change Settings" "Virtual machine"."Change Configuration"."Upgrade virtual machine compatibility" "Virtual machine".Interaction."Guest operating system management by VIX API"

vSphere object for role	When required	Required privileges in vCenter GUI
		"Virtual machine".Interaction."Power on" "Virtual machine".Interaction.Reset "Virtual machine"."Edit Inventory"."Create new" "Virtual machine"."Edit Inventory"."Create from existing" "Virtual machine"."Edit Inventory"."Remove" "Virtual machine".Provisioning."Clone virtual machine" "Virtual machine".Provisioning."Deploy template" "Virtual machine".Provisioning."Mark as template" Folder."Create folder" Folder."Delete folder"

Additionally, the user requires some **ReadOnly** permissions, and some of the roles require permission to propagate the permissions to child objects. These settings vary depending on whether or not you install the cluster into an existing folder.

**Example 18.6. Required permissions and propagation settings**

vSphere object	Folder type	Propagate to children	Permissions required
vSphere vCenter	Always	False	Listed required privileges
vSphere vCenter Datacenter	Existing folder	False	<b>ReadOnly</b> permission
	Installation program creates the folder	True	Listed required privileges
vSphere vCenter Cluster	Always	True	Listed required privileges
vSphere vCenter Datastore	Always	False	Listed required privileges
vSphere Switch	Always	False	<b>ReadOnly</b> permission

vSphere object	Folder type	Propagate to children	Permissions required
vSphere Port Group	Always	False	Listed required privileges
vSphere vCenter Virtual Machine Folder	Existing folder	True	Listed required privileges

For more information about creating an account with only the required privileges, see [vSphere Permissions and User Management Tasks](#) in the vSphere documentation.

### Using OpenShift Container Platform with vMotion

If you intend on using vMotion in your vSphere environment, consider the following before installing a OpenShift Container Platform cluster.

- OpenShift Container Platform generally supports compute-only vMotion. Using Storage vMotion can cause issues and is not supported.  
To help ensure the uptime of your compute and control plane nodes, it is recommended that you follow the VMware best practices for vMotion. It is also recommended to use VMware anti-affinity rules to improve the availability of OpenShift Container Platform during maintenance or hardware issues.

For more information about vMotion and anti-affinity rules, see the VMware vSphere documentation for [vMotion networking requirements](#) and [VM anti-affinity rules](#).

- If you are using vSphere volumes in your pods, migrating a VM across datastores either manually or through Storage vMotion causes, invalid references within OpenShift Container Platform persistent volume (PV) objects. These references prevent affected pods from starting up and can result in data loss.
- Similarly, OpenShift Container Platform does not support selective migration of VMDKs across datastores, using datastore clusters for VM provisioning or for dynamic or static provisioning of PVs, or using a datastore that is part of a datastore cluster for dynamic or static provisioning of PVs.

### Cluster resources

When you deploy an OpenShift Container Platform cluster that uses installer-provisioned infrastructure, the installation program must be able to create several resources in your vCenter instance.

A standard OpenShift Container Platform installation creates the following vCenter resources:

- 1 Folder
- 1 Tag category
- 1 Tag
- Virtual machines:
  - 1 template
  - 1 temporary bootstrap node
  - 3 control plane nodes

- 3 compute machines

Although these resources use 856 GB of storage, the bootstrap node is destroyed during the cluster installation process. A minimum of 800 GB of storage is required to use a standard cluster.

If you deploy more compute machines, the OpenShift Container Platform cluster will use more storage.

### Cluster limits

Available resources vary between clusters. The number of possible clusters within a vCenter is limited primarily by available storage space and any limitations on the number of required resources. Be sure to consider both limitations to the vCenter resources that the cluster creates and the resources that you require to deploy a cluster, such as IP addresses and networks.

### Networking requirements

You must use DHCP for the network and ensure that the DHCP server is configured to provide persistent IP addresses to the cluster machines. You must configure the default gateway to use the DHCP server. All nodes must be in the same VLAN. You cannot scale the cluster using a second VLAN as a Day 2 operation. Additionally, you must create the following networking resources before you install the OpenShift Container Platform cluster:



#### NOTE

It is recommended that each OpenShift Container Platform node in the cluster must have access to a Network Time Protocol (NTP) server that is discoverable via DHCP. Installation is possible without an NTP server. However, asynchronous server clocks will cause errors, which NTP server prevents.

### Required IP Addresses

An installer-provisioned vSphere installation requires two static IP addresses:

- The **API** address is used to access the cluster API.
- The **Ingress** address is used for cluster ingress traffic.

You must provide these IP addresses to the installation program when you install the OpenShift Container Platform cluster.

### DNS records

You must create DNS records for two static IP addresses in the appropriate DNS server for the vCenter instance that hosts your OpenShift Container Platform cluster. In each record, **<cluster\_name>** is the cluster name and **<base\_domain>** is the cluster base domain that you specify when you install the cluster. A complete DNS record takes the form: **<component>.<cluster\_name>.<base\_domain>..**

**Table 18.14. Required DNS records**

Component	Record	Description
API VIP	<b>api.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	This DNS A/AAAA or CNAME record must point to the load balancer for the control plane machines. This record must be resolvable by both clients external to the cluster and from all the nodes within the cluster.



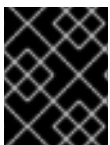
Component	Record	Description
Ingress VIP	*.apps.<cluster_name>.<base_domain>.	A wildcard DNS A/AAAA or CNAME record that points to the load balancer that targets the machines that run the Ingress router pods, which are the worker nodes by default. This record must be resolvable by both clients external to the cluster and from all the nodes within the cluster.

### 18.3.7. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.



#### IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



#### NOTE

You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

#### Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.

**NOTE**

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

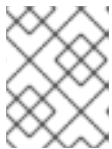
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.

**NOTE**

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

**Example output**

```
Agent pid 31874
```

**NOTE**

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1** Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

**Example output**

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

**Next steps**

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

### 18.3.8. Obtaining the installation program

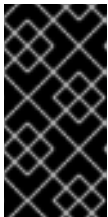
Before you install OpenShift Container Platform, download the installation file on a local computer.

#### Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space

#### Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



#### IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



#### IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

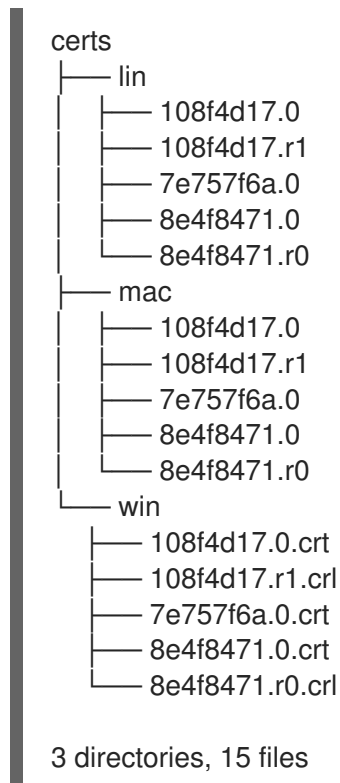
5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#) . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

### 18.3.9. Adding vCenter root CA certificates to your system trust

Because the installation program requires access to your vCenter's API, you must add your vCenter's trusted root CA certificates to your system trust before you install an OpenShift Container Platform cluster.

#### Procedure

1. From the vCenter home page, download the vCenter's root CA certificates. Click **Download trusted root CA certificates** in the vSphere Web Services SDK section. The **<vCenter>/certs/download.zip** file downloads.
2. Extract the compressed file that contains the vCenter root CA certificates. The contents of the compressed file resemble the following file structure:



3. Add the files for your operating system to the system trust. For example, on a Fedora operating system, run the following command:

```
# cp certs/lin/* /etc/pki/ca-trust/source/anchors
```

4. Update your system trust. For example, on a Fedora operating system, run the following command:

```
# update-ca-trust extract
```

### 18.3.10. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on VMware vSphere.

#### Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

#### Procedure

1. Create the **install-config.yaml** file.

- a. Change to the directory that contains the installation program and run the following command:

```
$. /openshift-install create install-config --dir <installation_directory> 1
```

- 1** For **<installation\_directory>**, specify the directory name to store the files that the installation program creates.



### IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

- b. At the prompts, provide the configuration details for your cloud:
- i. Optional: Select an SSH key to use to access your cluster machines.

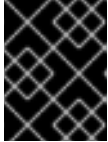


### NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

- ii. Select **vsphere** as the platform to target.
- iii. Specify the name of your vCenter instance.
- iv. Specify the user name and password for the vCenter account that has the required permissions to create the cluster.  
The installation program connects to your vCenter instance.
- v. Select the datacenter in your vCenter instance to connect to.
- vi. Select the default vCenter datastore to use.
- vii. Select the vCenter cluster to install the OpenShift Container Platform cluster in. The installation program uses the root resource pool of the vSphere cluster as the default resource pool.
- viii. Select the network in the vCenter instance that contains the virtual IP addresses and DNS records that you configured.
- ix. Enter the virtual IP address that you configured for control plane API access.
- x. Enter the virtual IP address that you configured for cluster ingress.
- xi. Enter the base domain. This base domain must be the same one that you used in the DNS records that you configured.

- xii. Enter a descriptive name for your cluster. The cluster name must be the same one that you used in the DNS records that you configured.
  - xiii. Paste the [pull secret from the Red Hat OpenShift Cluster Manager](#) .
2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.
  3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



### IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

#### 18.3.10.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.



### NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.



### IMPORTANT

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

#### 18.3.10.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 18.15. Required parameters

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String

Parameter	Description	Values
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;</b> . <b>&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}</b> . <b>{{.baseDomain}}</b> .	String of lowercase letters and hyphens (-), such as <b>dev</b> .
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws</b> , <b>baremetal</b> , <b>azure</b> , <b>gcp</b> , <b>openstack</b> , <b>ovirt</b> , <b>vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } }</pre>

### 18.3.10.1.2. Network configuration parameters


You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

Table 18.16. Network parameters

Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	Object   <b>NOTE</b> You cannot modify parameters specified by the <b>networking</b> object after installation.
<b>networking.networkType</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .
<b>networking.clusterNetwork</b>	The IP address blocks for pods.  The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b> .  If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example:  <pre>networking:   clusterNetwork:   - cidr: 10.128.0.0/14     hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	Required if you use <b>networking.clusterNetwork</b> . An IP address block.  An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b> .
<b>networking.clusterNetwork.hostPrefix</b>	The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b> . A <b>hostPrefix</b> value of <b>23</b> provides 510 ( $2^{(32 - 23)} - 2$ ) pod IP addresses.	A subnet prefix.  The default value is <b>23</b> .




Parameter	Description	Values
<b>networking.serviceNetwork</b>	<p>The IP address block for services. The default value is <b>172.30.0.0/16</b>.</p> <p>The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.</p>	<p>An array with an IP address block in CIDR format. For example:</p> <pre>networking:   serviceNetwork:     - 172.30.0.0/16</pre>
<b>networking.machineNetwork</b>	<p>The IP address blocks for machines.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   machineNetwork:     - cidr: 10.0.0.0/16</pre>
<b>networking.machineNetwork.cidr</b>	<p>Required if you use <b>networking.machineNetwork</b>. An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b>.</p>	<p>An IP network block in CIDR notation.</p> <p>For example, <b>10.0.0.0/16</b>.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p> </div> </div>

### 18.3.10.1.3. Optional configuration parameters



Optional installation configuration parameters are described in the following table:

Table 18.17. Optional parameters


Parameter	Description	Values
<b>additionalTrustBundle</b>	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
<b>compute</b>	The configuration for the machines that comprise the compute nodes.	Array of <b>MachinePool</b> objects.
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String

Parameter	Description	Values
<b>compute.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b>
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String

Parameter	Description	Values
<b>controlPlane.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platform</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>controlPlane.replicas</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.

Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.</p> <p> <b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators reference content</i>.</p> <p> <b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p>	<b>Mint, Passthrough, Manual</b> or an empty string ("").

Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start;"> <div style="width: 60px; height: 60px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 60px; height: 60px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<b>Internal</b> or <b>External</b> . The default value is <b>External</b> .  Setting this field to <b>Internal</b> is not supported on non-cloud platforms.

Parameter	Description	Values
<b>sshKey</b>	<p>The SSH key or keys to authenticate access your cluster machines.</p>  <p><b>NOTE</b></p> <p>For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.</p>	<p>One or more keys. For example:</p> <pre>sshKey:   &lt;key1&gt;   &lt;key2&gt;   &lt;key3&gt;</pre>

#### 18.3.10.1.4. Additional VMware vSphere configuration parameters

Additional VMware vSphere configuration parameters are described in the following table:

Table 18.18. Additional VMware vSphere cluster parameters

Parameter	Description	Values
<b>platform.vsphere.vcenter</b>	The fully-qualified hostname or IP address of the vCenter server.	String
<b>platform.vsphere.username</b>	The user name to use to connect to the vCenter instance with. This user must have at least the roles and privileges that are required for <a href="#">static or dynamic persistent volume provisioning</a> in vSphere.	String
<b>platform.vsphere.password</b>	The password for the vCenter user name.	String
<b>platform.vsphere.datacenter</b>	The name of the datacenter to use in the vCenter instance.	String
<b>platform.vsphere.defaultDatastore</b>	The name of the default datastore to use for provisioning volumes.	String

Parameter	Description	Values
<b>platform.vsphere.folder</b>	<i>Optional.</i> The absolute path of an existing folder where the installation program creates the virtual machines. If you do not provide this value, the installation program creates a folder that is named with the infrastructure ID in the datacenter virtual machine folder.	String, for example, <code>/&lt;datacenter_name&gt;/vm/&lt;folder_name&gt;/&lt;subfolder_name&gt;</code> .
<b>platform.vsphere.network</b>	The network in the vCenter instance that contains the virtual IP addresses and DNS records that you configured.	String
<b>platform.vsphere.cluster</b>	The vCenter cluster to install the OpenShift Container Platform cluster in.	String
<b>platform.vsphere.apiVIP</b>	The virtual IP (VIP) address that you configured for control plane API access.	An IP address, for example <b>128.0.0.1</b> .
<b>platform.vsphere.ingressVIP</b>	The virtual IP (VIP) address that you configured for cluster ingress.	An IP address, for example <b>128.0.0.1</b> .

#### 18.3.10.1.5. Optional VMware vSphere machine pool configuration parameters

Optional VMware vSphere machine pool configuration parameters are described in the following table:

Table 18.19. Optional VMware vSphere machine pool parameters

Parameter	Description	Values
<b>platform.vsphere.clusterOSImage</b>	The location from which the installer downloads the RHCOS image. You must set this parameter to perform an installation in a restricted network.	An HTTP or HTTPS URL, optionally with a SHA-256 checksum. For example, <code>https://mirror.openshift.com/images/rhcos-&lt;version&gt;-vmware.&lt;architecture&gt;.ova</code> .
<b>platform.vsphere.osDisk.diskSizeGB</b>	The size of the disk in gigabytes.	Integer

Parameter	Description	Values
<b>platform.vsphere.cpus</b>	The total number of virtual processor cores to assign a virtual machine. The value of <b>platform.vsphere.cpus</b> must be a multiple of <b>platform.vsphere.coresPerSocket</b> value.	Integer
<b>platform.vsphere.coresPerSocket</b>	The number of cores per socket in a virtual machine. The number of virtual sockets on the virtual machine is <b>platform.vsphere.cpus/platform.vsphere.coresPerSocket</b> . The default value for control plane nodes and worker nodes is <b>4</b> and <b>2</b> , respectively.	Integer
<b>platform.vsphere.memoryMB</b>	The size of a virtual machine's memory in megabytes.	Integer

### 18.3.10.2. Sample install-config.yaml file for an installer-provisioned VMware vSphere cluster

You can customize the install-config.yaml file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```

apiVersion: v1
baseDomain: example.com ❶
compute: ❷
- hyperthreading: Enabled ❸
  name: worker
  replicas: 3
  platform:
    vsphere: ❹
      cpus: 2
      coresPerSocket: 2
      memoryMB: 8192
      osDisk:
        diskSizeGB: 120
controlPlane: ❺
hyperthreading: Enabled ❻
name: master
replicas: 3
platform:
  vsphere: ❼
    cpus: 4
    coresPerSocket: 2
    memoryMB: 16384
    osDisk:

```



```

diskSizeGB: 120
metadata:
  name: cluster 8
platform:
  vsphere:
    vcenter: your.vcenter.server
    username: username
    password: password
    datacenter: datacenter
    defaultDatastore: datastore
    folder: folder
    network: VM_Network
    cluster: vsphere_cluster_name 9
    apiVIP: api_vip
    ingressVIP: ingress_vip
fips: false
pullSecret: '{"auths": ...}'
sshKey: 'ssh-ed25519 AAAA...'

```

- 1** The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.
- 2** **5** The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. Only one control plane pool is used.
- 3** **6** Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.



### IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Your machines must use at least 8 CPUs and 32 GB of RAM if you disable simultaneous multithreading.

- 4** **7** Optional: Provide additional configuration for the machine pool parameters for the compute and control plane machines.
- 8** The cluster name that you specified in your DNS records.
- 9** The vSphere cluster to install the OpenShift Container Platform cluster in. The installation program uses the root resource pool of the vSphere cluster as the default resource pool.

### 18.3.10.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

#### Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



## NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

## Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
  additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
...

```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations. You must include vCenter's IP address and the IP range that you use for its machines.
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

**NOTE**

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

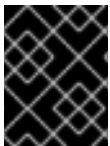
The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

**NOTE**

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

### 18.3.11. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.

**IMPORTANT**

You can run the **create cluster** command of the installation program only once, during initial installation.

#### Prerequisites

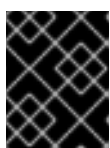
- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

#### Procedure

1. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
--log-level=info 2
```

- 1** For **<installation\_directory>**, specify the location of your customized **./install-config.yaml** file.
- 2** To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

**IMPORTANT**

Use the **openshift-install** command from the bastion hosted in the VMC environment.

**NOTE**

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

When the cluster deployment completes, directions for accessing your cluster, including a link to its web console and credentials for the **kubeadmin** user, display in your terminal.

**Example output**

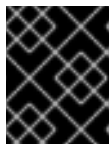
```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Ee6gm-ymBZj-
Wt5AL"
INFO Time elapsed: 36m22s
```

**NOTE**

The cluster access and credential information also outputs to **<installation\_directory>/.openshift\_install.log** when an installation succeeds.

**IMPORTANT**

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

**IMPORTANT**

You must not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

**18.3.12. Installing the OpenShift CLI by downloading the binary**

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



## IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

### Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

```
$ tar xvf <file>
```

5. Place the **oc** binary in a directory that is on your **PATH**.  
To check your **PATH**, execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

## Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your **PATH**.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### 18.3.13. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

#### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

#### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

#### Example output

```
system:admin
```

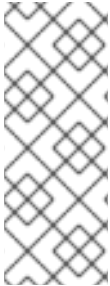
### 18.3.14. Creating registry storage

After you install the cluster, you must create storage for the Registry Operator.

#### 18.3.14.1. Image registry removed during installation

On platforms that do not provide shareable object storage, the OpenShift Image Registry Operator bootstraps itself as **Removed**. This allows **openshift-installer** to complete installations on these platform types.

After installation, you must edit the Image Registry Operator configuration to switch the **managementState** from **Removed** to **Managed**.



#### NOTE

The Prometheus console provides an **ImageRegistryRemoved** alert, for example:

"Image Registry has been removed. **ImageStreamTags**, **BuildConfigs** and **DeploymentConfigs** which reference **ImageStreamTags** may not work as expected. Please configure storage and update the config to **Managed** state by editing `configs.imageregistry.operator.openshift.io`."

#### 18.3.14.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

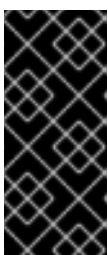
Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

##### 18.3.14.2.1. Configuring registry storage for VMware vSphere

As a cluster administrator, following installation you must configure your registry to use storage.

#### Prerequisites

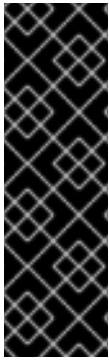
- Cluster administrator permissions.
- A cluster on VMware vSphere.
- Persistent storage provisioned for your cluster, such as Red Hat OpenShift Container Storage.



#### IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have "100Gi" capacity.



## IMPORTANT

Testing shows issues with using the NFS server on RHEL as storage backend for core services. This includes the OpenShift Container Registry and Quay, Prometheus for monitoring storage, and Elasticsearch for logging storage. Therefore, using RHEL NFS to back PVs used by core services is not recommended.

Other NFS implementations on the marketplace might not have these issues. Contact the individual NFS implementation vendor for more information on any testing that was possibly completed against these OpenShift Container Platform core components.

## Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.



## NOTE

When using shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

## Example output

```
No resources found in openshift-image-registry namespace
```



## NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

## Example output

```
storage:
  pvc:
    claim: 1
```

- 1** Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** persistent volume claim (PVC). The PVC is generated based on the default storage class. However, be aware that the default storage class might provide ReadWriteOnce (RWO) volumes, such as a RADOS Block Device (RBD), which can cause issues when replicating to more than one replica.



4. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

### Example output

```
NAME          VERSION          AVAILABLE PROGRESSING DEGRADED
SINCE MESSAGE
image-registry 4.7              True      False      False    6h50m
```

#### 18.3.14.2.2. Configuring block registry storage for VMware vSphere

To allow the image registry to use block storage types such as vSphere Virtual Machine Disk (VMDK) during upgrades as a cluster administrator, you can use the **Recreate** rollout strategy.



### IMPORTANT

Block storage volumes are supported but not recommended for use with image registry on production clusters. An installation where the registry is configured on block storage is not highly available because the registry cannot have more than one replica.

### Procedure

1. To set the image registry storage as a block storage type, patch the registry so that it uses the **Recreate** rollout strategy and runs with only **1** replica:

```
$ oc patch config.imageregistry.operator.openshift.io/cluster --type=merge -p '{"spec": {"rolloutStrategy": "Recreate", "replicas": 1}}'
```

2. Provision the PV for the block storage device, and create a PVC for that volume. The requested block volume uses the ReadWriteOnce (RWO) access mode.
  - a. Create a **pvc.yaml** file with the following contents to define a VMware vSphere **PersistentVolumeClaim** object:

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: image-registry-storage 1
  namespace: openshift-image-registry 2
spec:
  accessModes:
  - ReadWriteOnce 3
  resources:
    requests:
      storage: 100Gi 4
```

- 1 A unique name that represents the **PersistentVolumeClaim** object.
- 2 The namespace for the **PersistentVolumeClaim** object, which is **openshift-image-registry**.
- 3 The access mode of the persistent volume claim. With **ReadWriteOnce**, the volume can be mounted with read and write permissions by a single node.

- 4 The size of the persistent volume claim.

- b. Create the **PersistentVolumeClaim** object from the file:

```
$ oc create -f pvc.yaml -n openshift-image-registry
```

3. Edit the registry configuration so that it references the correct PVC:

```
$ oc edit config.imageregistry.operator.openshift.io -o yaml
```

### Example output

```
storage:
  pvc:
    claim: 1
```

- 1 Creating a custom PVC allows you to leave the **claim** field blank for the default automatic creation of an **image-registry-storage** PVC.

For instructions about configuring registry storage so that it references the correct PVC, see [Configuring the registry for vSphere](#).

## 18.3.15. Backing up VMware vSphere volumes

OpenShift Container Platform provisions new volumes as independent persistent disks to freely attach and detach the volume on any node in the cluster. As a consequence, it is not possible to back up volumes that use snapshots, or to restore volumes from snapshots. See [Snapshot Limitations](#) for more information.

### Procedure

To create a backup of persistent volumes:

1. Stop the application that is using the persistent volume.
2. Clone the persistent volume.
3. Restart the application.
4. Create a backup of the cloned volume.
5. Delete the cloned volume.

## 18.3.16. Steal clock accounting

By default, the installation program provisions the cluster's virtual machines without enabling the steal clock accounting parameter (**stealclock.enabled**). Enabling steal clock accounting can help with troubleshooting cluster issues. After the cluster is deployed, use the vSphere Client to enable this parameter on each of the virtual machines.

For more information, see this [Red Hat knowledge base article](#).

### 18.3.17. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

#### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

### 18.3.18. Next steps

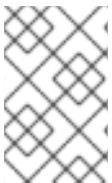
- [Customize your cluster](#).
- If necessary, you can [opt out of remote health reporting](#).
- [Set up your registry and configure registry storage](#).
- Optional: [View the events from the vSphere Problem Detector Operator](#) to determine if the cluster has permission or storage configuration issues.

## 18.4. INSTALLING A CLUSTER ON VMC WITH NETWORK CUSTOMIZATIONS

In OpenShift Container Platform version 4.9, you can install a cluster on your VMware vSphere instance using installer-provisioned infrastructure with customized network configuration options by deploying it to [VMware Cloud \(VMC\) on AWS](#).

Once you configure your VMC environment for OpenShift Container Platform deployment, you use the OpenShift Container Platform installation program from the bastion management host, co-located in the VMC environment. The installation program and control plane automates the process of deploying and managing the resources needed for the OpenShift Container Platform cluster.

By customizing your OpenShift Container Platform network configuration, your cluster can coexist with existing IP address allocations in your environment and integrate with existing VXLAN configurations. To customize the installation, you modify parameters in the **install-config.yaml** file before you install the cluster. You must set most of the network configuration parameters during installation, and you can modify only **kubeProxy** configuration parameters in a running cluster.

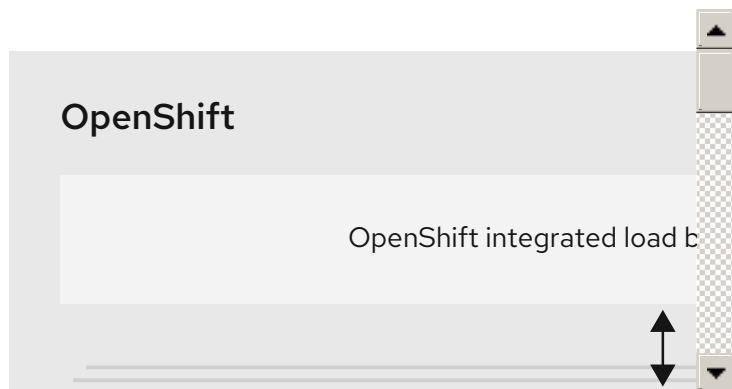


#### NOTE

OpenShift Container Platform supports deploying a cluster to a single VMware vCenter only. Deploying a cluster with machines/machine sets on multiple vCenters is not supported.

### 18.4.1. Setting up VMC for vSphere

You can install OpenShift Container Platform on VMware Cloud (VMC) on AWS hosted vSphere clusters to enable applications to be deployed and managed both on-premise and off-premise, across the hybrid cloud.



You must configure several options in your VMC environment prior to installing OpenShift Container Platform on VMware vSphere. Ensure your VMC environment has the following prerequisites:

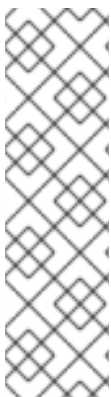
- Create a non-exclusive, DHCP-enabled, NSX-T network segment and subnet. Other virtual machines (VMs) can be hosted on the subnet, but at least eight IP addresses must be available for the OpenShift Container Platform deployment.
- Allocate two IP addresses, outside the DHCP range, and configure them with reverse DNS records.
  - A DNS record for **api.<cluster\_name>.<base\_domain>** pointing to the allocated IP address.
  - A DNS record for **\*.apps.<cluster\_name>.<base\_domain>** pointing to the allocated IP address.
- Configure the following firewall rules:
  - An ANY:ANY firewall rule between the OpenShift Container Platform compute network and the internet. This is used by nodes and applications to download container images.
  - An ANY:ANY firewall rule between the installation host and the software-defined data center (SDDC) management network on port 443. This allows you to upload the Red Hat Enterprise Linux CoreOS (RHCOS) OVA during deployment.
  - An HTTPS firewall rule between the OpenShift Container Platform compute network and vCenter. This connection allows OpenShift Container Platform to communicate with vCenter for provisioning and managing nodes, persistent volume claims (PVCs), and other resources.
- You must have the following information to deploy OpenShift Container Platform:
  - The OpenShift Container Platform cluster name, such as **vmc-prod-1**.
  - The base DNS name, such as **companyname.com**.
  - If not using the default, the pod network CIDR and services network CIDR must be identified, which are set by default to **10.128.0.0/14** and **172.30.0.0/16**, respectively. These CIDRs are used for pod-to-pod and pod-to-service communication and are not accessible externally; however, they must not overlap with existing subnets in your organization.
  - The following vCenter information:
    - vCenter hostname, username, and password
    - Datacenter name, such as **SDDC-Datacenter**

- Cluster name, such as **Cluster-1**
- Network name
- Datastore name, such as **WorkloadDatastore**

**NOTE**

It is recommended to move your vSphere cluster to the VMC **Compute-ResourcePool** resource pool after your cluster installation is finished.

- A Linux-based host deployed to VMC as a bastion.
  - The bastion host can be Red Hat Enterprise Linux (RHEL) or any another Linux-based host; it must have internet connectivity and the ability to upload an OVA to the ESXi hosts.
  - Download and install the OpenShift CLI tools to the bastion host.
    - The **openshift-install** installation program
    - The OpenShift CLI (**oc**) tool

**NOTE**

You cannot use the VMware NSX Container Plugin for Kubernetes (NCP), and NSX is not used as the OpenShift SDN. The version of NSX currently available with VMC is incompatible with the version of NCP certified with OpenShift Container Platform.

However, the NSX DHCP service is used for virtual machine IP management with the full-stack automated OpenShift Container Platform deployment and with nodes provisioned, either manually or automatically, by the Machine API integration with vSphere. Additionally, NSX firewall rules are created to enable access with the OpenShift Container Platform cluster and between the bastion host and the VMC vSphere hosts.

### 18.4.1.1. VMC Sizer tool

VMware Cloud on AWS is built on top of AWS bare metal infrastructure; this is the same bare metal infrastructure which runs AWS native services. When a VMware cloud on AWS software-defined data center (SDDC) is deployed, you consume these physical server nodes and run the VMware ESXi hypervisor in a single tenant fashion. This means the physical infrastructure is not accessible to anyone else using VMC. It is important to consider how many physical hosts you will need to host your virtual infrastructure.

To determine this, VMware provides the [VMC on AWS Sizer](#). With this tool, you can define the resources you intend to host on VMC:

- Types of workloads
- Total number of virtual machines
- Specification information such as:
  - Storage requirements
  - vCPUs

- vRAM
- Overcommit ratios

With these details, the sizer tool can generate a report, based on VMware best practices, and recommend your cluster configuration and the number of hosts you will need.

### 18.4.2. vSphere prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You provisioned [block registry storage](#). For more information on persistent storage, see [Understanding persistent storage](#).
- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.



#### NOTE

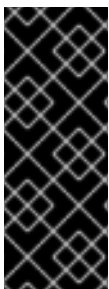
Be sure to also review this site list if you are configuring a proxy.

### 18.4.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



#### IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

### 18.4.4. VMware vSphere infrastructure requirements

You must install the OpenShift Container Platform cluster on a VMware vSphere version 6 or 7 instance that meets the requirements for the components that you use.

**Table 18.20. Version requirements for vSphere virtual environments**

Virtual environment product	Required version
VM hardware version	13 or later
vSphere ESXi hosts	6.5 or later
vCenter host	6.5 or later



### IMPORTANT

Installing a cluster on VMware vSphere version 6.7U2 or earlier and virtual hardware version 13 is now deprecated. These versions are still fully supported, but support will be removed in a future version of OpenShift Container Platform. Hardware version 15 is now the default for vSphere virtual machines in OpenShift Container Platform. To update the hardware version for your vSphere nodes, see the "Updating hardware on nodes running in vSphere" article.

**Table 18.21. Minimum supported vSphere version for VMware components**

Component	Minimum supported versions	Description
Hypervisor	vSphere 6.5 and later with HW version 13	This version is the minimum version that Red Hat Enterprise Linux CoreOS (RHCOS) supports. See the <a href="#">Red Hat Enterprise Linux 8 supported hypervisors list</a> .
Storage with in-tree drivers	vSphere 6.5 and later	This plugin creates vSphere storage by using the in-tree storage drivers for vSphere included in OpenShift Container Platform.

If you use a vSphere version 6.5 instance, consider upgrading to 6.7U3 or 7.0 before you install OpenShift Container Platform.



### IMPORTANT

You must ensure that the time on your ESXi hosts is synchronized before you install OpenShift Container Platform. See [Edit Time Configuration for a Host](#) in the VMware documentation.

#### 18.4.5. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate.

Review the following details about the required network ports.

Table 18.22. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	<b>1936</b>	Metrics
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> and the Cluster Version Operator on port <b>9099</b> .
	<b>10250-10259</b>	The default ports that Kubernetes reserves
	<b>10256</b>	openshift-sdn
UDP	<b>4789</b>	virtual extensible LAN (VXLAN)
	<b>6081</b>	Geneve
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> .
	<b>500</b>	IPsec IKE packets
	<b>4500</b>	IPsec NAT-T packets
TCP/UDP	<b>30000-32767</b>	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 18.23. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	<b>6443</b>	Kubernetes API

Table 18.24. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	<b>2379-2380</b>	etcd server and peer ports

#### Additional resources

- To update the hardware version for your vSphere nodes, see [Updating hardware on nodes running in vSphere](#).



## 18.4.6. vCenter requirements

Before you install an OpenShift Container Platform cluster on your vCenter that uses infrastructure that the installer provisions, you must prepare your environment.

### Required vCenter account privileges

To install an OpenShift Container Platform cluster in a vCenter, the installation program requires access to an account with privileges to read and create the required resources. Using an account that has global administrative privileges is the simplest way to access all of the necessary permissions.

If you cannot use an account with global administrative privileges, you must create roles to grant the privileges necessary for OpenShift Container Platform cluster installation. While most of the privileges are always required, some are required only if you plan for the installation program to provision a folder to contain the OpenShift Container Platform cluster on your vCenter instance, which is the default behavior. You must create or amend vSphere roles for the specified objects to grant the required privileges.

An additional role is required if the installation program is to create a vSphere virtual machine folder.

**Example 18.7. Roles and privileges required for installation in vSphere API**

vSphere object for role	When required	Required privileges in vSphere API
vSphere vCenter	Always	<b>Cns.Searchable</b> <b>InventoryService.Tagging.AttachTag</b> <b>InventoryService.Tagging.CreateCategory</b> <b>InventoryService.Tagging.CreateTag</b> <b>InventoryService.Tagging.DeleteCategory</b> <b>InventoryService.Tagging.DeleteTag</b> <b>InventoryService.Tagging.EditCategory</b> <b>InventoryService.Tagging.EditTag</b> <b>Sessions.ValidateSession</b> <b>StorageProfile.Update</b> <b>StorageProfile.View</b>
vSphere vCenter Cluster	Always	<b>Host.Config.StorageResource.AssignVMToPool</b> <b>VApp.AssignResourcePool</b> <b>VApp.Import</b> <b>VirtualMachine.Config.AddNewDisk</b>

vSphere object for role	When required	Required privileges in vSphere API
vSphere Datastore	Always	<b>Datastore.AllocateSpace</b> <b>Datastore.Browse</b> <b>Datastore.FileManagement</b> <b>InventoryService.Tagging.ObjectAttachable</b>
vSphere Port Group	Always	<b>Network.Assign</b>
Virtual Machine Folder	Always	<b>InventoryService.Tagging.ObjectAttachable</b> <b>Resource.AssignVMToPool</b> <b>VApp.Import</b> <b>VirtualMachine.Config.AddExistingDisk</b> <b>VirtualMachine.Config.AddNewDisk</b> <b>VirtualMachine.Config.AddRemoveDevice</b> <b>VirtualMachine.Config.AdvancedConfig</b> <b>VirtualMachine.Config.Annotation</b> <b>VirtualMachine.Config.CPUCount</b> <b>VirtualMachine.Config.DiskExtend</b> <b>VirtualMachine.Config.DiskLease</b> <b>VirtualMachine.Config.EditDevice</b> <b>VirtualMachine.Config.Memory</b> <b>VirtualMachine.Config.RemoveDisk</b> <b>VirtualMachine.Config.Rename</b> <b>VirtualMachine.Config.ResetGuestInfo</b> <b>VirtualMachine.Config.Resource</b> <b>VirtualMachine.Config.Settings</b> <b>VirtualMachine.Config.UpgradeVirtualHardware</b> <b>VirtualMachine.Interact.GuestControl</b> <b>VirtualMachine.Interact.PowerOff</b> <b>VirtualMachine.Interact.PowerOn</b> <b>VirtualMachine.Interact.Res</b>

vSphere object for role	When required	Required privileges in vSphere API
		<b>VirtualMachine.Inventory.Create</b> <b>VirtualMachine.Inventory.CreateFromExisting</b> <b>VirtualMachine.Inventory.Delete</b> <b>VirtualMachine.Provisioning.Clone</b> <b>VirtualMachine.Provisioning.MarkAsTemplate</b> <b>VirtualMachine.Provisioning.DeployTemplate</b>
vSphere vCenter Datacenter	If the installation program creates the virtual machine folder	<b>InventoryService.Tagging.ObjectAttachable</b> <b>Resource.AssignVMToPool</b> <b>VApp.Import</b> <b>VirtualMachine.Config.AddExistingDisk</b> <b>VirtualMachine.Config.AddNewDisk</b> <b>VirtualMachine.Config.AddRemoveDevice</b> <b>VirtualMachine.Config.AdvancedConfig</b> <b>VirtualMachine.Config.Annotation</b> <b>VirtualMachine.Config.CPUCount</b> <b>VirtualMachine.Config.DiskExtend</b> <b>VirtualMachine.Config.DiskLease</b> <b>VirtualMachine.Config.EditDevice</b> <b>VirtualMachine.Config.Memory</b> <b>VirtualMachine.Config.RemoveDisk</b> <b>VirtualMachine.Config.Rename</b> <b>VirtualMachine.Config.ResetGuestInfo</b> <b>VirtualMachine.Config.Resource</b> <b>VirtualMachine.Config.Settings</b> <b>VirtualMachine.Config.UpgradeVirtualHardware</b> <b>VirtualMachine.Interact.GuestControl</b> <b>VirtualMachine.Interact.PowerOff</b>

vSphere object for role	When required	Required privileges in vSphere API
		<b>VirtualMachine.Interact.PowerOff</b> <b>VirtualMachine.Interact.Reset</b> <b>VirtualMachine.Inventory.Create</b> <b>VirtualMachine.Inventory.CreateFromExisting</b> <b>VirtualMachine.Inventory.Delete</b> <b>VirtualMachine.Provisioning.Clone</b> <b>VirtualMachine.Provisioning.DeployTemplate</b> <b>VirtualMachine.Provisioning.MarkAsTemplate</b> <b>Folder.Create</b> <b>Folder.Delete</b>

Example 18.8. Roles and privileges required for installation in vCenter graphical user interface (GUI)

vSphere object for role	When required	Required privileges in vCenter GUI
vSphere vCenter	Always	<b>Cns.Searchable</b> <b>"vSphere Tagging"."Assign or Unassign vSphere Tag"</b> <b>"vSphere Tagging"."Create vSphere Tag Category"</b> <b>"vSphere Tagging"."Create vSphere Tag"</b> <b>vSphere Tagging"."Delete vSphere Tag Category"</b> <b>"vSphere Tagging"."Delete vSphere Tag"</b> <b>"vSphere Tagging"."Edit vSphere Tag Category"</b> <b>"vSphere Tagging"."Edit vSphere Tag"</b> <b>Sessions."Validate session"</b> <b>"Profile-driven storage"."Profile-driven storage update"</b> <b>"Profile-driven storage"."Profile-driven storage view"</b>

vSphere object for role	When required	Required privileges in vCenter GUI
vSphere vCenter Cluster	If VMs will be created in the cluster root	<b>Host.Configuration."Storage partition configuration"</b> <b>Resource."Assign virtual machine to resource pool"</b> <b>VApp."Assign resource pool"</b> <b>VApp.Import</b> <b>"Virtual machine"."Change Configuration"."Add new disk"</b>
vSphere vCenter Resource Pool	If an existing resource pool is provided	<b>Host.Configuration."Storage partition configuration"</b> <b>Resource."Assign virtual machine to resource pool"</b> <b>VApp."Assign resource pool"</b> <b>VApp.Import</b> <b>"Virtual machine"."Change Configuration"."Add new disk"</b>
vSphere Datastore	Always	<b>Datastore."Allocate space"</b> <b>Datastore."Browse datastore"</b> <b>Datastore."Low level file operations"</b> <b>"vSphere Tagging"."Assign or Unassign vSphere Tag on Object"</b>
vSphere Port Group	Always	<b>Network."Assign network"</b>
Virtual Machine Folder	Always	<b>"vSphere Tagging"."Assign or Unassign vSphere Tag on Object"</b> <b>Resource."Assign virtual machine to resource pool"</b> <b>VApp.Import</b> <b>"Virtual machine"."Change Configuration"."Add existing disk"</b> <b>"Virtual machine"."Change Configuration"."Add new disk"</b> <b>"Virtual machine"."Change Configuration"."Add or remove device"</b> <b>"Virtual machine"."Change Configuration"."Advanced configuration"</b>

vSphere object for role	When required	Required privileges in vCenter GUI
		<p>"Virtual machine"."Change Configuration".Set annotation"</p> <p>"Virtual machine"."Change Configuration"."Change CPU count"</p> <p>"Virtual machine"."Change Configuration"."Extend virtual disk"</p> <p>"Virtual machine"."Change Configuration"."Acquire disk lease"</p> <p>"Virtual machine"."Change Configuration"."Modify device settings"</p> <p>"Virtual machine"."Change Configuration"."Change Memory"</p> <p>"Virtual machine"."Change Configuration"."Remove disk"</p> <p>"Virtual machine"."Change Configuration".Rename</p> <p>"Virtual machine"."Change Configuration"."Reset guest information"</p> <p>"Virtual machine"."Change Configuration"."Change resource"</p> <p>"Virtual machine"."Change Configuration"."Change Settings"</p> <p>"Virtual machine"."Change Configuration"."Upgrade virtual machine compatibility"</p> <p>"Virtual machine".Interaction."Guest operating system management by VIX API"</p> <p>"Virtual machine".Interaction."Power off"</p> <p>"Virtual machine".Interaction."Power on"</p> <p>"Virtual machine".Interaction.Reset</p> <p>"Virtual machine"."Edit Inventory"."Create new"</p> <p>"Virtual machine"."Edit Inventory"."Create from existing"</p> <p>"Virtual machine"."Edit Inventory"."Remove"</p> <p>"Virtual</p>

vSphere object for role	When required	Required privileges in vCenter GUI
		<b>machine".Provisioning."Clone virtual machine"</b> <b>machine".Provisioning."Mark as template"</b> <b>"Virtual machine".Provisioning."Deploy template"</b>
vSphere vCenter Datacenter	If the installation program creates the virtual machine folder	<b>"vSphere Tagging". "Assign or Unassign vSphere Tag on Object"</b> <b>Resource."Assign virtual machine to resource pool"</b> <b>VApp.Import</b> <b>"Virtual machine". "Change Configuration". "Add existing disk"</b> <b>"Virtual machine". "Change Configuration". "Add new disk"</b> <b>"Virtual machine". "Change Configuration". "Add or remove device"</b> <b>"Virtual machine". "Change Configuration". "Advanced configuration"</b> <b>"Virtual machine". "Change Configuration". "Set annotation"</b> <b>"Virtual machine". "Change Configuration". "Change CPU count"</b> <b>"Virtual machine". "Change Configuration". "Extend virtual disk"</b> <b>"Virtual machine". "Change Configuration". "Acquire disk lease"</b> <b>"Virtual machine". "Change Configuration". "Modify device settings"</b> <b>"Virtual machine". "Change Configuration". "Change Memory"</b> <b>"Virtual machine". "Change Configuration". "Remove disk"</b> <b>"Virtual machine". "Change Configuration". Rename</b> <b>"Virtual machine". "Change Configuration". "Reset guest information"</b> <b>"Virtual machine". "Change Configuration". "Change resource"</b>

vSphere object for role	When required	"Virtual machine"."Change Configuration". "Change Settings"
		"Virtual machine"."Change Configuration"."Upgrade virtual machine compatibility" "Virtual machine".Interaction."Guest operating system management by VIX API" "Virtual machine".Interaction."Power off" "Virtual machine".Interaction."Power on" "Virtual machine".Interaction.Reset "Virtual machine"."Edit Inventory"."Create new" "Virtual machine"."Edit Inventory"."Create from existing" "Virtual machine"."Edit Inventory"."Remove" "Virtual machine".Provisioning."Clone virtual machine" "Virtual machine".Provisioning."Deploy template" "Virtual machine".Provisioning."Mark as template" Folder."Create folder" Folder."Delete folder"

Additionally, the user requires some **ReadOnly** permissions, and some of the roles require permission to propagate the permissions to child objects. These settings vary depending on whether or not you install the cluster into an existing folder.

**Example 18.9. Required permissions and propagation settings**

vSphere object	Folder type	Propagate to children	Permissions required
vSphere vCenter	Always	False	Listed required privileges
vSphere vCenter Datacenter	Existing folder	False	<b>ReadOnly</b> permission



vSphere object	Folder type	Propagate to children	Permissions required
	Installation program creates the folder	True	Listed required privileges
vSphere vCenter Cluster	Always	True	Listed required privileges
vSphere vCenter Datastore	Always	False	Listed required privileges
vSphere Switch	Always	False	<b>ReadOnly</b> permission
vSphere Port Group	Always	False	Listed required privileges
vSphere vCenter Virtual Machine Folder	Existing folder	True	Listed required privileges

For more information about creating an account with only the required privileges, see [vSphere Permissions and User Management Tasks](#) in the vSphere documentation.

### Using OpenShift Container Platform with vMotion

If you intend on using vMotion in your vSphere environment, consider the following before installing a OpenShift Container Platform cluster.

- OpenShift Container Platform generally supports compute-only vMotion. Using Storage vMotion can cause issues and is not supported.  
To help ensure the uptime of your compute and control plane nodes, it is recommended that you follow the VMware best practices for vMotion. It is also recommended to use VMware anti-affinity rules to improve the availability of OpenShift Container Platform during maintenance or hardware issues.

For more information about vMotion and anti-affinity rules, see the VMware vSphere documentation for [vMotion networking requirements](#) and [VM anti-affinity rules](#).

- If you are using vSphere volumes in your pods, migrating a VM across datastores either manually or through Storage vMotion causes, invalid references within OpenShift Container Platform persistent volume (PV) objects. These references prevent affected pods from starting up and can result in data loss.
- Similarly, OpenShift Container Platform does not support selective migration of VMDKs across datastores, using datastore clusters for VM provisioning or for dynamic or static provisioning of PVs, or using a datastore that is part of a datastore cluster for dynamic or static provisioning of PVs.

### Cluster resources

When you deploy an OpenShift Container Platform cluster that uses installer-provisioned infrastructure, the installation program must be able to create several resources in your vCenter instance.

A standard OpenShift Container Platform installation creates the following vCenter resources:

- 1 Folder
- 1 Tag category
- 1 Tag
- Virtual machines:
  - 1 template
  - 1 temporary bootstrap node
  - 3 control plane nodes
  - 3 compute machines

Although these resources use 856 GB of storage, the bootstrap node is destroyed during the cluster installation process. A minimum of 800 GB of storage is required to use a standard cluster.

If you deploy more compute machines, the OpenShift Container Platform cluster will use more storage.

### Cluster limits

Available resources vary between clusters. The number of possible clusters within a vCenter is limited primarily by available storage space and any limitations on the number of required resources. Be sure to consider both limitations to the vCenter resources that the cluster creates and the resources that you require to deploy a cluster, such as IP addresses and networks.

### Networking requirements

You must use DHCP for the network and ensure that the DHCP server is configured to provide persistent IP addresses to the cluster machines. You must configure the default gateway to use the DHCP server. All nodes must be in the same VLAN. You cannot scale the cluster using a second VLAN as a Day 2 operation. Additionally, you must create the following networking resources before you install the OpenShift Container Platform cluster:



#### NOTE

It is recommended that each OpenShift Container Platform node in the cluster must have access to a Network Time Protocol (NTP) server that is discoverable via DHCP. Installation is possible without an NTP server. However, asynchronous server clocks will cause errors, which NTP server prevents.

### Required IP Addresses

An installer-provisioned vSphere installation requires two static IP addresses:

- The **API** address is used to access the cluster API.
- The **Ingress** address is used for cluster ingress traffic.

You must provide these IP addresses to the installation program when you install the OpenShift Container Platform cluster.

### DNS records

You must create DNS records for two static IP addresses in the appropriate DNS server for the vCenter instance that hosts your OpenShift Container Platform cluster. In each record, **<cluster\_name>** is the cluster name and **<base\_domain>** is the cluster base domain that you specify when you install the

cluster. A complete DNS record takes the form: **<component>.<cluster\_name>.<base\_domain>.**

**Table 18.25. Required DNS records**

Component	Record	Description
API VIP	<b>api.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	This DNS A/AAAA or CNAME record must point to the load balancer for the control plane machines. This record must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
Ingress VIP	<b>*.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A wildcard DNS A/AAAA or CNAME record that points to the load balancer that targets the machines that run the Ingress router pods, which are the worker nodes by default. This record must be resolvable by both clients external to the cluster and from all the nodes within the cluster.

### 18.4.7. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.



#### IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



#### NOTE

You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

#### Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.



#### NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.



#### NOTE

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

#### Example output

```
Agent pid 31874
```



#### NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1 Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

### Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

### Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

## 18.4.8. Obtaining the installation program

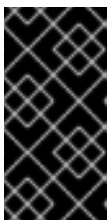
Before you install OpenShift Container Platform, download the installation file on a local computer.

### Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space

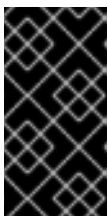
### Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



#### IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



#### IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#). This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform

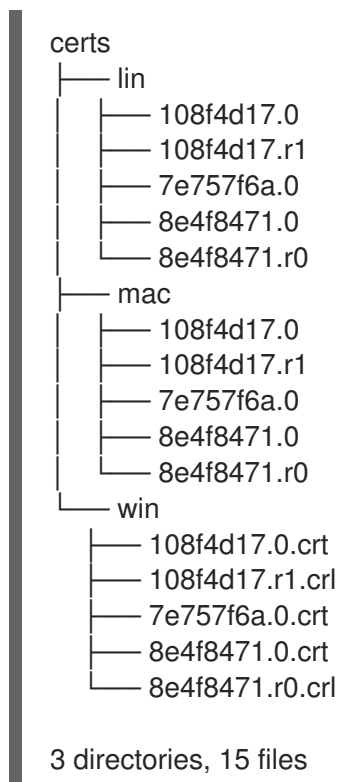
components.

### 18.4.9. Adding vCenter root CA certificates to your system trust

Because the installation program requires access to your vCenter's API, you must add your vCenter's trusted root CA certificates to your system trust before you install an OpenShift Container Platform cluster.

#### Procedure

1. From the vCenter home page, download the vCenter's root CA certificates. Click **Download trusted root CA certificates** in the vSphere Web Services SDK section. The **<vCenter>/certs/download.zip** file downloads.
2. Extract the compressed file that contains the vCenter root CA certificates. The contents of the compressed file resemble the following file structure:



3. Add the files for your operating system to the system trust. For example, on a Fedora operating system, run the following command:

```
# cp certs/lin/* /etc/pki/ca-trust/source/anchors
```

4. Update your system trust. For example, on a Fedora operating system, run the following command:

```
# update-ca-trust extract
```

### 18.4.10. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on VMware vSphere.

## Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain service principal permissions at the subscription level.

## Procedure

1. Create the **install-config.yaml** file.
  - a. Change to the directory that contains the installation program and run the following command:

```

$ ./openshift-install create install-config --dir <installation_directory> 1

```

- 1 For **<installation\_directory>**, specify the directory name to store the files that the installation program creates.



### IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

- b. At the prompts, provide the configuration details for your cloud:
  - i. Optional: Select an SSH key to use to access your cluster machines.

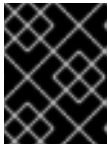


### NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

- ii. Select **vsphere** as the platform to target.
- iii. Specify the name of your vCenter instance.
- iv. Specify the user name and password for the vCenter account that has the required permissions to create the cluster.  
The installation program connects to your vCenter instance.
- v. Select the datacenter in your vCenter instance to connect to.
- vi. Select the default vCenter datastore to use.
- vii. Select the vCenter cluster to install the OpenShift Container Platform cluster in. The installation program uses the root resource pool of the vSphere cluster as the default resource pool.

- viii. Select the network in the vCenter instance that contains the virtual IP addresses and DNS records that you configured.
  - ix. Enter the virtual IP address that you configured for control plane API access.
  - x. Enter the virtual IP address that you configured for cluster ingress.
  - xi. Enter the base domain. This base domain must be the same one that you used in the DNS records that you configured.
  - xii. Enter a descriptive name for your cluster. The cluster name must be the same one that you used in the DNS records that you configured.
  - xiii. Paste the [pull secret from the Red Hat OpenShift Cluster Manager](#) .
2. Modify the **install-config.yaml** file. You can find more information about the available parameters in the "Installation configuration parameters" section.
  3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



### IMPORTANT

The **install-config.yaml** file is consumed during the installation process. If you want to reuse the file, you must back it up now.

#### 18.4.10.1. Installation configuration parameters

Before you deploy an OpenShift Container Platform cluster, you provide parameter values to describe your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.



### NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.



### IMPORTANT

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

#### 18.4.10.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 18.26. Required parameters

Parameter	Description	Values
-----------	-------------	--------



Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;</b> . <b>&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}</b> . <b>{{.baseDomain}}</b> .	String of lowercase letters and hyphens (-), such as <b>dev</b> .
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws</b> , <b>baremetal</b> , <b>azure</b> , <b>gcp</b> , <b>openstack</b> , <b>ovirt</b> , <b>vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object


Parameter	Description	Values
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } }</pre>


#### 18.4.10.1.2. Network configuration parameters

You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

Table 18.27. Network parameters

Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	Object <div style="display: flex; align-items: center; margin-top: 10px;">  <div> <p><b>NOTE</b></p> <p>You cannot modify parameters specified by the <b>networking</b> object after installation.</p> </div> </div>
<b>networking.networkType</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .


Parameter	Description	Values
<b>networking.clusterNetwork</b>	<p>The IP address blocks for pods.</p> <p>The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b>.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   clusterNetwork:     - cidr: 10.128.0.0/14       hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	<p>Required if you use <b>networking.clusterNetwork</b>. An IP address block.</p> <p>An IPv4 network.</p>	<p>An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b>.</p>
<b>networking.clusterNetwork.hostPrefix</b>	<p>The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b>. A <b>hostPrefix</b> value of <b>23</b> provides 510 (<math>2^{(32 - 23)} - 2</math>) pod IP addresses.</p>	<p>A subnet prefix.</p> <p>The default value is <b>23</b>.</p>
<b>networking.serviceNetwork</b>	<p>The IP address block for services. The default value is <b>172.30.0.0/16</b>.</p> <p>The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.</p>	<p>An array with an IP address block in CIDR format. For example:</p> <pre>networking:   serviceNetwork:     - 172.30.0.0/16</pre>
<b>networking.machineNetwork</b>	<p>The IP address blocks for machines.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   machineNetwork:     - cidr: 10.0.0.0/16</pre>
<b>networking.machineNetwork.cidr</b>	<p>Required if you use <b>networking.machineNetwork</b>. An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b>.</p>	<p>An IP network block in CIDR notation.</p> <p>For example, <b>10.0.0.0/16</b>.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p> </div> </div>



## 18.4.10.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:


Table 18.28. Optional parameters

Parameter	Description	Values
<b>additionalTrustBundle</b>	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
<b>compute</b>	The configuration for the machines that comprise the compute nodes.	Array of <b>MachinePool</b> objects.
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String
<b>compute.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div data-bbox="486 1312 593 1630" style="background-color: #333; color: #fff; padding: 5px; width: 60px; height: 140px; margin-bottom: 10px;"> </div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p>	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>

Parameter	Description	Values
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String
<b>controlPlane.hypertreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div data-bbox="485 1093 592 1411" style="background-color: black; color: white; padding: 5px; display: inline-block; vertical-align: middle;">  </div> <p style="margin-left: 20px;"><b>IMPORTANT</b></p> <p style="margin-left: 20px;">If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platform</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>controlPlane.replicas</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.

Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.</p> <p> <b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators</i> reference content.</p> <p> <b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p>	<b>Mint, Passthrough, Manual</b> or an empty string ("").

Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start;"> <div style="width: 40px; height: 40px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 40px; height: 40px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<b>Internal</b> or <b>External</b> . The default value is <b>External</b> .  Setting this field to <b>Internal</b> is not supported on non-cloud platforms.

Parameter	Description	Values
<b>sshKey</b>	<p>The SSH key or keys to authenticate access your cluster machines.</p>  <p><b>NOTE</b></p> <p>For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.</p>	<p>One or more keys. For example:</p> <pre>sshKey:   &lt;key1&gt;   &lt;key2&gt;   &lt;key3&gt;</pre>

#### 18.4.10.1.4. Additional VMware vSphere configuration parameters

Additional VMware vSphere configuration parameters are described in the following table:

Table 18.29. Additional VMware vSphere cluster parameters

Parameter	Description	Values
<b>platform.vsphere.vcenter</b>	The fully-qualified hostname or IP address of the vCenter server.	String
<b>platform.vsphere.username</b>	The user name to use to connect to the vCenter instance with. This user must have at least the roles and privileges that are required for <a href="#">static or dynamic persistent volume provisioning</a> in vSphere.	String
<b>platform.vsphere.password</b>	The password for the vCenter user name.	String
<b>platform.vsphere.datacenter</b>	The name of the datacenter to use in the vCenter instance.	String
<b>platform.vsphere.defaultDatastore</b>	The name of the default datastore to use for provisioning volumes.	String



Parameter	Description	Values
<b>platform.vsphere.folder</b>	<i>Optional.</i> The absolute path of an existing folder where the installation program creates the virtual machines. If you do not provide this value, the installation program creates a folder that is named with the infrastructure ID in the datacenter virtual machine folder.	String, for example, <code>/&lt;datacenter_name&gt;/vm/&lt;folder_name&gt;/&lt;subfolder_name&gt;</code> .
<b>platform.vsphere.network</b>	The network in the vCenter instance that contains the virtual IP addresses and DNS records that you configured.	String
<b>platform.vsphere.cluster</b>	The vCenter cluster to install the OpenShift Container Platform cluster in.	String
<b>platform.vsphere.apiVIP</b>	The virtual IP (VIP) address that you configured for control plane API access.	An IP address, for example <b>128.0.0.1</b> .
<b>platform.vsphere.ingressVIP</b>	The virtual IP (VIP) address that you configured for cluster ingress.	An IP address, for example <b>128.0.0.1</b> .

#### 18.4.10.1.5. Optional VMware vSphere machine pool configuration parameters

Optional VMware vSphere machine pool configuration parameters are described in the following table:

Table 18.30. Optional VMware vSphere machine pool parameters

Parameter	Description	Values
<b>platform.vsphere.clusterOSImage</b>	The location from which the installer downloads the RHCOS image. You must set this parameter to perform an installation in a restricted network.	An HTTP or HTTPS URL, optionally with a SHA-256 checksum. For example, <code>https://mirror.openshift.com/images/rhcos-&lt;version&gt;-vmware.&lt;architecture&gt;.ova</code> .
<b>platform.vsphere.osDisk.diskSizeGB</b>	The size of the disk in gigabytes.	Integer

Parameter	Description	Values
<b>platform.vsphere.cpus</b>	The total number of virtual processor cores to assign a virtual machine. The value of <b>platform.vsphere.cpus</b> must be a multiple of <b>platform.vsphere.coresPerSocket</b> value.	Integer
<b>platform.vsphere.coresPerSocket</b>	The number of cores per socket in a virtual machine. The number of virtual sockets on the virtual machine is <b>platform.vsphere.cpus/platform.vsphere.coresPerSocket</b> . The default value for control plane nodes and worker nodes is <b>4</b> and <b>2</b> , respectively.	Integer
<b>platform.vsphere.memoryMB</b>	The size of a virtual machine's memory in megabytes.	Integer

#### 18.4.10.2. Sample install-config.yaml file for an installer-provisioned VMware vSphere cluster

You can customize the install-config.yaml file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```

apiVersion: v1
baseDomain: example.com ❶
compute: ❷
- hyperthreading: Enabled ❸
  name: worker
  replicas: 3
  platform:
    vsphere: ❹
      cpus: 2
      coresPerSocket: 2
      memoryMB: 8192
      osDisk:
        diskSizeGB: 120
controlPlane: ❺
  hyperthreading: Enabled ❻
  name: master
  replicas: 3
  platform:
    vsphere: ❼
      cpus: 4
      coresPerSocket: 2
      memoryMB: 16384
      osDisk:

```

```

    diskSizeGB: 120
  metadata:
    name: cluster 8
  networking:
    clusterNetwork:
      - cidr: 10.128.0.0/14
        hostPrefix: 23
    machineNetwork:
      - cidr: 10.0.0.0/16
    networkType: OpenShiftSDN
    serviceNetwork:
      - 172.30.0.0/16
  platform:
    vsphere:
      vcenter: your.vcenter.server
      username: username
      password: password
      datacenter: datacenter
      defaultDatastore: datastore
      folder: folder
      network: VM_Network
      cluster: vsphere_cluster_name 9
      apiVIP: api_vip
      ingressVIP: ingress_vip
  fips: false
  pullSecret: '{"auths": ...}'
  sshKey: 'ssh-ed25519 AAAA...'

```

- 1** The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.
- 2 5** The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. Only one control plane pool is used.
- 3 6** Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.



### IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Your machines must use at least 8 CPUs and 32 GB of RAM if you disable simultaneous multithreading.

- 4 7** Optional: Provide additional configuration for the machine pool parameters for the compute and control plane machines.
- 8** The cluster name that you specified in your DNS records.
- 9** The vSphere cluster to install the OpenShift Container Platform cluster in. The installation program uses the root resource pool of the vSphere cluster as the default resource pool.

### 18.4.10.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

#### Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



#### NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

#### Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
  additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
  ...
```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations. You must include vCenter's IP address and the IP range that you use for its machines.
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle**

**NOTE**

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

**NOTE**

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

### 18.4.11. Network configuration phases

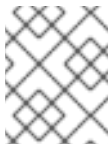
There are two phases prior to OpenShift Container Platform installation where you can customize the network configuration.

#### Phase 1

You can customize the following network-related fields in the **install-config.yaml** file before you create the manifest files:

- **networking.networkType**
- **networking.clusterNetwork**
- **networking.serviceNetwork**
- **networking.machineNetwork**

For more information on these fields, refer to *Installation configuration parameters*.

**NOTE**

Set the **networking.machineNetwork** to match the CIDR that the preferred NIC resides in.

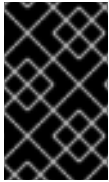
#### Phase 2

After creating the manifest files by running **openshift-install create manifests**, you can define a customized Cluster Network Operator manifest with only the fields you want to modify. You can use the manifest to specify advanced network configuration.

You cannot override the values specified in phase 1 in the **install-config.yaml** file during phase 2. However, you can further customize the cluster network provider during phase 2.

### 18.4.12. Specifying advanced network configuration

You can use advanced network configuration for your cluster network provider to integrate your cluster into your existing network environment. You can specify advanced network configuration only before you install the cluster.



## IMPORTANT

Customizing your network configuration by modifying the OpenShift Container Platform manifest files created by the installation program is not supported. Applying a manifest file that you create, as in the following procedure, is supported.

### Prerequisites

- You have created the **install-config.yaml** file and completed any modifications to it.

### Procedure

- Change to the directory that contains the installation program and create the manifests:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

- 1** **<installation\_directory>** specifies the name of the directory that contains the **install-config.yaml** file for your cluster.

- Create a stub manifest file for the advanced network configuration that is named **cluster-network-03-config.yml** in the **<installation\_directory>/manifests/** directory:

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
```

- Specify the advanced network configuration for your cluster in the **cluster-network-03-config.yml** file, such as in the following examples:

#### Specify a different VXLAN port for the OpenShift SDN network provider

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    openshiftSDNConfig:
      vxlanPort: 4800
```

#### Enable IPsec for the OVN-Kubernetes network provider

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    ovnKubernetesConfig:
      ipsecConfig: {}
```

4. Optional: Back up the **manifests/cluster-network-03-config.yml** file. The installation program consumes the **manifests/** directory when you create the Ignition config files.

### 18.4.13. Cluster Network Operator configuration

The configuration for the cluster network is specified as part of the Cluster Network Operator (CNO) configuration and stored in a custom resource (CR) object that is named **cluster**. The CR specifies the fields for the **Network** API in the **operator.openshift.io** API group.

The CNO configuration inherits the following fields during cluster installation from the **Network** API in the **Network.config.openshift.io** API group and these fields cannot be changed:

#### **clusterNetwork**

IP address pools from which pod IP addresses are allocated.

#### **serviceNetwork**

IP address pool for services.

#### **defaultNetwork.type**

Cluster network provider, such as OpenShift SDN or OVN-Kubernetes.

You can specify the cluster network provider configuration for your cluster by setting the fields for the **defaultNetwork** object in the CNO object named **cluster**.

#### 18.4.13.1. Cluster Network Operator configuration object

The fields for the Cluster Network Operator (CNO) are described in the following table:

Table 18.31. Cluster Network Operator configuration object


Field	Type	Description
<b>metadata.name</b>	<b>string</b>	The name of the CNO object. This name is always <b>cluster</b> .
<b>spec.clusterNetwork</b>	<b>array</b>	<p>A list specifying the blocks of IP addresses from which pod IP addresses are allocated and the subnet prefix length assigned to each individual node in the cluster. For example:</p> <pre>spec:   clusterNetwork:   - cidr: 10.128.0.0/19     hostPrefix: 23   - cidr: 10.128.32.0/19     hostPrefix: 23</pre> <p>You can customize this field only in the <b>install-config.yaml</b> file before you create the manifests. The value is read-only in the manifest file.</p>

Field	Type	Description
<b>spec.serviceNetwork</b>	<b>array</b>	<p>A block of IP addresses for services. The OpenShift SDN and OVN-Kubernetes Container Network Interface (CNI) network providers support only a single IP address block for the service network. For example:</p> <pre>spec:   serviceNetwork:   - 172.30.0.0/14</pre> <p>You can customize this field only in the <b>install-config.yaml</b> file before you create the manifests. The value is read-only in the manifest file.</p>
<b>spec.defaultNetwork</b>	<b>object</b>	Configures the Container Network Interface (CNI) cluster network provider for the cluster network.
<b>spec.kubeProxyConfig</b>	<b>object</b>	The fields for this object specify the kube-proxy configuration. If you are using the OVN-Kubernetes cluster network provider, the kube-proxy configuration has no effect.

#### defaultNetwork object configuration

The values for the **defaultNetwork** object are defined in the following table:

Table 18.32. **defaultNetwork** object

Field	Type	Description
<b>type</b>	<b>string</b>	<p>Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b>. The cluster network provider is selected during installation. This value cannot be changed after cluster installation.</p> <div style="display: flex; align-items: center;">  <div> <p><b>NOTE</b></p> <p>OpenShift Container Platform uses the OpenShift SDN Container Network Interface (CNI) cluster network provider by default.</p> </div> </div>
<b>openshiftSDNConfig</b>	<b>object</b>	This object is only valid for the OpenShift SDN cluster network provider.
<b>ovnKubernetesConfig</b>	<b>object</b>	This object is only valid for the OVN-Kubernetes cluster network provider.

#### Configuration for the OpenShift SDN CNI cluster network provider

The following table describes the configuration fields for the OpenShift SDN Container Network Interface (CNI) cluster network provider.



Table 18.33. openshiftSDNConfig object

Field	Type	Description
<b>mode</b>	<b>string</b>	<p>Configures the network isolation mode for OpenShift SDN. The default value is <b>NetworkPolicy</b>.</p> <p>The values <b>Multitenant</b> and <b>Subnet</b> are available for backwards compatibility with OpenShift Container Platform 3.x but are not recommended. This value cannot be changed after cluster installation.</p>
<b>mtu</b>	<b>integer</b>	<p>The maximum transmission unit (MTU) for the VXLAN overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU.</p> <p>If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes.</p> <p>If your cluster requires different MTU values for different nodes, you must set this value to <b>50</b> less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of <b>9001</b>, and some have an MTU of <b>1500</b>, you must set this value to <b>1450</b>.</p> <p>This value cannot be changed after cluster installation.</p>
<b>vxlanPort</b>	<b>integer</b>	<p>The port to use for all VXLAN packets. The default value is <b>4789</b>. This value cannot be changed after cluster installation.</p> <p>If you are running in a virtualized environment with existing nodes that are part of another VXLAN network, then you might be required to change this. For example, when running an OpenShift SDN overlay on top of VMware NSX-T, you must select an alternate port for the VXLAN, because both SDNs use the same default VXLAN port number.</p> <p>On Amazon Web Services (AWS), you can select an alternate port for the VXLAN between port <b>9000</b> and port <b>9999</b>.</p>

### Example OpenShift SDN configuration

```
defaultNetwork:
  type: OpenShiftSDN
  openshiftSDNConfig:
    mode: NetworkPolicy
    mtu: 1450
    vxlanPort: 4789
```

### Configuration for the OVN-Kubernetes CNI cluster network provider

The following table describes the configuration fields for the OVN-Kubernetes CNI cluster network provider.

**Table 18.34. `ovnKubernetesConfig` object**

Field	Type	Description
<b>mtu</b>	<b>integer</b>	<p>The maximum transmission unit (MTU) for the Geneve (Generic Network Virtualization Encapsulation) overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU.</p> <p>If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes.</p> <p>If your cluster requires different MTU values for different nodes, you must set this value to <b>100</b> less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of <b>9001</b>, and some have an MTU of <b>1500</b>, you must set this value to <b>1400</b>.</p> <p>This value cannot be changed after cluster installation.</p>
<b>genevePort</b>	<b>integer</b>	The port to use for all Geneve packets. The default value is <b>6081</b> . This value cannot be changed after cluster installation.
<b>ipsecConfig</b>	<b>object</b>	Specify an empty object to enable IPsec encryption. This value cannot be changed after cluster installation.
<b>policyAuditConfig</b>	<b>object</b>	Specify a configuration object for customizing network policy audit logging. If unset, the defaults audit log settings are used.

**Table 18.35. `policyAuditConfig` object**

Field	Type	Description
<b>rateLimit</b>	integer	The maximum number of messages to generate every second per node. The default value is <b>20</b> messages per second.
<b>maxFileSize</b>	integer	The maximum size for the audit log in bytes. The default value is <b>50000000</b> or 50 MB.

Field	Type	Description
<b>destination</b>	string	<p>One of the following additional audit log targets:</p> <p><b>libc</b> The libc <b>syslog()</b> function of the journald process on the host.</p> <p><b>udp:&lt;host&gt;:&lt;port&gt;</b> A syslog server. Replace <b>&lt;host&gt;:&lt;port&gt;</b> with the host and port of the syslog server.</p> <p><b>unix:&lt;file&gt;</b> A Unix Domain Socket file specified by <b>&lt;file&gt;</b>.</p> <p><b>null</b> Do not send the audit logs to any additional target.</p>
<b>syslogFacility</b>	string	The syslog facility, such as <b>kern</b> , as defined by RFC5424. The default value is <b>local0</b> .

### Example OVN-Kubernetes configuration

```
defaultNetwork:
  type: OVNKubernetes
  ovnKubernetesConfig:
    mtu: 1400
    genevePort: 6081
    ipsecConfig: {}
```

### kubeProxyConfig object configuration

The values for the **kubeProxyConfig** object are defined in the following table:

Table 18.36. kubeProxyConfig object

Field	Type	Description
<b>iptablesSyncPeriod</b>	string	<p>The refresh period for <b>iptables</b> rules. The default value is <b>30s</b>. Valid suffixes include <b>s</b>, <b>m</b>, and <b>h</b> and are described in the <a href="#">Go time package</a> documentation.</p> <div style="display: flex; align-items: flex-start;"> <div style="flex: 1; border: 1px solid #ccc; background: repeating-linear-gradient(45deg, transparent, transparent 2px, #ccc 2px, #ccc 4px); margin-right: 10px;"></div> <div style="flex: 2;"> <p><b>NOTE</b></p> <p>Because of performance improvements introduced in OpenShift Container Platform 4.3 and greater, adjusting the <b>iptablesSyncPeriod</b> parameter is no longer necessary.</p> </div> </div>

Field	Type	Description
<b>proxyArguments.iptables-min-sync-period</b>	<b>array</b>	<p>The minimum duration before refreshing <b>iptables</b> rules. This field ensures that the refresh does not happen too frequently. Valid suffixes include <b>s</b>, <b>m</b>, and <b>h</b> and are described in the <a href="#">Go time package</a>. The default value is:</p> <pre>kubeProxyConfig:   proxyArguments:     iptables-min-sync-period:       - 0s</pre>

### 18.4.14. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



#### IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

#### Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

#### Procedure

1. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
--log-level=info 2
```

- 1** For **<installation\_directory>**, specify the location of your customized **./install-config.yaml** file.
- 2** To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.



#### IMPORTANT

Use the **openshift-install** command from the bastion hosted in the VMC environment.

**NOTE**

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

When the cluster deployment completes, directions for accessing your cluster, including a link to its web console and credentials for the **kubeadmin** user, display in your terminal.

**Example output**

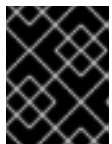
```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Ee6gm-ymBZj-
Wt5AL"
INFO Time elapsed: 36m22s
```

**NOTE**

The cluster access and credential information also outputs to **<installation\_directory>/openshift\_install.log** when an installation succeeds.

**IMPORTANT**

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

**IMPORTANT**

You must not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

**18.4.15. Installing the OpenShift CLI by downloading the binary**

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



## IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

### Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

```
$ tar xvf <file>
```

5. Place the **oc** binary in a directory that is on your **PATH**.  
To check your **PATH**, execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

## Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your **PATH**.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### 18.4.16. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

#### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

#### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

#### Example output

```
system:admin
```

## 18.4.17. Creating registry storage

After you install the cluster, you must create storage for the registry Operator.

### 18.4.17.1. Image registry removed during installation

On platforms that do not provide shareable object storage, the OpenShift Image Registry Operator bootstraps itself as **Removed**. This allows **openshift-installer** to complete installations on these platform types.

After installation, you must edit the Image Registry Operator configuration to switch the **managementState** from **Removed** to **Managed**.



#### NOTE

The Prometheus console provides an **ImageRegistryRemoved** alert, for example:

"Image Registry has been removed. **ImageStreamTags**, **BuildConfigs** and **DeploymentConfigs** which reference **ImageStreamTags** may not work as expected. Please configure storage and update the config to **Managed** state by editing `configs.imageregistry.operator.openshift.io`."

### 18.4.17.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

#### 18.4.17.2.1. Configuring registry storage for VMware vSphere

As a cluster administrator, following installation you must configure your registry to use storage.

#### Prerequisites

- Cluster administrator permissions.
- A cluster on VMware vSphere.
- Persistent storage provisioned for your cluster, such as Red Hat OpenShift Container Storage.



#### IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.



- Must have "100Gi" capacity.



## IMPORTANT

Testing shows issues with using the NFS server on RHEL as storage backend for core services. This includes the OpenShift Container Registry and Quay, Prometheus for monitoring storage, and Elasticsearch for logging storage. Therefore, using RHEL NFS to back PVs used by core services is not recommended.

Other NFS implementations on the marketplace might not have these issues. Contact the individual NFS implementation vendor for more information on any testing that was possibly completed against these OpenShift Container Platform core components.

## Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.



## NOTE

When using shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

## Example output

```
No resources found in openshift-image-registry namespace
```



## NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

## Example output

```
storage:
  pvc:
    claim: 1
```

- 1** Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** persistent volume claim (PVC). The PVC is generated based on the default storage class. However, be aware that the default storage class might provide ReadWriteOnce (RWO) volumes, such as a RADOS Block Device (RBD), which can cause issues when replicating to more than one replica.

4. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

#### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED
image-registry	4.7	True	False	6h50m

#### 18.4.17.2.2. Configuring block registry storage for VMware vSphere

To allow the image registry to use block storage types such as vSphere Virtual Machine Disk (VMDK) during upgrades as a cluster administrator, you can use the **Recreate** rollout strategy.



#### IMPORTANT

Block storage volumes are supported but not recommended for use with image registry on production clusters. An installation where the registry is configured on block storage is not highly available because the registry cannot have more than one replica.

#### Procedure

1. To set the image registry storage as a block storage type, patch the registry so that it uses the **Recreate** rollout strategy and runs with only **1** replica:

```
$ oc patch config.imageregistry.operator.openshift.io/cluster --type=merge -p '{"spec": {"rolloutStrategy": "Recreate", "replicas": 1}}'
```

2. Provision the PV for the block storage device, and create a PVC for that volume. The requested block volume uses the ReadWriteOnce (RWO) access mode.
  - a. Create a **pvc.yaml** file with the following contents to define a VMware vSphere **PersistentVolumeClaim** object:

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: image-registry-storage 1
  namespace: openshift-image-registry 2
spec:
  accessModes:
  - ReadWriteOnce 3
  resources:
    requests:
      storage: 100Gi 4
```

- 1 A unique name that represents the **PersistentVolumeClaim** object.
- 2 The namespace for the **PersistentVolumeClaim** object, which is **openshift-image-registry**.
- 3 The access mode of the persistent volume claim. With **ReadWriteOnce**, the volume can be mounted with read and write permissions by a single node.

- 4 The size of the persistent volume claim.

- b. Create the **PersistentVolumeClaim** object from the file:

```
$ oc create -f pvc.yaml -n openshift-image-registry
```

3. Edit the registry configuration so that it references the correct PVC:

```
$ oc edit config.imageregistry.operator.openshift.io -o yaml
```

### Example output

```
storage:
  pvc:
    claim: 1
```

- 1 Creating a custom PVC allows you to leave the **claim** field blank for the default automatic creation of an **image-registry-storage** PVC.

For instructions about configuring registry storage so that it references the correct PVC, see [Configuring the registry for vSphere](#).

## 18.4.18. Backing up VMware vSphere volumes

OpenShift Container Platform provisions new volumes as independent persistent disks to freely attach and detach the volume on any node in the cluster. As a consequence, it is not possible to back up volumes that use snapshots, or to restore volumes from snapshots. See [Snapshot Limitations](#) for more information.

### Procedure

To create a backup of persistent volumes:

1. Stop the application that is using the persistent volume.
2. Clone the persistent volume.
3. Restart the application.
4. Create a backup of the cloned volume.
5. Delete the cloned volume.

## 18.4.19. Steal clock accounting

By default, the installation program provisions the cluster's virtual machines without enabling the steal clock accounting parameter (**stealclock.enabled**). Enabling steal clock accounting can help with troubleshooting cluster issues. After the cluster is deployed, use the vSphere Client to enable this parameter on each of the virtual machines.

For more information, see this [Red Hat knowledge base article](#).

## 18.4.20. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

## 18.4.21. Next steps

- [Customize your cluster](#).
- If necessary, you can [opt out of remote health reporting](#).
- [Set up your registry and configure registry storage](#).
- Optional: [View the events from the vSphere Problem Detector Operator](#) to determine if the cluster has permission or storage configuration issues.

## 18.5. INSTALLING A CLUSTER ON VMC IN A RESTRICTED NETWORK

In OpenShift Container Platform version 4.9, you can install a cluster on VMware vSphere infrastructure in a restricted network by deploying it to [VMware Cloud \(VMC\) on AWS](#).

Once you configure your VMC environment for OpenShift Container Platform deployment, you use the OpenShift Container Platform installation program from the bastion management host, co-located in the VMC environment. The installation program and control plane automates the process of deploying and managing the resources needed for the OpenShift Container Platform cluster.

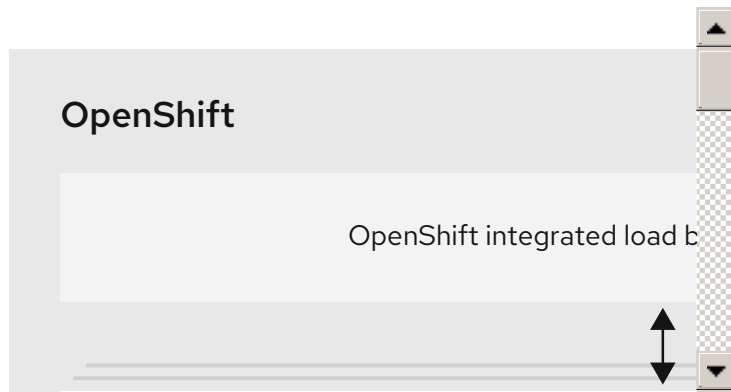


### NOTE

OpenShift Container Platform supports deploying a cluster to a single VMware vCenter only. Deploying a cluster with machines/machine sets on multiple vCenters is not supported.

### 18.5.1. Setting up VMC for vSphere

You can install OpenShift Container Platform on VMware Cloud (VMC) on AWS hosted vSphere clusters to enable applications to be deployed and managed both on-premise and off-premise, across the hybrid cloud.



You must configure several options in your VMC environment prior to installing OpenShift Container Platform on VMware vSphere. Ensure your VMC environment has the following prerequisites:

- Create a non-exclusive, DHCP-enabled, NSX-T network segment and subnet. Other virtual machines (VMs) can be hosted on the subnet, but at least eight IP addresses must be available for the OpenShift Container Platform deployment.
- Allocate two IP addresses, outside the DHCP range, and configure them with reverse DNS records.
  - A DNS record for **api.<cluster\_name>.<base\_domain>** pointing to the allocated IP address.
  - A DNS record for **\*.apps.<cluster\_name>.<base\_domain>** pointing to the allocated IP address.
- Configure the following firewall rules:
  - An ANY:ANY firewall rule between the installation host and the software-defined data center (SDDC) management network on port 443. This allows you to upload the Red Hat Enterprise Linux CoreOS (RHCOS) OVA during deployment.
  - An HTTPS firewall rule between the OpenShift Container Platform compute network and vCenter. This connection allows OpenShift Container Platform to communicate with vCenter for provisioning and managing nodes, persistent volume claims (PVCs), and other resources.
- You must have the following information to deploy OpenShift Container Platform:
  - The OpenShift Container Platform cluster name, such as **vmc-prod-1**.
  - The base DNS name, such as **companyname.com**.
  - If not using the default, the pod network CIDR and services network CIDR must be identified, which are set by default to **10.128.0.0/14** and **172.30.0.0/16**, respectively. These CIDRs are used for pod-to-pod and pod-to-service communication and are not accessible externally; however, they must not overlap with existing subnets in your organization.
  - The following vCenter information:
    - vCenter hostname, username, and password
    - Datacenter name, such as **SDDC-Datacenter**
    - Cluster name, such as **Cluster-1**

- Network name
- Datastore name, such as **WorkloadDatastore**

**NOTE**

It is recommended to move your vSphere cluster to the VMC **Compute-ResourcePool** resource pool after your cluster installation is finished.

- A Linux-based host deployed to VMC as a bastion.
  - The bastion host can be Red Hat Enterprise Linux (RHEL) or any another Linux-based host; it must have internet connectivity and the ability to upload an OVA to the ESXi hosts.
  - Download and install the OpenShift CLI tools to the bastion host.
    - The **openshift-install** installation program
    - The OpenShift CLI (**oc**) tool

**NOTE**

You cannot use the VMware NSX Container Plugin for Kubernetes (NCP), and NSX is not used as the OpenShift SDN. The version of NSX currently available with VMC is incompatible with the version of NCP certified with OpenShift Container Platform.

However, the NSX DHCP service is used for virtual machine IP management with the full-stack automated OpenShift Container Platform deployment and with nodes provisioned, either manually or automatically, by the Machine API integration with vSphere. Additionally, NSX firewall rules are created to enable access with the OpenShift Container Platform cluster and between the bastion host and the VMC vSphere hosts.

### 18.5.1.1. VMC Sizer tool

VMware Cloud on AWS is built on top of AWS bare metal infrastructure; this is the same bare metal infrastructure which runs AWS native services. When a VMware cloud on AWS software-defined data center (SDDC) is deployed, you consume these physical server nodes and run the VMware ESXi hypervisor in a single tenant fashion. This means the physical infrastructure is not accessible to anyone else using VMC. It is important to consider how many physical hosts you will need to host your virtual infrastructure.

To determine this, VMware provides the [VMC on AWS Sizer](#). With this tool, you can define the resources you intend to host on VMC:

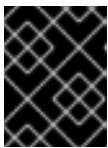
- Types of workloads
- Total number of virtual machines
- Specification information such as:
  - Storage requirements
  - vCPUs
  - vRAM

- Overcommit ratios

With these details, the sizer tool can generate a report, based on VMware best practices, and recommend your cluster configuration and the number of hosts you will need.

## 18.5.2. vSphere prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You [created a registry on your mirror host](#) and obtained the **imageContentSources** data for your version of OpenShift Container Platform.



### IMPORTANT

Because the installation media is on the mirror host, you can use that computer to complete all installation steps.

- You provisioned [block registry storage](#). For more information on persistent storage, see [Understanding persistent storage](#).
- If you use a firewall and plan to use the Telemetry service, you [configured the firewall to allow the sites](#) that your cluster requires access to.



### NOTE

If you are configuring a proxy, be sure to also review this site list.

## 18.5.3. About installations in restricted networks

In OpenShift Container Platform 4.9, you can perform an installation that does not require an active connection to the internet to obtain software components. Restricted network installations can be completed using installer-provisioned infrastructure or user-provisioned infrastructure, depending on the cloud platform to which you are installing the cluster.

If you choose to perform a restricted network installation on a cloud platform, you still require access to its cloud APIs. Some cloud functions, like Amazon Web Service's Route 53 DNS and IAM services, require internet access. Depending on your network, you might require less internet access for an installation on bare metal hardware or on VMware vSphere.

To complete a restricted network installation, you must create a registry that mirrors the contents of the OpenShift Container Platform registry and contains the installation media. You can create this registry on a mirror host, which can access both the internet and your closed network, or by using other methods that meet your restrictions.

### 18.5.3.1. Additional limits

Clusters in restricted networks have the following additional limitations and restrictions:

- The **ClusterVersion** status includes an **Unable to retrieve available updates** error.

- By default, you cannot use the contents of the Developer Catalog because you cannot access the required image stream tags.

#### 18.5.4. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to obtain the images that are necessary to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



#### IMPORTANT

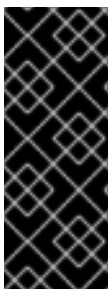
If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

#### 18.5.5. VMware vSphere infrastructure requirements

You must install the OpenShift Container Platform cluster on a VMware vSphere version 6 or 7 instance that meets the requirements for the components that you use.

**Table 18.37. Version requirements for vSphere virtual environments**

Virtual environment product	Required version
VM hardware version	13 or later
vSphere ESXi hosts	6.5 or later
vCenter host	6.5 or later



#### IMPORTANT

Installing a cluster on VMware vSphere version 6.7U2 or earlier and virtual hardware version 13 is now deprecated. These versions are still fully supported, but support will be removed in a future version of OpenShift Container Platform. Hardware version 15 is now the default for vSphere virtual machines in OpenShift Container Platform. To update the hardware version for your vSphere nodes, see the "Updating hardware on nodes running in vSphere" article.

**Table 18.38. Minimum supported vSphere version for VMware components**



Component	Minimum supported versions	Description
Hypervisor	vSphere 6.5 and later with HW version 13	This version is the minimum version that Red Hat Enterprise Linux CoreOS (RHCOS) supports. See the <a href="#">Red Hat Enterprise Linux 8 supported hypervisors list</a> .
Storage with in-tree drivers	vSphere 6.5 and later	This plugin creates vSphere storage by using the in-tree storage drivers for vSphere included in OpenShift Container Platform.

If you use a vSphere version 6.5 instance, consider upgrading to 6.7U3 or 7.0 before you install OpenShift Container Platform.



### IMPORTANT

You must ensure that the time on your ESXi hosts is synchronized before you install OpenShift Container Platform. See [Edit Time Configuration for a Host](#) in the VMware documentation.

## 18.5.6. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate.

Review the following details about the required network ports.

**Table 18.39. Ports used for all-machine to all-machine communications**

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	<b>1936</b>	Metrics
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> and the Cluster Version Operator on port <b>9099</b> .
	<b>10250-10259</b>	The default ports that Kubernetes reserves
	<b>10256</b>	openshift-sdn
UDP	<b>4789</b>	virtual extensible LAN (VXLAN)
	<b>6081</b>	Geneve

Protocol	Port	Description
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> .
	<b>500</b>	IPsec IKE packets
	<b>4500</b>	IPsec NAT-T packets
TCP/UDP	<b>30000-32767</b>	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 18.40. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	<b>6443</b>	Kubernetes API

Table 18.41. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	<b>2379-2380</b>	etcd server and peer ports

### Additional resources

- To update the hardware version for your vSphere nodes, see [Updating hardware on nodes running in vSphere](#).

### 18.5.7. vCenter requirements

Before you install an OpenShift Container Platform cluster on your vCenter that uses infrastructure that the installer provisions, you must prepare your environment.

#### Required vCenter account privileges

To install an OpenShift Container Platform cluster in a vCenter, the installation program requires access to an account with privileges to read and create the required resources. Using an account that has global administrative privileges is the simplest way to access all of the necessary permissions.

If you cannot use an account with global administrative privileges, you must create roles to grant the privileges necessary for OpenShift Container Platform cluster installation. While most of the privileges are always required, some are required only if you plan for the installation program to provision a folder to contain the OpenShift Container Platform cluster on your vCenter instance, which is the default behavior. You must create or amend vSphere roles for the specified objects to grant the required privileges.

An additional role is required if the installation program is to create a vSphere virtual machine folder.

## Example 18.10. Roles and privileges required for installation in vSphere API

vSphere object for role	When required	Required privileges in vSphere API
vSphere vCenter	Always	<b>Cns.Searchable</b> <b>InventoryService.Tagging.AttachTag</b> <b>InventoryService.Tagging.CreateCategory</b> <b>InventoryService.Tagging.CreateTag</b> <b>InventoryService.Tagging.DeleteCategory</b> <b>InventoryService.Tagging.DeleteTag</b> <b>InventoryService.Tagging.EditCategory</b> <b>InventoryService.Tagging.EditTag</b> <b>Sessions.ValidateSession</b> <b>StorageProfile.Update</b> <b>StorageProfile.View</b>
vSphere vCenter Cluster	Always	<b>Host.Config.StorageResource.AssignVMToPool</b> <b>VApp.AssignResourcePool</b> <b>VApp.Import</b> <b>VirtualMachine.Config.AddNewDisk</b>
vSphere Datastore	Always	<b>Datastore.AllocateSpace</b> <b>Datastore.Browse</b> <b>Datastore.FileManagement</b> <b>InventoryService.Tagging.ObjectAttachable</b>
vSphere Port Group	Always	<b>Network.Assign</b>
Virtual Machine Folder	Always	<b>InventoryService.Tagging.ObjectAttachable</b> <b>Resource.AssignVMToPool</b> <b>VApp.Import</b> <b>VirtualMachine.Config.AddExistingDisk</b> <b>VirtualMachine.Config.AddNewDisk</b> <b>VirtualMachine.Config.AddRemoveDevice</b> <b>VirtualMachine.Config.AdvancedConfig</b> <b>VirtualMachine.Config.Annotation</b>

vSphere object for role	When required	VirtualMachine.Config.CPU Required privileges in vSphere API VirtualMachine.Config.Disk Extend
		VirtualMachine.Config.Disk Lease VirtualMachine.Config.Edit Device VirtualMachine.Config.Mem ory VirtualMachine.Config.Rem oveDisk VirtualMachine.Config.Rena me VirtualMachine.Config.Rese tGuestInfo VirtualMachine.Config.Reso urce VirtualMachine.Config.Setti ngs VirtualMachine.Config.Upgr adeVirtualHardware VirtualMachine.Interact.Gue stControl VirtualMachine.Interact.Pow erOff VirtualMachine.Interact.Pow erOn VirtualMachine.Interact.Res et VirtualMachine.Inventory.Cr eate VirtualMachine.Inventory.Cr eateFromExisting VirtualMachine.Inventory.D elete VirtualMachine.Provisionin g.Clone VirtualMachine.Provisionin g.MarkAsTemplate VirtualMachine.Provisionin g.DeployTemplate
vSphere vCenter Datacenter	If the installation program creates the virtual machine folder	InventoryService.Tagging.O bjectAttachable Resource.AssignVMToPool VApp.Import VirtualMachine.Config.Add ExistingDisk VirtualMachine.Config.Add NewDisk VirtualMachine.Config.Add RemoveDevice VirtualMachine.Config.Adva ncedConfig VirtualMachine.Config.Anno tation

vSphere object for role	When required	VirtualMachine.Config.CPU Count VirtualMachine.Config.Disk Extend VirtualMachine.Config.Disk Lease VirtualMachine.Config.Edit Device VirtualMachine.Config.Mem ory VirtualMachine.Config.Rem oveDisk VirtualMachine.Config.Rena me VirtualMachine.Config.Rese tGuestInfo VirtualMachine.Config.Reso urce VirtualMachine.Config.Setti ngs VirtualMachine.Config.Upgr adeVirtualHardware VirtualMachine.Interact.Gue stControl VirtualMachine.Interact.Pow erOff VirtualMachine.Interact.Pow erOn VirtualMachine.Interact.Res et VirtualMachine.Inventory.Cr eate VirtualMachine.Inventory.Cr eateFromExisting VirtualMachine.Inventory.D elete VirtualMachine.Provisionin g.Clone VirtualMachine.Provisionin g.DeployTemplate VirtualMachine.Provisionin g.MarkAsTemplate Folder.Create Folder.Delete

Example 18.11. Roles and privileges required for installation in vCenter graphical user interface (GUI)

vSphere object for role	When required	Required privileges in vCenter GUI

vSphere object for role	When required	Required privileges in vCenter GUI
vSphere vCenter	Always	<b>Cns.Searchable</b> <b>"vSphere Tagging"."Assign or Unassign vSphere Tag"</b> <b>"vSphere Tagging"."Create vSphere Tag Category"</b> <b>"vSphere Tagging"."Create vSphere Tag"</b> <b>vSphere Tagging"."Delete vSphere Tag Category"</b> <b>"vSphere Tagging"."Delete vSphere Tag"</b> <b>"vSphere Tagging"."Edit vSphere Tag Category"</b> <b>"vSphere Tagging"."Edit vSphere Tag"</b> <b>Sessions."Validate session"</b> <b>"Profile-driven storage"."Profile-driven storage update"</b> <b>"Profile-driven storage"."Profile-driven storage view"</b>
vSphere vCenter Cluster	If VMs will be created in the cluster root	<b>Host.Configuration."Storage partition configuration"</b> <b>Resource."Assign virtual machine to resource pool"</b> <b>VApp."Assign resource pool"</b> <b>VApp.Import</b> <b>"Virtual machine"."Change Configuration"."Add new disk"</b>
vSphere vCenter Resource Pool	If an existing resource pool is provided	<b>Host.Configuration."Storage partition configuration"</b> <b>Resource."Assign virtual machine to resource pool"</b> <b>VApp."Assign resource pool"</b> <b>VApp.Import</b> <b>"Virtual machine"."Change Configuration"."Add new disk"</b>

vSphere object for role	When required	Required privileges in vCenter GUI
vSphere Datastore	Always	<b>Datastore."Allocate space"</b> <b>Datastore."Browse datastore"</b> <b>Datastore."Low level file operations"</b> <b>"vSphere Tagging"."Assign or Unassign vSphere Tag on Object"</b>
vSphere Port Group	Always	<b>Network."Assign network"</b>
Virtual Machine Folder	Always	<b>"vSphere Tagging"."Assign or Unassign vSphere Tag on Object"</b> <b>Resource."Assign virtual machine to resource pool"</b> <b>VApp.Import</b> <b>"Virtual machine"."Change Configuration"."Add existing disk"</b> <b>"Virtual machine"."Change Configuration"."Add new disk"</b> <b>"Virtual machine"."Change Configuration"."Add or remove device"</b> <b>"Virtual machine"."Change Configuration"."Advanced configuration"</b> <b>"Virtual machine"."Change Configuration"."Set annotation"</b> <b>"Virtual machine"."Change Configuration"."Change CPU count"</b> <b>"Virtual machine"."Change Configuration"."Extend virtual disk"</b> <b>"Virtual machine"."Change Configuration"."Acquire disk lease"</b> <b>"Virtual machine"."Change Configuration"."Modify device settings"</b> <b>"Virtual machine"."Change Configuration"."Change Memory"</b> <b>"Virtual machine"."Change Configuration"."Remove disk"</b> <b>"Virtual machine"."Change</b>

vSphere object for role	When required	Configuration".Rename Virtual machine".Change GUI Configuration".Reset guest information"
		"Virtual machine".Change Configuration".Change resource" "Virtual machine".Change Configuration".Change Settings" "Virtual machine".Change Configuration".Upgrade virtual machine compatibility" "Virtual machine".Interaction."Gues t operating system management by VIX API" "Virtual machine".Interaction."Powe r off" "Virtual machine".Interaction."Powe r on" "Virtual machine".Interaction.Reset "Virtual machine".Edit Inventory".Create new" "Virtual machine".Edit Inventory".Create from existing" "Virtual machine".Edit Inventory".Remove" "Virtual machine".Provisioning."Clo ne virtual machine" "Virtual machine".Provisioning."Mar k as template" "Virtual machine".Provisioning."De ploy template"
vSphere vCenter Datacenter	If the installation program creates the virtual machine folder	"vSphere Tagging".Assign or Unassign vSphere Tag on Object" Resource."Assign virtual machine to resource pool" VApp.Import "Virtual machine".Change Configuration".Add existing disk" "Virtual machine".Change Configuration".Add new disk" "Virtual machine".Change



vSphere object for role	When required	Configuration". "Add or Remove device Virtual machine". "Change Configuration". "Advanced configuration" "Virtual machine". "Change Configuration". "Set annotation" "Virtual machine". "Change Configuration". "Change CPU count" "Virtual machine". "Change Configuration". "Extend virtual disk" "Virtual machine". "Change Configuration". "Acquire disk lease" "Virtual machine". "Change Configuration". "Modify device settings" "Virtual machine". "Change Configuration". "Change Memory" "Virtual machine". "Change Configuration". "Remove disk" "Virtual machine". "Change Configuration". Rename "Virtual machine". "Change Configuration". "Reset guest information" "Virtual machine". "Change Configuration". "Change resource" "Virtual machine". "Change Configuration". "Change Settings" "Virtual machine". "Change Configuration". "Upgrade virtual machine compatibility" "Virtual machine". Interaction. "Guest operating system management by VIX API" "Virtual machine". Interaction. "Power off" "Virtual machine". Interaction. "Power on" "Virtual machine". Interaction. Reset "Virtual machine". "Edit Inventory". "Create new" "Virtual machine". "Edit

vSphere object for role	When required	Inventory". "Create from existing virtual machine". "Edit virtual machine". "Edit virtual machine". "Remove virtual machine". "Provisioning. "Clone virtual machine" virtual machine". "Provisioning. "Deploy template" virtual machine". "Provisioning. "Mark as template" Folder. "Create folder" Folder. "Delete folder"

Additionally, the user requires some **ReadOnly** permissions, and some of the roles require permission to propagate the permissions to child objects. These settings vary depending on whether or not you install the cluster into an existing folder.

#### Example 18.12. Required permissions and propagation settings

vSphere object	Folder type	Propagate to children	Permissions required
vSphere vCenter	Always	False	Listed required privileges
vSphere vCenter Datacenter	Existing folder	False	<b>ReadOnly</b> permission
	Installation program creates the folder	True	Listed required privileges
vSphere vCenter Cluster	Always	True	Listed required privileges
vSphere vCenter Datastore	Always	False	Listed required privileges
vSphere Switch	Always	False	<b>ReadOnly</b> permission
vSphere Port Group	Always	False	Listed required privileges
vSphere vCenter Virtual Machine Folder	Existing folder	True	Listed required privileges

For more information about creating an account with only the required privileges, see [vSphere Permissions and User Management Tasks](#) in the vSphere documentation.

## Using OpenShift Container Platform with vMotion

If you intend on using vMotion in your vSphere environment, consider the following before installing a OpenShift Container Platform cluster.

- OpenShift Container Platform generally supports compute-only vMotion. Using Storage vMotion can cause issues and is not supported.  
To help ensure the uptime of your compute and control plane nodes, it is recommended that you follow the VMware best practices for vMotion. It is also recommended to use VMware anti-affinity rules to improve the availability of OpenShift Container Platform during maintenance or hardware issues.

For more information about vMotion and anti-affinity rules, see the VMware vSphere documentation for [vMotion networking requirements](#) and [VM anti-affinity rules](#).

- If you are using vSphere volumes in your pods, migrating a VM across datastores either manually or through Storage vMotion causes, invalid references within OpenShift Container Platform persistent volume (PV) objects. These references prevent affected pods from starting up and can result in data loss.
- Similarly, OpenShift Container Platform does not support selective migration of VMDKs across datastores, using datastore clusters for VM provisioning or for dynamic or static provisioning of PVs, or using a datastore that is part of a datastore cluster for dynamic or static provisioning of PVs.

### Cluster resources

When you deploy an OpenShift Container Platform cluster that uses installer-provisioned infrastructure, the installation program must be able to create several resources in your vCenter instance.

A standard OpenShift Container Platform installation creates the following vCenter resources:

- 1 Folder
- 1 Tag category
- 1 Tag
- Virtual machines:
  - 1 template
  - 1 temporary bootstrap node
  - 3 control plane nodes
  - 3 compute machines

Although these resources use 856 GB of storage, the bootstrap node is destroyed during the cluster installation process. A minimum of 800 GB of storage is required to use a standard cluster.

If you deploy more compute machines, the OpenShift Container Platform cluster will use more storage.

### Cluster limits

Available resources vary between clusters. The number of possible clusters within a vCenter is limited primarily by available storage space and any limitations on the number of required resources. Be sure to consider both limitations to the vCenter resources that the cluster creates and the resources that you require to deploy a cluster, such as IP addresses and networks.

## Networking requirements

You must use DHCP for the network and ensure that the DHCP server is configured to provide persistent IP addresses to the cluster machines. You must configure the default gateway to use the DHCP server. All nodes must be in the same VLAN. You cannot scale the cluster using a second VLAN as a Day 2 operation. The VM in your restricted network must have access to vCenter so that it can provision and manage nodes, persistent volume claims (PVCs), and other resources. Additionally, you must create the following networking resources before you install the OpenShift Container Platform cluster:



### NOTE

It is recommended that each OpenShift Container Platform node in the cluster must have access to a Network Time Protocol (NTP) server that is discoverable via DHCP. Installation is possible without an NTP server. However, asynchronous server clocks will cause errors, which NTP server prevents.

## Required IP Addresses

An installer-provisioned vSphere installation requires two static IP addresses:

- The **API** address is used to access the cluster API.
- The **Ingress** address is used for cluster ingress traffic.

You must provide these IP addresses to the installation program when you install the OpenShift Container Platform cluster.

## DNS records

You must create DNS records for two static IP addresses in the appropriate DNS server for the vCenter instance that hosts your OpenShift Container Platform cluster. In each record, **<cluster\_name>** is the cluster name and **<base\_domain>** is the cluster base domain that you specify when you install the cluster. A complete DNS record takes the form: **<component>.<cluster\_name>.<base\_domain>..**

**Table 18.42. Required DNS records**

Component	Record	Description
API VIP	<b>api.&lt;cluster_name&gt;.&lt;base_domain&gt;..</b>	This DNS A/AAAA or CNAME record must point to the load balancer for the control plane machines. This record must be resolvable by both clients external to the cluster and from all the nodes within the cluster.

Component	Record	Description
Ingress VIP	*.apps.<cluster_name>.<base_domain>.	A wildcard DNS A/AAAA or CNAME record that points to the load balancer that targets the machines that run the Ingress router pods, which are the worker nodes by default. This record must be resolvable by both clients external to the cluster and from all the nodes within the cluster.

### 18.5.8. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.



#### IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



#### NOTE

You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

#### Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.

**NOTE**

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

- View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

- Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.

**NOTE**

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

**Example output**

```
Agent pid 31874
```

**NOTE**

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

- Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1** Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

**Example output**

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

**Next steps**

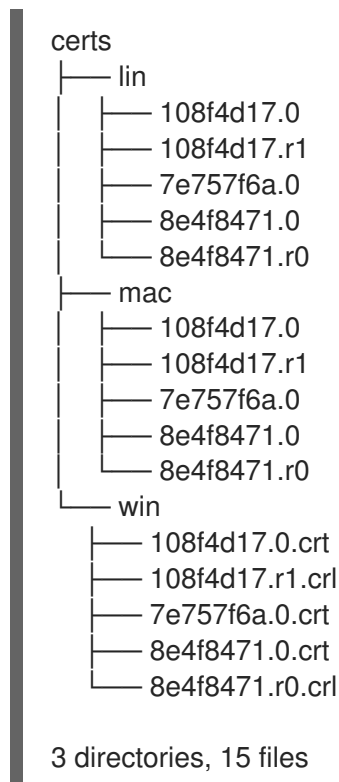
- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

### 18.5.9. Adding vCenter root CA certificates to your system trust

Because the installation program requires access to your vCenter's API, you must add your vCenter's trusted root CA certificates to your system trust before you install an OpenShift Container Platform cluster.

#### Procedure

1. From the vCenter home page, download the vCenter's root CA certificates. Click **Download trusted root CA certificates** in the vSphere Web Services SDK section. The **<vCenter>/certs/download.zip** file downloads.
2. Extract the compressed file that contains the vCenter root CA certificates. The contents of the compressed file resemble the following file structure:



3. Add the files for your operating system to the system trust. For example, on a Fedora operating system, run the following command:

```
# cp certs/lin/* /etc/pki/ca-trust/source/anchors
```

4. Update your system trust. For example, on a Fedora operating system, run the following command:

```
# update-ca-trust extract
```

### 18.5.10. Creating the RHCOS image for restricted network installations

Download the Red Hat Enterprise Linux CoreOS (RHCOS) image to install OpenShift Container Platform on a restricted network VMware vSphere environment.

## Prerequisites

- Obtain the OpenShift Container Platform installation program. For a restricted network installation, the program is on your mirror registry host.

## Procedure

1. Log in to the Red Hat Customer Portal's [Product Downloads page](#).
2. Under **Version**, select the most recent release of OpenShift Container Platform 4.9 for RHEL 8.



### IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image versions that match your OpenShift Container Platform version if they are available.

3. Download the **Red Hat Enterprise Linux CoreOS (RHCOS) - vSphere** image.
4. Upload the image you downloaded to a location that is accessible from the bastion server.

The image is now available for a restricted installation. Note the image name or location for use in OpenShift Container Platform deployment.

## 18.5.11. Creating the installation configuration file

You can customize the OpenShift Container Platform cluster you install on VMware vSphere.

### Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster. For a restricted network installation, these files are on your mirror host.
- Have the **imageContentSources** values that were generated during mirror registry creation.
- Obtain the contents of the certificate for your mirror registry.
- Retrieve a Red Hat Enterprise Linux CoreOS (RHCOS) image and upload it to an accessible location.
- Obtain service principal permissions at the subscription level.

### Procedure

1. Create the **install-config.yaml** file.
  - a. Change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install create install-config --dir <installation_directory> 1
```

- 1** For **<installation\_directory>**, specify the directory name to store the files that the installation program creates.





## IMPORTANT

Specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

- b. At the prompts, provide the configuration details for your cloud:
  - i. Optional: Select an SSH key to use to access your cluster machines.



## NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

- ii. Select **vsphere** as the platform to target.
  - iii. Specify the name of your vCenter instance.
  - iv. Specify the user name and password for the vCenter account that has the required permissions to create the cluster.  
The installation program connects to your vCenter instance.
  - v. Select the datacenter in your vCenter instance to connect to.
  - vi. Select the default vCenter datastore to use.
  - vii. Select the vCenter cluster to install the OpenShift Container Platform cluster in. The installation program uses the root resource pool of the vSphere cluster as the default resource pool.
  - viii. Select the network in the vCenter instance that contains the virtual IP addresses and DNS records that you configured.
  - ix. Enter the virtual IP address that you configured for control plane API access.
  - x. Enter the virtual IP address that you configured for cluster ingress.
  - xi. Enter the base domain. This base domain must be the same one that you used in the DNS records that you configured.
  - xii. Enter a descriptive name for your cluster. The cluster name must be the same one that you used in the DNS records that you configured.
  - xiii. Paste the [pull secret from the Red Hat OpenShift Cluster Manager](#) .
2. In the **install-config.yaml** file, set the value of **platform.vsphere.clusterOSImage** to the image location or name. For example:

```
platform:
vsphere:
```

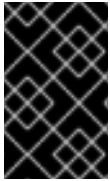


your account on the cloud platform that hosts your cluster and optionally customize your cluster's platform. When you create the **install-config.yaml** installation configuration file, you provide values for the required parameters through the command line. If you customize your cluster, you can modify the **install-config.yaml** file to provide more details about the platform.



#### NOTE

After installation, you cannot modify these parameters in the **install-config.yaml** file.



#### IMPORTANT

The **openshift-install** command does not validate field names for parameters. If an incorrect name is specified, the related file or object is not created, and no error is reported. Ensure that the field names for any parameters that are specified are correct.

#### 18.5.11.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

Table 18.43. Required parameters

Parameter	Description	Values
<b>apiVersion</b>	The API version for the <b>install-config.yaml</b> content. The current version is <b>v1</b> . The installer may also support older API versions.	String
<b>baseDomain</b>	The base domain of your cloud provider. The base domain is used to create routes to your OpenShift Container Platform cluster components. The full DNS name for your cluster is a combination of the <b>baseDomain</b> and <b>metadata.name</b> parameter values that uses the <b>&lt;metadata.name&gt;</b> . <b>&lt;baseDomain&gt;</b> format.	A fully-qualified domain or subdomain name, such as <b>example.com</b> .
<b>metadata</b>	Kubernetes resource <b>ObjectMeta</b> , from which only the <b>name</b> parameter is consumed.	Object
<b>metadata.name</b>	The name of the cluster. DNS records for the cluster are all subdomains of <b>{{.metadata.name}}</b> . <b>{{.baseDomain}}</b> .	String of lowercase letters and hyphens (-), such as <b>dev</b> .

Parameter	Description	Values
<b>platform</b>	The configuration for the specific platform upon which to perform the installation: <b>aws</b> , <b>baremetal</b> , <b>azure</b> , <b>gcp</b> , <b>openstack</b> , <b>ovirt</b> , <b>vsphere</b> , or <b>{}</b> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object
<b>pullSecret</b>	Get a <a href="#">pull secret from the Red Hat OpenShift Cluster Manager</a> to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{   "auths":{     "cloud.openshift.com":{       "auth":"b3Blb=",       "email":"you@example.com"     },     "quay.io":{       "auth":"b3Blb=",       "email":"you@example.com"     }   } }</pre>

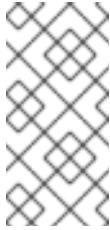
#### 18.5.11.1.2. Network configuration parameters


You can customize your installation configuration based on the requirements of your existing network infrastructure. For example, you can expand the IP address block for the cluster network or provide different IP address blocks than the defaults.

Only IPv4 addresses are supported.

**Table 18.44. Network parameters**

Parameter	Description	Values
-----------	-------------	--------

Parameter	Description	Values
<b>networking</b>	The configuration for the cluster network.	Object  <b>NOTE</b> You cannot modify parameters specified by the <b>networking</b> object after installation.
<b>networking.networkType</b>	The cluster network provider Container Network Interface (CNI) plugin to install.	Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b> . <b>OpenShiftSDN</b> is a CNI provider for all-Linux networks. <b>OVNKubernetes</b> is a CNI provider for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OpenShiftSDN</b> .
<b>networking.clusterNetwork</b>	The IP address blocks for pods.  The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b> .  If you specify multiple IP address blocks, the blocks must not overlap.	An array of objects. For example:  <pre>networking:   clusterNetwork:     - cidr: 10.128.0.0/14       hostPrefix: 23</pre>
<b>networking.clusterNetwork.cidr</b>	Required if you use <b>networking.clusterNetwork</b> . An IP address block.  An IPv4 network.	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b> .
<b>networking.clusterNetwork.hostPrefix</b>	The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a <b>/23</b> subnet out of the given <b>cidr</b> . A <b>hostPrefix</b> value of <b>23</b> provides 510 ( $2^{(32 - 23)} - 2$ ) pod IP addresses.	A subnet prefix.  The default value is <b>23</b> .


Parameter	Description	Values
<b>networking.serviceNetwork</b>	<p>The IP address block for services. The default value is <b>172.30.0.0/16</b>.</p> <p>The OpenShift SDN and OVN-Kubernetes network providers support only a single IP address block for the service network.</p>	<p>An array with an IP address block in CIDR format. For example:</p> <pre>networking:   serviceNetwork:   - 172.30.0.0/16</pre>
<b>networking.machineNetwork</b>	<p>The IP address blocks for machines.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking:   machineNetwork:   - cidr: 10.0.0.0/16</pre>
<b>networking.machineNetwork.cidr</b>	<p>Required if you use <b>networking.machineNetwork</b>. An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt. For libvirt, the default value is <b>192.168.126.0/24</b>.</p>	<p>An IP network block in CIDR notation.</p> <p>For example, <b>10.0.0.0/16</b>.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p> </div> </div>


### 18.5.11.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:



Table 18.45. Optional parameters

Parameter	Description	Values
<b>additionalTrustBundle</b>	<p>A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.</p>	String
<b>compute</b>	<p>The configuration for the machines that comprise the compute nodes.</p>	Array of <b>MachinePool</b> objects.


Parameter	Description	Values
<b>compute.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String
<b>compute.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>compute.name</b>	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>
<b>compute.platform</b>	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere</b> , or <b>{}</b>
<b>compute.replicas</b>	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
<b>controlPlane</b>	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
<b>controlPlane.architecture</b>	Determines the instruction set architecture of the machines in the pool. Currently, heterogeneous clusters are not supported, so all pools must specify the same architecture. Valid values are <b>amd64</b> (the default).	String

Parameter	Description	Values
<b>controlPlane.hyperthreading</b>	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div style="display: flex; align-items: center;">  <div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p> </div> </div>	<b>Enabled</b> or <b>Disabled</b>
<b>controlPlane.name</b>	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
<b>controlPlane.platform</b>	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, openstack, ovirt, vsphere, or {}</b>
<b>controlPlane.replicas</b>	The number of control plane machines to provision.	The only supported value is <b>3</b> , which is the default value.



Parameter	Description	Values
<b>credentialsMode</b>	<p>The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.</p> <div data-bbox="485 510 595 862" style="border: 1px solid black; padding: 5px; margin-bottom: 10px;">  </div> <p><b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information on CCO modes, see the <i>Cloud Credential Operator</i> entry in the <i>Cluster Operators reference content</i>.</p> <div data-bbox="485 907 595 1258" style="border: 1px solid black; padding: 5px;">  </div> <p><b>NOTE</b></p> <p>If your AWS account has service control policies (SCP) enabled, you must configure the <b>credentialsMode</b> parameter to <b>Mint</b>, <b>Passthrough</b> or <b>Manual</b>.</p>	<b>Mint, Passthrough, Manual</b> or an empty string ("").

Parameter	Description	Values
<b>fips</b>	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p> <div style="display: flex; align-items: flex-start;"> <div style="width: 40px; height: 40px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>IMPORTANT</b></p> <p>The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the <b>x86_64</b> architecture.</p> </div> </div> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="width: 40px; height: 40px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px); margin-right: 10px;"></div> <div> <p><b>NOTE</b></p> <p>If you are using Azure File storage, you cannot enable FIPS mode.</p> </div> </div>	<b>false</b> or <b>true</b>
<b>imageContentSources</b>	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
<b>imageContentSources.source</b>	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
<b>imageContentSources.mirrors</b>	Specify one or more repositories that may also contain the same images.	Array of strings
<b>publish</b>	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<b>Internal</b> or <b>External</b> . The default value is <b>External</b> .  Setting this field to <b>Internal</b> is not supported on non-cloud platforms.

Parameter	Description	Values
<b>sshKey</b>	<p>The SSH key or keys to authenticate access your cluster machines.</p>  <p><b>NOTE</b></p> <p>For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.</p>	<p>One or more keys. For example:</p> <pre>sshKey: &lt;key1&gt; &lt;key2&gt; &lt;key3&gt;</pre>

#### 18.5.11.1.4. Additional VMware vSphere configuration parameters

Additional VMware vSphere configuration parameters are described in the following table:

Table 18.46. Additional VMware vSphere cluster parameters

Parameter	Description	Values
<b>platform.vsphere.vCenter</b>	The fully-qualified hostname or IP address of the vCenter server.	String
<b>platform.vsphere.username</b>	The user name to use to connect to the vCenter instance with. This user must have at least the roles and privileges that are required for <a href="#">static or dynamic persistent volume provisioning</a> in vSphere.	String
<b>platform.vsphere.password</b>	The password for the vCenter user name.	String
<b>platform.vsphere.datacenter</b>	The name of the datacenter to use in the vCenter instance.	String
<b>platform.vsphere.defaultDatastore</b>	The name of the default datastore to use for provisioning volumes.	String

Parameter	Description	Values
<b>platform.vsphere.folder</b>	<i>Optional.</i> The absolute path of an existing folder where the installation program creates the virtual machines. If you do not provide this value, the installation program creates a folder that is named with the infrastructure ID in the datacenter virtual machine folder.	String, for example, <code>/&lt;datacenter_name&gt;/vm/&lt;folder_name&gt;/&lt;subfolder_name&gt;</code> .
<b>platform.vsphere.network</b>	The network in the vCenter instance that contains the virtual IP addresses and DNS records that you configured.	String
<b>platform.vsphere.cluster</b>	The vCenter cluster to install the OpenShift Container Platform cluster in.	String
<b>platform.vsphere.apiVIP</b>	The virtual IP (VIP) address that you configured for control plane API access.	An IP address, for example <b>128.0.0.1</b> .
<b>platform.vsphere.ingressVIP</b>	The virtual IP (VIP) address that you configured for cluster ingress.	An IP address, for example <b>128.0.0.1</b> .

#### 18.5.11.1.5. Optional VMware vSphere machine pool configuration parameters

Optional VMware vSphere machine pool configuration parameters are described in the following table:

Table 18.47. Optional VMware vSphere machine pool parameters

Parameter	Description	Values
<b>platform.vsphere.clusterOSImage</b>	The location from which the installer downloads the RHCOS image. You must set this parameter to perform an installation in a restricted network.	An HTTP or HTTPS URL, optionally with a SHA-256 checksum. For example, <code>https://mirror.openshift.com/images/rhcos-&lt;version&gt;-vmware.&lt;architecture&gt;.ova</code> .
<b>platform.vsphere.osDisk.diskSizeGB</b>	The size of the disk in gigabytes.	Integer
<b>platform.vsphere.cpus</b>	The total number of virtual processor cores to assign a virtual machine. The value of <b>platform.vsphere.cpus</b> must be a multiple of <b>platform.vsphere.coresPerSocket</b> value.	Integer

Parameter	Description	Values
<b>platform.vsphere.coresPerSocket</b>	The number of cores per socket in a virtual machine. The number of virtual sockets on the virtual machine is <b>platform.vsphere.cpus/platform.vsphere.coresPerSocket</b> . The default value for control plane nodes and worker nodes is <b>4</b> and <b>2</b> , respectively.	Integer
<b>platform.vsphere.memoryMB</b>	The size of a virtual machine's memory in megabytes.	Integer

### 18.5.11.2. Sample install-config.yaml file for an installer-provisioned VMware vSphere cluster

You can customize the install-config.yaml file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```

apiVersion: v1
baseDomain: example.com 1
compute: 2
- hyperthreading: Enabled 3
  name: worker
  replicas: 3
  platform:
    vsphere: 4
      cpus: 2
      coresPerSocket: 2
      memoryMB: 8192
      osDisk:
        diskSizeGB: 120
controlPlane: 5
  hyperthreading: Enabled 6
  name: master
  replicas: 3
  platform:
    vsphere: 7
      cpus: 4
      coresPerSocket: 2
      memoryMB: 16384
      osDisk:
        diskSizeGB: 120
metadata:
  name: cluster 8
platform:
  vsphere:
    vcenter: your.vcenter.server
    username: username
    password: password
    datacenter: datacenter

```



- 12 Provide the contents of the certificate file that you used for your mirror registry.
- 13 Provide the **imageContentSources** section from the output of the command to mirror the repository.

### 18.5.11.3. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

#### Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



#### NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

#### Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
  additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
  ...
```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3

A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with `.` to match subdomains only. For

- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

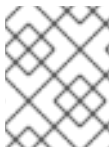


#### NOTE

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

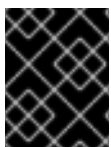


#### NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

## 18.5.12. Deploying the cluster

You can install OpenShift Container Platform on a compatible cloud platform.



#### IMPORTANT

You can run the **create cluster** command of the installation program only once, during initial installation.

### Prerequisites

- Configure an account with the cloud platform that hosts your cluster.
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

### Procedure

1. Change to the directory that contains the installation program and initialize the cluster deployment:

```
$ ./openshift-install create cluster --dir <installation_directory> \ 1
--log-level=info 2
```

- 1 For **<installation\_directory>**, specify the location of your customized **./install-config.yaml** file.



- 2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.



### IMPORTANT

Use the **openshift-install** command from the bastion hosted in the VMC environment.



### NOTE

If the cloud provider account that you configured on your host does not have sufficient permissions to deploy the cluster, the installation process stops, and the missing permissions are displayed.

When the cluster deployment completes, directions for accessing your cluster, including a link to its web console and credentials for the **kubeadmin** user, display in your terminal.

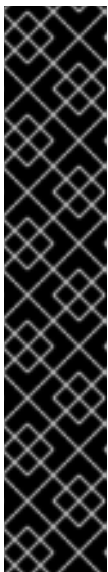
### Example output

```
...
INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export
KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Ee6gm-ymBZj-
Wt5AL"
INFO Time elapsed: 36m22s
```



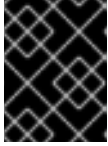
### NOTE

The cluster access and credential information also outputs to **<installation\_directory>/openshift\_install.log** when an installation succeeds.



### IMPORTANT

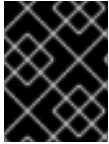
- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

**IMPORTANT**

You must not delete the installation program or the files that the installation program creates. Both are required to delete the cluster.

### 18.5.13. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

**IMPORTANT**

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

#### Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

##### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

```
$ tar xvf <file>
```

5. Place the **oc** binary in a directory that is on your **PATH**.  
To check your **PATH**, execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

#### Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

##### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.

5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

### Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### 18.5.14. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

#### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

#### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

#### Example output

```
system:admin
```

### 18.5.15. Disabling the default OperatorHub sources

Operator catalogs that source content provided by Red Hat and community projects are configured for OperatorHub by default during an OpenShift Container Platform installation. In a restricted network environment, you must disable the default catalogs as a cluster administrator.

#### Procedure

- Disable the sources for the default catalogs by adding **disableAllDefaultSources: true** to the **OperatorHub** object:

```
$ oc patch OperatorHub cluster --type json \
-p '[{"op": "add", "path": "/spec/disableAllDefaultSources", "value": true}]'
```

#### TIP

Alternatively, you can use the web console to manage catalog sources. From the **Administration** → **Cluster Settings** → **Configuration** → **OperatorHub** page, click the **Sources** tab, where you can create, delete, disable, and enable individual sources.

### 18.5.16. Creating registry storage

After you install the cluster, you must create storage for the Registry Operator.

#### 18.5.16.1. Image registry removed during installation

On platforms that do not provide shareable object storage, the OpenShift Image Registry Operator bootstraps itself as **Removed**. This allows **openshift-installer** to complete installations on these platform types.

After installation, you must edit the Image Registry Operator configuration to switch the **managementState** from **Removed** to **Managed**.



#### NOTE

The Prometheus console provides an **ImageRegistryRemoved** alert, for example:

"Image Registry has been removed. **ImageStreamTags**, **BuildConfigs** and **DeploymentConfigs** which reference **ImageStreamTags** may not work as expected. Please configure storage and update the config to **Managed** state by editing `configs.imageregistry.operator.openshift.io`."

#### 18.5.16.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

#### 18.5.16.2.1. Configuring registry storage for VMware vSphere

As a cluster administrator, following installation you must configure your registry to use storage.

##### Prerequisites

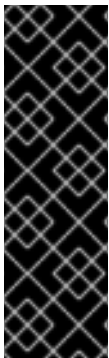
- Cluster administrator permissions.
- A cluster on VMware vSphere.
- Persistent storage provisioned for your cluster, such as Red Hat OpenShift Container Storage.



##### IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have "100Gi" capacity.



##### IMPORTANT

Testing shows issues with using the NFS server on RHEL as storage backend for core services. This includes the OpenShift Container Registry and Quay, Prometheus for monitoring storage, and Elasticsearch for logging storage. Therefore, using RHEL NFS to back PVs used by core services is not recommended.

Other NFS implementations on the marketplace might not have these issues. Contact the individual NFS implementation vendor for more information on any testing that was possibly completed against these OpenShift Container Platform core components.

##### Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.



##### NOTE

When using shared storage, review your security settings to prevent outside access.

- Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

### Example output

```
No resources found in openshift-image-registry namespace
```



### NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

- Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

### Example output

```
storage:
  pvc:
    claim: 1
```

- Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** persistent volume claim (PVC). The PVC is generated based on the default storage class. However, be aware that the default storage class might provide ReadWriteOnce (RWO) volumes, such as a RADOS Block Device (RBD), which can cause issues when replicating to more than one replica.

- Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED
image-registry	4.7	True	False	False

## 18.5.17. Steal clock accounting

By default, the installation program provisions the cluster's virtual machines without enabling the steal clock accounting parameter (**stealclock.enabled**). Enabling steal clock accounting can help with troubleshooting cluster issues. After the cluster is deployed, use the vSphere Client to enable this parameter on each of the virtual machines.

For more information, see this [Red Hat knowledge base article](#).

## 18.5.18. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

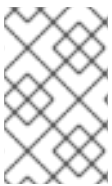
### 18.5.19. Next steps

- [Customize your cluster](#).
- [Configure image streams](#) for the Cluster Samples Operator and the **must-gather** tool.
- Learn how to [use Operator Lifecycle Manager \(OLM\) on restricted networks](#).
- If necessary, you can [opt out of remote health reporting](#).
- [Set up your registry and configure registry storage](#).

## 18.6. INSTALLING A CLUSTER ON VMC WITH USER-PROVISIONED INFRASTRUCTURE

In OpenShift Container Platform version 4.9, you can install a cluster on VMware vSphere infrastructure that you provision by deploying it to [VMware Cloud \(VMC\) on AWS](#).

Once you configure your VMC environment for OpenShift Container Platform deployment, you use the OpenShift Container Platform installation program from the bastion management host, co-located in the VMC environment. The installation program and control plane automates the process of deploying and managing the resources needed for the OpenShift Container Platform cluster.

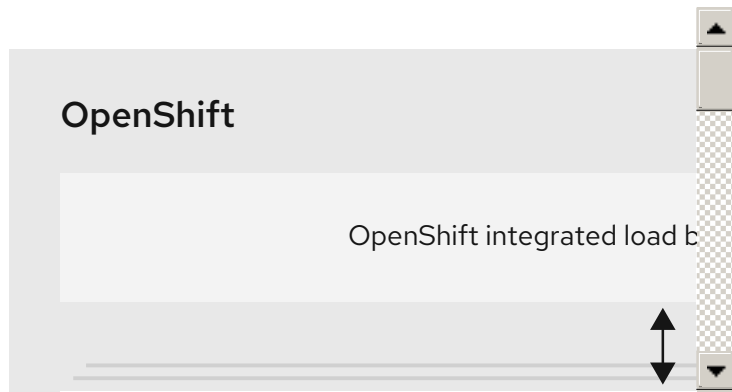


### NOTE

OpenShift Container Platform supports deploying a cluster to a single VMware vCenter only. Deploying a cluster with machines/machine sets on multiple vCenters is not supported.

### 18.6.1. Setting up VMC for vSphere

You can install OpenShift Container Platform on VMware Cloud (VMC) on AWS hosted vSphere clusters to enable applications to be deployed and managed both on-premise and off-premise, across the hybrid cloud.



You must configure several options in your VMC environment prior to installing OpenShift Container Platform on VMware vSphere. Ensure your VMC environment has the following prerequisites:

- Create a non-exclusive, DHCP-enabled, NSX-T network segment and subnet. Other virtual machines (VMs) can be hosted on the subnet, but at least eight IP addresses must be available for the OpenShift Container Platform deployment.
- Configure the following firewall rules:
  - An ANY:ANY firewall rule between the OpenShift Container Platform compute network and the internet. This is used by nodes and applications to download container images.
  - An ANY:ANY firewall rule between the installation host and the software-defined data center (SDDC) management network on port 443. This allows you to upload the Red Hat Enterprise Linux CoreOS (RHCOS) OVA during deployment.
  - An HTTPS firewall rule between the OpenShift Container Platform compute network and vCenter. This connection allows OpenShift Container Platform to communicate with vCenter for provisioning and managing nodes, persistent volume claims (PVCs), and other resources.
- You must have the following information to deploy OpenShift Container Platform:
  - The OpenShift Container Platform cluster name, such as **vmc-prod-1**.
  - The base DNS name, such as **companyname.com**.
  - If not using the default, the pod network CIDR and services network CIDR must be identified, which are set by default to **10.128.0.0/14** and **172.30.0.0/16**, respectively. These CIDRs are used for pod-to-pod and pod-to-service communication and are not accessible externally; however, they must not overlap with existing subnets in your organization.
  - The following vCenter information:
    - vCenter hostname, username, and password
    - Datacenter name, such as **SDDC-Datacenter**
    - Cluster name, such as **Cluster-1**
    - Network name
    - Datastore name, such as **WorkloadDatastore**



**NOTE**

It is recommended to move your vSphere cluster to the VMC **Compute-ResourcePool** resource pool after your cluster installation is finished.

- A Linux-based host deployed to VMC as a bastion.
  - The bastion host can be Red Hat Enterprise Linux (RHEL) or any another Linux-based host; it must have internet connectivity and the ability to upload an OVA to the ESXi hosts.
  - Download and install the OpenShift CLI tools to the bastion host.
    - The **openshift-install** installation program
    - The OpenShift CLI (**oc**) tool

**NOTE**

You cannot use the VMware NSX Container Plugin for Kubernetes (NCP), and NSX is not used as the OpenShift SDN. The version of NSX currently available with VMC is incompatible with the version of NCP certified with OpenShift Container Platform.

However, the NSX DHCP service is used for virtual machine IP management with the full-stack automated OpenShift Container Platform deployment and with nodes provisioned, either manually or automatically, by the Machine API integration with vSphere. Additionally, NSX firewall rules are created to enable access with the OpenShift Container Platform cluster and between the bastion host and the VMC vSphere hosts.

**18.6.1.1. VMC Sizer tool**

VMware Cloud on AWS is built on top of AWS bare metal infrastructure; this is the same bare metal infrastructure which runs AWS native services. When a VMware cloud on AWS software-defined data center (SDDC) is deployed, you consume these physical server nodes and run the VMware ESXi hypervisor in a single tenant fashion. This means the physical infrastructure is not accessible to anyone else using VMC. It is important to consider how many physical hosts you will need to host your virtual infrastructure.

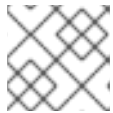
To determine this, VMware provides the [VMC on AWS Sizer](#). With this tool, you can define the resources you intend to host on VMC:

- Types of workloads
- Total number of virtual machines
- Specification information such as:
  - Storage requirements
  - vCPUs
  - vRAM
  - Overcommit ratios

With these details, the sizer tool can generate a report, based on VMware best practices, and recommend your cluster configuration and the number of hosts you will need.

### 18.6.2. vSphere prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You provisioned [block registry storage](#). For more information on persistent storage, see [Understanding persistent storage](#).
- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.



#### NOTE

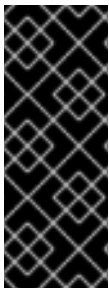
Be sure to also review this site list if you are configuring a proxy.

### 18.6.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



#### IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

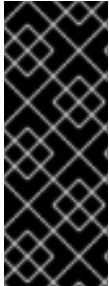
### 18.6.4. VMware vSphere infrastructure requirements

You must install the OpenShift Container Platform cluster on a VMware vSphere version 6 or 7 instance that meets the requirements for the components that you use.

**Table 18.48. Version requirements for vSphere virtual environments**

Virtual environment product	Required version
VM hardware version	13 or later
vSphere ESXi hosts	6.5 or later

Virtual environment product	Required version
vCenter host	6.5 or later



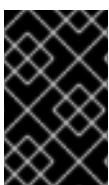
### IMPORTANT

Installing a cluster on VMware vSphere version 6.7U2 or earlier and virtual hardware version 13 is now deprecated. These versions are still fully supported, but support will be removed in a future version of OpenShift Container Platform. Hardware version 15 is now the default for vSphere virtual machines in OpenShift Container Platform. To update the hardware version for your vSphere nodes, see the "Updating hardware on nodes running in vSphere" article.

**Table 18.49. Minimum supported vSphere version for VMware components**

Component	Minimum supported versions	Description
Hypervisor	vSphere 6.5 and later with HW version 13	This version is the minimum version that Red Hat Enterprise Linux CoreOS (RHCOS) supports. See the <a href="#">Red Hat Enterprise Linux 8 supported hypervisors list</a> .
Storage with in-tree drivers	vSphere 6.5 and later	This plugin creates vSphere storage by using the in-tree storage drivers for vSphere included in OpenShift Container Platform.

If you use a vSphere version 6.5 instance, consider upgrading to 6.7U3 or 7.0 before you install OpenShift Container Platform.



### IMPORTANT

You must ensure that the time on your ESXi hosts is synchronized before you install OpenShift Container Platform. See [Edit Time Configuration for a Host](#) in the VMware documentation.

#### Additional resources

- To update the hardware version for your vSphere nodes, see [Updating hardware on nodes running in vSphere](#).

### 18.6.5. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

### 18.6.5.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

**Table 18.50. Minimum required hosts**

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.



#### IMPORTANT

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 7.9, or RHEL 8.4.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See [Red Hat Enterprise Linux technology capabilities and limits](#) .

### 18.6.5.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

**Table 18.51. Minimum resource requirements**

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 7.9, or RHEL 8.4 [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio:  $(\text{threads per core} \times \text{cores}) \times \text{sockets} = \text{vCPUs}$ .
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.

### 18.6.5.3. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

### 18.6.5.4. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.

It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.



#### NOTE

If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

### 18.6.5.4.1. Setting the cluster node hostnames through DHCP

On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

### 18.6.5.4.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.



#### IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

Table 18.52. Ports used for all-machine to all-machine communications

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	<b>1936</b>	Metrics
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> and the Cluster Version Operator on port <b>9099</b> .
	<b>10250-10259</b>	The default ports that Kubernetes reserves
	<b>10256</b>	openshift-sdn
UDP	<b>4789</b>	VXLAN and Geneve
	<b>6081</b>	VXLAN and Geneve
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> .
	<b>500</b>	IPsec IKE packets
	<b>4500</b>	IPsec NAT-T packets

Protocol	Port	Description
TCP/UDP	<b>30000-32767</b>	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

**Table 18.53. Ports used for all-machine to control plane communications**

Protocol	Port	Description
TCP	<b>6443</b>	Kubernetes API

**Table 18.54. Ports used for control plane machine to control plane machine communications**

Protocol	Port	Description
TCP	<b>2379-2380</b>	etcd server and peer ports

### NTP configuration for user-provisioned infrastructure

OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service*.

If a DHCP server provides NTP server information, the chrony time service on the Red Hat Enterprise Linux CoreOS (RHCOS) machines read the information and can sync the clock with the NTP servers.

### 18.6.5.5. User-provisioned DNS requirements

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API
- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines

Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.


DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.

**NOTE**

It is recommended to use a DHCP server to provide the hostnames to each cluster node. See the *DHCP recommendations for user-provisioned infrastructure* section for more information.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, **<cluster\_name>** is the cluster name and **<base\_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster\_name>.<base\_domain>..**

**Table 18.55. Required DNS records**

Component	Record	Description
Kubernetes API	<b>api.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
	<b>api-int.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster.
		 <p><b>IMPORTANT</b></p> <p>The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.</p>
Routes	<b>*.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
		For example, <b>console-openshift-console.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;</b> is used as a wildcard route to the OpenShift Container Platform console.
Bootstrap machine	<b>bootstrap.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.



Component	Record	Description
Control plane machines	<b>&lt;master&gt;&lt;n&gt;. &lt;cluster_name&gt;. &lt;base_domain&gt;.</b>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.
Compute machines	<b>&lt;worker&gt;&lt;n&gt;. &lt;cluster_name&gt;. &lt;base_domain&gt;.</b>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.



## NOTE

In OpenShift Container Platform 4.4 and later, you do not need to specify etcd host and SRV records in your DNS configuration.

## TIP

You can use the **dig** command to verify name and reverse name resolution. See the section on *Validating DNS resolution for user-provisioned infrastructure* for detailed validation steps.

### 18.6.5.5.1. Example DNS configuration for user-provisioned clusters

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is **ocp4** and the base domain is **example.com**.

#### Example DNS A record configuration for a user-provisioned cluster

The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

#### Example 18.13. Sample DNS zone database

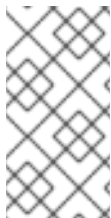
```
$TTL 1W
@ IN SOA ns1.example.com. root (
    2019070700 ; serial
    3H ; refresh (3 hours)
    30M ; retry (30 minutes)
    2W ; expiry (2 weeks)
    1W ) ; minimum (1 week)
IN NS ns1.example.com.
IN MX 10 smtp.example.com.
;
;
ns1.example.com. IN A 192.168.1.5
smtp.example.com. IN A 192.168.1.5
;
helper.example.com. IN A 192.168.1.5
```

```

helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com. IN A 192.168.1.5 1
api-int.ocp4.example.com. IN A 192.168.1.5 2
;
*.apps.ocp4.example.com. IN A 192.168.1.5 3
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 4
;
master0.ocp4.example.com. IN A 192.168.1.97 5
master1.ocp4.example.com. IN A 192.168.1.98 6
master2.ocp4.example.com. IN A 192.168.1.99 7
;
worker0.ocp4.example.com. IN A 192.168.1.11 8
worker1.ocp4.example.com. IN A 192.168.1.7 9
;
;EOF

```

- 1 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.
- 2 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.
- 3 Provides name resolution for the wildcard routes. The record refers to the IP address of the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



#### NOTE

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

- 4 Provides name resolution for the bootstrap machine.
- 5 6 7 Provides name resolution for the control plane machines.
- 8 9 Provides name resolution for the compute machines.

### Example DNS PTR record configuration for a user-provisioned cluster

The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

#### Example 18.14. Sample DNS zone database for reverse records

```

$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial

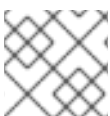
```

```

3H ; refresh (3 hours)
30M ; retry (30 minutes)
2W ; expiry (2 weeks)
1W ) ; minimum (1 week)
IN NS ns1.example.com.
;
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. 2
;
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. 3
;
97.1.168.192.in-addr.arpa. IN PTR master0.ocp4.example.com. 4
98.1.168.192.in-addr.arpa. IN PTR master1.ocp4.example.com. 5
99.1.168.192.in-addr.arpa. IN PTR master2.ocp4.example.com. 6
;
11.1.168.192.in-addr.arpa. IN PTR worker0.ocp4.example.com. 7
7.1.168.192.in-addr.arpa. IN PTR worker1.ocp4.example.com. 8
;
;EOF

```

- 1 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.
- 2 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.
- 3 Provides reverse DNS resolution for the bootstrap machine.
- 4 5 6 Provides reverse DNS resolution for the control plane machines.
- 7 8 Provides reverse DNS resolution for the compute machines.



#### NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard.

#### 18.6.5.6. Load balancing requirements for user-provisioned infrastructure

Before you install OpenShift Container Platform, you must provision the API and application ingress load balancing infrastructure. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.



#### NOTE

If you want to deploy the API and application ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer.** Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:

- Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the API routes.
- A stateless load balancing algorithm. The options vary based on the load balancer implementation.

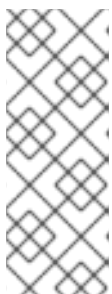
**NOTE**

Session persistence is not required for the API load balancer to function properly.

Configure the following ports on both the front and back of the load balancers:

**Table 18.56. API load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
<b>6443</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the <b>/readyz</b> endpoint for the API server health check probe.	X	X	Kubernetes API server
<b>22623</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server

**NOTE**

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the **/readyz** endpoint to the removal of the API server instance from the pool. Within the time frame after **/readyz** returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application ingress load balancer.** Provides an ingress point for application traffic flowing in from outside the cluster. Configure the following conditions:
  - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the ingress routes.
  - A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

**TIP**

If the true IP address of the client can be seen by the application ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

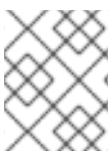
Configure the following ports on both the front and back of the load balancers:

**Table 18.57. Application ingress load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
<b>443</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic
<b>80</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic
<b>1936</b>	The worker nodes that run the Ingress Controller pods, by default. You must configure the <b>/healthz/ready</b> endpoint for the ingress health check probe.	X	X	HTTP traffic

**NOTE**

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

**NOTE**

A working configuration for the Ingress router is required for an OpenShift Container Platform cluster. You must configure the Ingress router after the control plane initializes.

#### 18.6.5.6.1. Example load balancer configuration for user-provisioned clusters

This section provides an example API and application ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an **/etc/haproxy/haproxy.cfg** configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing one load balancing solution over another.

**NOTE**

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

## Example 18.15. Sample API and application ingress load balancer configuration

```
global
log      127.0.0.1 local2
pidfile  /var/run/haproxy.pid
maxconn  4000
daemon

defaults
mode      http
log       global
option    dontlognull
option    http-server-close
option    redispatch
retries   3
timeout   http-request 10s
timeout   queue        1m
timeout   connect      10s
timeout   client       1m
timeout   server       1m
timeout   http-keep-alive 10s
timeout   check        10s
maxconn   3000

frontend stats
bind *:1936
mode      http
log       global
maxconn  10
stats enable
stats hide-version
stats refresh 30s
stats show-node
stats show-desc Stats for ocp4 cluster 1
stats auth admin:ocp4
stats uri /stats

listen api-server-6443 2
bind *:6443
mode tcp
server bootstrap bootstrap.ocp4.example.com:6443 check inter 1s backup 3
server master0 master0.ocp4.example.com:6443 check inter 1s
server master1 master1.ocp4.example.com:6443 check inter 1s
server master2 master2.ocp4.example.com:6443 check inter 1s

listen machine-config-server-22623 4
bind *:22623
mode tcp
server bootstrap bootstrap.ocp4.example.com:22623 check inter 1s backup 5
server master0 master0.ocp4.example.com:22623 check inter 1s
server master1 master1.ocp4.example.com:22623 check inter 1s
server master2 master2.ocp4.example.com:22623 check inter 1s

listen ingress-router-443 6
bind *:443
mode tcp
balance source
server worker0 worker0.ocp4.example.com:443 check inter 1s
server worker1 worker1.ocp4.example.com:443 check inter 1s

listen ingress-router-80 7
```

```
bind *:80
mode tcp
balance source
server worker0 worker0.ocp4.example.com:80 check inter 1s
server worker1 worker1.ocp4.example.com:80 check inter 1s
```

- 1 In the example, the cluster name is **ocp4**.
- 2 Port **6443** handles the Kubernetes API traffic and points to the control plane machines.
- 3 5 The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.
- 4 Port **22623** handles the machine config server traffic and points to the control plane machines.
- 6 Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.
- 7 Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



#### NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

#### TIP

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltp** on the HAProxy node.



#### NOTE

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running **setsebool -P haproxy\_connect\_any=1**.

### 18.6.6. Preparing the user-provisioned infrastructure

Before you install OpenShift Container Platform on user-provisioned infrastructure, you must prepare the underlying infrastructure.

This section provides details about the high-level steps required to set up your cluster infrastructure in preparation for an OpenShift Container Platform installation. This includes configuring IP networking and network connectivity for your cluster nodes, enabling the required ports through your firewall, and setting up the required DNS and load balancing infrastructure.

After preparation, your cluster infrastructure must meet the requirements outlined in the *Requirements for a cluster with user-provisioned infrastructure* section.

## Prerequisites

- You have reviewed the [OpenShift Container Platform 4.x Tested Integrations](#) page.
- You have reviewed the infrastructure requirements detailed in the *Requirements for a cluster with user-provisioned infrastructure* section.

## Procedure

1. If you are using DHCP to provide the IP networking configuration to your cluster nodes, configure your DHCP service.
  - a. Add persistent IP addresses for the nodes to your DHCP server configuration. In your configuration, match the MAC address of the relevant network interface to the intended IP address for each node.
  - b. When you use DHCP to configure IP addressing for the cluster machines, the machines also obtain the DNS server information through DHCP. Define the persistent DNS server address that is used by the cluster nodes through your DHCP server configuration.



### NOTE

If you are not using a DHCP service, you must provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

- c. Define the hostnames of your cluster nodes in your DHCP server configuration. See the *Setting the cluster node hostnames through DHCP* section for details about hostname considerations.



### NOTE

If you are not using a DHCP service, the cluster nodes obtain their hostname through a reverse DNS lookup.

2. Ensure that your network infrastructure provides the required network connectivity between the cluster components. See the *Networking requirements for user-provisioned infrastructure* section for details about the requirements.
3. Configure your firewall to enable the ports required for the OpenShift Container Platform cluster components to communicate. See *Networking requirements for user-provisioned infrastructure* section for details about the ports that are required.
4. Setup the required DNS infrastructure for your cluster.
  - a. Configure DNS name resolution for the Kubernetes API, the application wildcard, the bootstrap machine, the control plane machines, and the compute machines.
  - b. Configure reverse DNS resolution for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.  
See the *User-provisioned DNS requirements* section for more information about the OpenShift Container Platform DNS requirements.



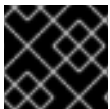
5. Validate your DNS configuration.
  - a. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses in the responses correspond to the correct components.
  - b. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names in the responses correspond to the correct components.  
See the *Validating DNS resolution for user-provisioned infrastructure* section for detailed DNS validation steps.
6. Provision the required API and application ingress load balancing infrastructure. See the *Load balancing requirements for user-provisioned infrastructure* section for more information about the requirements.

**NOTE**

Some load balancing solutions require the DNS name resolution for the cluster nodes to be in place before the load balancing is initialized.

### 18.6.7. Validating DNS resolution for user-provisioned infrastructure

You can validate your DNS configuration before installing OpenShift Container Platform on user-provisioned infrastructure.

**IMPORTANT**

The validation steps detailed in this section must succeed before you install your cluster.

**Prerequisites**

- You have configured the required DNS records for your user-provisioned infrastructure.

**Procedure**

1. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses contained in the responses correspond to the correct components.
  - a. Perform a lookup against the Kubernetes API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api.<cluster_name>.<base_domain> 1
```

- 1** Replace **<nameserver\_ip>** with the IP address of the nameserver, **<cluster\_name>** with your cluster name, and **<base\_domain>** with your base domain name.

**Example output**

```
api.ocp4.example.com. 0 IN A 192.168.1.5
```

- b. Perform a lookup against the Kubernetes internal API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api-int.<cluster_name>.<base_domain>
```

#### Example output

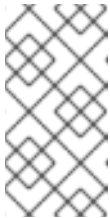
```
api-int.ocp4.example.com. 0 IN A 192.168.1.5
```

- c. Test an example **\*.apps.<cluster\_name>.<base\_domain>** DNS wildcard lookup. All of the application wildcard lookups must resolve to the IP address of the application ingress load balancer:

```
$ dig +noall +answer @<nameserver_ip> random.apps.<cluster_name>.<base_domain>
```

#### Example output

```
random.apps.ocp4.example.com. 0 IN A 192.168.1.5
```



#### NOTE

In the example outputs, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

You can replace **random** with another wildcard value. For example, you can query the route to the OpenShift Container Platform console:

```
$ dig +noall +answer @<nameserver_ip> console-openshift-console.apps.<cluster_name>.<base_domain>
```

#### Example output

```
console-openshift-console.apps.ocp4.example.com. 0 IN A 192.168.1.5
```

- d. Run a lookup against the bootstrap DNS record name. Check that the result points to the IP address of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> bootstrap.<cluster_name>.<base_domain>
```

#### Example output

```
bootstrap.ocp4.example.com. 0 IN A 192.168.1.96
```

- e. Use this method to perform lookups against the DNS record names for the control plane and compute nodes. Check that the results correspond to the IP addresses of each node.
2. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names contained in the responses correspond to the correct components.

- a. Perform a reverse lookup against the IP address of the API load balancer. Check that the response includes the record names for the Kubernetes API and the Kubernetes internal API:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.5
```

### Example output

```
5.1.168.192.in-addr.arpa. 0 IN PTR api-int.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. 0 IN PTR api.ocp4.example.com. 2
```

- 1 Provides the record name for the Kubernetes internal API.
- 2 Provides the record name for the Kubernetes API.



### NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard. No validation step is needed for reverse DNS resolution against the IP address of the application ingress load balancer.

- b. Perform a reverse lookup against the IP address of the bootstrap node. Check that the result points to the DNS record name of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.96
```

### Example output

```
96.1.168.192.in-addr.arpa. 0 IN PTR bootstrap.ocp4.example.com.
```

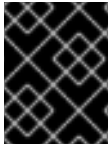
- c. Use this method to perform reverse lookups against the IP addresses for the control plane and compute nodes. Check that the results correspond to the DNS record names of each node.

## 18.6.8. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.

**IMPORTANT**

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

**NOTE**

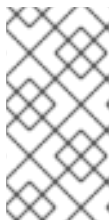
You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

**Procedure**

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.

**NOTE**

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.

**NOTE**

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

**Example output**

Agent pid 31874



#### NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1** Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

#### Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

#### Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program. If you install a cluster on infrastructure that you provision, you must provide the key to the installation program.

### 18.6.9. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

#### Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space

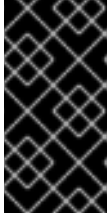
#### Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



#### IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



### IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#) . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

## 18.6.10. Manually creating the installation configuration file

For user-provisioned installations of OpenShift Container Platform, you manually generate your installation configuration file.

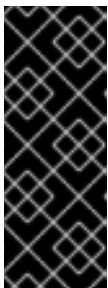
### Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

### Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```



### IMPORTANT

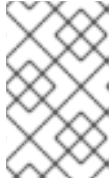
You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation\_directory>**.



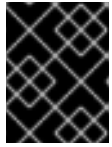
### NOTE

You must name this configuration file **install-config.yaml**.

**NOTE**

For some platform types, you can alternatively run `./openshift-install create install-config --dir <installation_directory>` to generate an `install-config.yaml` file. You can provide details about your cluster configuration at the prompts.

3. Back up the `install-config.yaml` file so that you can use it to install multiple clusters.

**IMPORTANT**

The `install-config.yaml` file is consumed during the next step of the installation process. You must back it up now.

### 18.6.10.1. Sample `install-config.yaml` file for VMware vSphere

You can customize the `install-config.yaml` file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```

apiVersion: v1
baseDomain: example.com 1
compute:
- hyperthreading: Enabled 2 3
  name: worker
  replicas: 0 4
controlPlane:
  hyperthreading: Enabled 5 6
  name: master
  replicas: 3 7
metadata:
  name: test 8
platform:
  vsphere:
    vcenter: your.vcenter.server 9
    username: username 10
    password: password 11
    datacenter: datacenter 12
    defaultDatastore: datastore 13
    folder: "/<datacenter_name>/vm/<folder_name>/<subfolder_name>" 14
  fips: false 15
  pullSecret: '{"auths": ...}' 16
  sshKey: 'ssh-ed25519 AAAA...' 17

```

- 1 The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.
- 2 5 The **controlPlane** section is a single mapping, but the compute section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. Although both sections currently define a single machine pool, it is possible that future versions of OpenShift Container Platform will support defining multiple compute pools during installation. Only one control plane pool is used.

- 3 6 Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You



### IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Your machines must use at least 8 CPUs and 32 GB of RAM if you disable simultaneous multithreading.

- 4 You must set the value of the **replicas** parameter to **0**. This parameter controls the number of workers that the cluster creates and manages for you, which are functions that the cluster does not perform when you use user-provisioned infrastructure. You must manually deploy worker machines for the cluster to use before you finish installing OpenShift Container Platform.
- 7 The number of control plane machines that you add to the cluster. Because the cluster uses this values as the number of etcd endpoints in the cluster, the value must match the number of control plane machines that you deploy.
- 8 The cluster name that you specified in your DNS records.
- 9 The fully-qualified hostname or IP address of the vCenter server.
- 10 The name of the user for accessing the server. This user must have at least the roles and privileges that are required for [static or dynamic persistent volume provisioning](#) in vSphere.
- 11 The password associated with the vSphere user.
- 12 The vSphere datacenter.
- 13 The default vSphere datastore to use.
- 14 Optional: For installer-provisioned infrastructure, the absolute path of an existing folder where the installation program creates the virtual machines, for example, `/<datacenter_name>/vm/<folder_name>/<subfolder_name>`. If you do not provide this value, the installation program creates a top-level folder in the datacenter virtual machine folder that is named with the infrastructure ID. If you are providing the infrastructure for the cluster, omit this parameter.
- 15 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.



### IMPORTANT

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

- 16 The pull secret that you obtained from [OpenShift Cluster Manager](#). This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.
- 17 The public portion of the default SSH key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).



### 18.6.10.2. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

#### Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



#### NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

#### Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
  additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
...

```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations. You must include vCenter's IP address and the IP range that you use for its machines.
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to

**additionalTrustBundle** and at least one proxy setting, the **proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.



#### NOTE

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



#### NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

### 18.6.11. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.



#### IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

#### Prerequisites

- You obtained the OpenShift Container Platform installation program.
- You created the **install-config.yaml** installation configuration file.

## Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

- 1 For **<installation\_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

2. Remove the Kubernetes manifest files that define the control plane machines and compute machine sets:

```
$ rm -f openshift/99_openshift-cluster-api_master-machines-*.yaml openshift/99_openshift-cluster-api_worker-machineset-*.yaml
```

Because you create and manage these resources yourself, you do not have to initialize them.

- You can preserve the machine set files to create compute machines by using the machine API, but you must update references to them to match your environment.
3. Check that the **mastersSchedulable** parameter in the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:
    - a. Open the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** file.
    - b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.
    - c. Save and exit the file.
  4. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

- 1 For **<installation\_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation\_directory>/auth** directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

### 18.6.12. Extracting the infrastructure name

The Ignition config files contain a unique cluster identifier that you can use to uniquely identify your cluster in VMware Cloud on AWS. If you plan to use the cluster identifier as the name of your virtual machine folder, you must extract it.

### Prerequisites

- You obtained the OpenShift Container Platform installation program and the pull secret for your cluster.
- You generated the Ignition config files for your cluster.
- You installed the **jq** package.

### Procedure

- To extract and view the infrastructure name from the Ignition config file metadata, run the following command:

```
$ jq -r .infraID <installation_directory>/metadata.json 1
```

- 1 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

### Example output

```
openshift-vw9j6 1
```

- 1 The output of this command is your cluster name and a random string.

## 18.6.13. Installing RHCOS and starting the OpenShift Container Platform bootstrap process

To install OpenShift Container Platform on user-provisioned infrastructure on VMware vSphere, you must install Red Hat Enterprise Linux CoreOS (RHCOS) on vSphere hosts. When you install RHCOS, you must provide the Ignition config file that was generated by the OpenShift Container Platform installation program for the type of machine you are installing. If you have configured suitable networking, DNS, and load balancing infrastructure, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS machines have rebooted.

### Prerequisites

- You have obtained the Ignition config files for your cluster.
- You have access to an HTTP server that you can access from your computer and that the machines that you create can access.
- You have created a [vSphere cluster](#).

### Procedure

1. Upload the bootstrap Ignition config file, which is named **<installation\_directory>/bootstrap.ign**, that the installation program created to your HTTP server. Note the URL of this file.
2. Save the following secondary Ignition config file for your bootstrap node to your computer as **<installation\_directory>/merge-bootstrap.ign**:

```
{
  "ignition": {
    "config": {
      "merge": [
        {
          "source": "<bootstrap_ignition_config_url>", 1
          "verification": {}
        }
      ]
    },
    "timeouts": {},
    "version": "3.2.0"
  },
  "networkd": {},
  "passwd": {},
  "storage": {},
  "systemd": {}
}
```

- 1 Specify the URL of the bootstrap Ignition config file that you hosted.

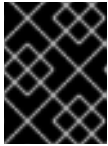
When you create the virtual machine (VM) for the bootstrap machine, you use this Ignition config file.

3. Locate the following Ignition config files that the installation program created:
  - **<installation\_directory>/master.ign**
  - **<installation\_directory>/worker.ign**
  - **<installation\_directory>/merge-bootstrap.ign**
4. Convert the Ignition config files to Base64 encoding. Later in this procedure, you must add these files to the extra configuration parameter **guestinfo.ignition.config.data** in your VM. For example, if you use a Linux operating system, you can use the **base64** command to encode the files.

```
$ base64 -w0 <installation_directory>/master.ign > <installation_directory>/master.64
```

```
$ base64 -w0 <installation_directory>/worker.ign > <installation_directory>/worker.64
```

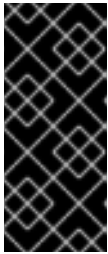
```
$ base64 -w0 <installation_directory>/merge-bootstrap.ign > <installation_directory>/merge-bootstrap.64
```



### IMPORTANT

If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

5. Obtain the RHCOS OVA image. Images are available from the [RHCOS image mirror](#) page.



### IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download an image with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image version that matches your OpenShift Container Platform version if it is available.

The filename contains the OpenShift Container Platform version number in the format **rhcos-vmware.<architecture>.ova**.

6. In the vSphere Client, create a folder in your datacenter to store your VMs.
  - a. Click the **VMs and Templates** view.
  - b. Right-click the name of your datacenter.
  - c. Click **New Folder → New VM and Template Folder**.
  - d. In the window that is displayed, enter the folder name. If you did not specify an existing folder in the **install-config.yaml** file, then create a folder with the same name as the infrastructure ID. You use this folder name so vCenter dynamically provisions storage in the appropriate location for its Workspace configuration.
7. In the vSphere Client, create a template for the OVA image and then clone the template as needed.



### NOTE

In the following steps, you create a template and then clone the template for all of your cluster machines. You then provide the location for the Ignition config file for that cloned machine type when you provision the VMs.

- a. From the **Hosts and Clusters** tab, right-click your cluster name and select **Deploy OVF Template**.
- b. On the **Select an OVF** tab, specify the name of the RHCOS OVA file that you downloaded.
- c. On the **Select a name and folder** tab, set a **Virtual machine name** for your template, such as **Template-RHCOS**. Click the name of your vSphere cluster and select the folder you created in the previous step.
- d. On the **Select a compute resource** tab, click the name of your vSphere cluster.
- e. On the **Select storage** tab, configure the storage options for your VM.
  - Select **Thin Provision** or **Thick Provision**, based on your storage preferences.

- Select the datastore that you specified in your **install-config.yaml** file.
- f. On the **Select network** tab, specify the network that you configured for the cluster, if available.
  - g. When creating the OVF template, do not specify values on the **Customize template** tab or configure the template any further.



### IMPORTANT

Do not start the original VM template. The VM template must remain off and must be cloned for new RHCOS machines. Starting the VM template configures the VM template as a VM on the platform, which prevents it from being used as a template that machine sets can apply configurations to.

8. Optional: Update the configured virtual hardware version in the VM template, if necessary. Follow [Upgrading a virtual machine to the latest hardware version](#) in the VMware documentation for more information.



### IMPORTANT

It is recommended that you update the hardware version of the VM template to version 15 before creating VMs from it, if necessary. Using hardware version 13 for your cluster nodes running on vSphere is now deprecated. If your imported template defaults to hardware version 13, you must ensure that your ESXi host is on 6.7U3 or later before upgrading the VM template to hardware version 15. If your vSphere version is less than 6.7U3, you can skip this upgrade step; however, a future version of OpenShift Container Platform is scheduled to remove support for hardware version 13 and vSphere versions less than 6.7U3.

9. After the template deploys, deploy a VM for a machine in the cluster.
  - a. Right-click the template name and click **Clone → Clone to Virtual Machine**
  - b. On the **Select a name and folder** tab, specify a name for the VM. You might include the machine type in the name, such as **control-plane-0** or **compute-1**.
  - c. On the **Select a name and folder** tab, select the name of the folder that you created for the cluster.
  - d. On the **Select a compute resource** tab, select the name of a host in your datacenter.
  - e. Optional: On the **Select storage** tab, customize the storage options.
  - f. On the **Select clone options**, select **Customize this virtual machine's hardware**
  - g. On the **Customize hardware** tab, click **VM Options → Advanced**.
    - Optional: Override default DHCP networking in vSphere. To enable static IP networking:
      - i. Set your static IP configuration:

```
$ export IPCFG="ip=<ip>::<gateway>:<netmask>:<hostname>:<iface>:none
nameserver=svr1 [nameserver=svr2 [nameserver=svr3 [...]]]"
```

**Example command**

```
$ export IPCFG="ip=192.168.100.101::192.168.100.254:255.255.255.0::none
nameserver=8.8.8.8"
```

- ii. Set the **guestinfo.afterburn.initrd.network-kargs** property before booting a VM from an OVA in vSphere:

```
$ govc vm.change -vm "<vm_name>" -e "guestinfo.afterburn.initrd.network-
kargs=${IPCFG}"
```

- Optional: In the event of cluster performance issues, from the **Latency Sensitivity** list, select **High**. Ensure that your VM's CPU and memory reservation have the following values:
    - Memory reservation value must be equal to its configured memory size.
    - CPU reservation value must be at least the number of low latency virtual CPUs multiplied by the measured physical CPU speed.
  - Click **Edit Configuration**, and on the **Configuration Parameters** window, search the list of available parameters for steal clock accounting (**stealclock.enable**). If it is available, set its value to **TRUE**. Enabling steal clock accounting can help with troubleshooting cluster issues.
  - Click **Add Configuration Params**. Define the following parameter names and values:
    - **guestinfo.ignition.config.data**: Locate the base-64 encoded files that you created previously in this procedure, and paste the contents of the base64-encoded Ignition config file for this machine type.
    - **guestinfo.ignition.config.data.encoding**: Specify **base64**.
    - **disk.EnableUUID**: Specify **TRUE**.
    - **stealclock.enable**: If this parameter was not defined, add it and specify **TRUE**.
  - h. In the **Virtual Hardware** panel of the **Customize hardware** tab, modify the specified values as required. Ensure that the amount of RAM, CPU, and disk storage meets the minimum requirements for the machine type.
  - i. Complete the configuration and power on the VM.
10. Create the rest of the machines for your cluster by following the preceding steps for each machine.

**IMPORTANT**

You must create the bootstrap and control plane machines at this time. Because some pods are deployed on compute machines by default, also create at least two compute machines before you install the cluster.

**18.6.14. Adding more compute machines to a cluster in vSphere**



You can add more compute machines to a user-provisioned OpenShift Container Platform cluster on VMware vSphere.

### Prerequisites

- Obtain the base64-encoded Ignition file for your compute machines.
- You have access to the vSphere template that you created for your cluster.

### Procedure

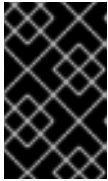
1. After the template deploys, deploy a VM for a machine in the cluster.
  - a. Right-click the template's name and click **Clone → Clone to Virtual Machine**
  - b. On the **Select a name and folder** tab, specify a name for the VM. You might include the machine type in the name, such as **compute-1**.
  - c. On the **Select a name and folder** tab, select the name of the folder that you created for the cluster.
  - d. On the **Select a compute resource** tab, select the name of a host in your datacenter.
  - e. Optional: On the **Select storage** tab, customize the storage options.
  - f. On the **Select clone options**, select **Customize this virtual machine's hardware**
  - g. On the **Customize hardware** tab, click **VM Options → Advanced**.
    - From the **Latency Sensitivity** list, select **High**.
    - Click **Edit Configuration**, and on the **Configuration Parameters** window, click **Add Configuration Params**. Define the following parameter names and values:
      - **guestinfo.ignition.config.data**: Paste the contents of the base64-encoded compute Ignition config file for this machine type.
      - **guestinfo.ignition.config.data.encoding**: Specify **base64**.
      - **disk.EnableUUID**: Specify **TRUE**.
  - h. In the **Virtual Hardware** panel of the **Customize hardware** tab, modify the specified values as required. Ensure that the amount of RAM, CPU, and disk storage meets the minimum requirements for the machine type. Also, make sure to select the correct network under **Add network adapter** if there are multiple networks available.
  - i. Complete the configuration and power on the VM.
2. Continue to create more compute machines for your cluster.

### 18.6.15. Disk partitioning

In most cases, data partitions are originally created by installing RHCOS, rather than by installing another operating system. In such cases, the OpenShift Container Platform installer should be allowed to configure your disk partitions.

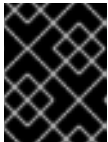
However, there are two cases where you might want to intervene to override the default partitioning when installing an OpenShift Container Platform node:

- **Create separate partitions:** For greenfield installations on an empty disk, you might want to add separate storage to a partition. This is officially supported for making **/var** or a subdirectory of **/var**, such as **/var/lib/etcd**, a separate partition, but not both.



### IMPORTANT

For disk sizes larger than 100GB, and especially disk sizes larger than 1TB, create a separate **/var** partition. See "Creating a separate **/var** partition" and this [Red Hat Knowledgebase article](#) for more information.



### IMPORTANT

Kubernetes supports only two file system partitions. If you add more than one partition to the original configuration, Kubernetes cannot monitor all of them.

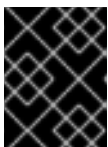
- **Retain existing partitions:** For a brownfield installation where you are reinstalling OpenShift Container Platform on an existing node and want to retain data partitions installed from your previous operating system, there are both boot arguments and options to **coreos-installer** that allow you to retain existing data partitions.

## Creating a separate **/var** partition

In general, disk partitioning for OpenShift Container Platform should be left to the installer. However, there are cases where you might want to create separate partitions in a part of the filesystem that you expect to grow.

OpenShift Container Platform supports the addition of a single partition to attach storage to either the **/var** partition or a subdirectory of **/var**. For example:

- **/var/lib/containers:** Holds container-related content that can grow as more images and containers are added to a system.
- **/var/lib/etcd:** Holds data that you might want to keep separate for purposes such as performance optimization of etcd storage.
- **/var:** Holds data that you might want to keep separate for purposes such as auditing.



### IMPORTANT

For disk sizes larger than 100GB, and especially larger than 1TB, create a separate **/var** partition.

Storing the contents of a **/var** directory separately makes it easier to grow storage for those areas as needed and reinstall OpenShift Container Platform at a later date and keep that data intact. With this method, you will not have to pull all your containers again, nor will you have to copy massive log files when you update systems.

Because **/var** must be in place before a fresh installation of Red Hat Enterprise Linux CoreOS (RHCOS), the following procedure sets up the separate **/var** partition by creating a machine config manifest that is inserted during the **openshift-install** preparation phases of an OpenShift Container Platform installation.

## Procedure

1. Create a directory to hold the OpenShift Container Platform installation files:

```
$ mkdir $HOME/clusterconfig
```

2. Run **openshift-install** to create a set of files in the **manifest** and **openshift** subdirectories. Answer the system questions as you are prompted:

```
$ openshift-install create manifests --dir $HOME/clusterconfig
? SSH Public Key ...
$ ls $HOME/clusterconfig/openshift/
99_kubeadmin-password-secret.yaml
99_openshift-cluster-api_master-machines-0.yaml
99_openshift-cluster-api_master-machines-1.yaml
99_openshift-cluster-api_master-machines-2.yaml
...
```

3. Create a Butane config that configures the additional partition. For example, name the file **\$HOME/clusterconfig/98-var-partition.bu**, change the disk device name to the name of the storage device on the **worker** systems, and set the storage size as appropriate. This example places the **/var** directory on a separate partition:

```
variant: openshift
version: 4.9.0
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 98-var-partition
storage:
  disks:
    - device: /dev/<device_name> 1
      partitions:
        - label: var
          start_mib: <partition_start_offset> 2
          size_mib: <partition_size> 3
      filesystems:
        - device: /dev/disk/by-partlabel/var
          path: /var
          format: xfs
          mount_options: [defaults, prjquota] 4
          with_mount_unit: true
```

- 1 The storage device name of the disk that you want to partition.
- 2 When adding a data partition to the boot disk, a minimum value of 25000 mebibytes is recommended. The root file system is automatically resized to fill all available space up to the specified offset. If no value is specified, or if the specified value is smaller than the recommended minimum, the resulting root file system will be too small, and future reinstalls of RHCOS might overwrite the beginning of the data partition.
- 3 The size of the data partition in mebibytes.
- 4 The **prjquota** mount option must be enabled for filesystems used for container storage.

**NOTE**

When creating a separate **/var** partition, you cannot use different instance types for worker nodes, if the different instance types do not have the same device name.

4. Create a manifest from the Butane config and save it to the **clusterconfig/openshift** directory. For example, run the following command:

```
$ butane $HOME/clusterconfig/98-var-partition.bu -o $HOME/clusterconfig/openshift/98-var-partition.yaml
```

5. Run **openshift-install** again to create Ignition configs from a set of files in the **manifest** and **openshift** subdirectories:

```
$ openshift-install create ignition-configs --dir $HOME/clusterconfig
$ ls $HOME/clusterconfig/
auth bootstrap.ign master.ign metadata.json worker.ign
```

Now you can use the Ignition config files as input to the vSphere installation procedures to install Red Hat Enterprise Linux CoreOS (RHCOS) systems.

### 18.6.16. Updating the bootloader using bootupd

To update the bootloader by using **bootupd**, you must either install **bootupd** on RHCOS machines manually or provide a machine config with the enabled **systemd** unit. Unlike **grubby** or other bootloader tools, **bootupd** does not manage kernel space configuration such as passing kernel arguments.

After you have installed **bootupd**, you can manage it remotely from the OpenShift Container Platform cluster.

**NOTE**

It is recommended that you use **bootupd** only on bare metal or virtualized hypervisor installations, such as for protection against the BootHole vulnerability.

#### Manual install method

You can manually install **bootupd** by using the **bootctl** command-line tool.

1. Inspect the system status:

```
# bootupctl status
```

#### Example output

```
Component EFI
Installed: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
Update: At latest version
```

2. RHCOS images created without **bootupd** installed on them require an explicit adoption phase. If the system status is **Adoptable**, perform the adoption:

```
# bootupctl adopt-and-update
```

### Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

- If an update is available, apply the update so that the changes take effect on the next reboot:

```
# bootupctl update
```

### Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

## Machine config method

Another way to enable **bootupd** is by providing a machine config.

- Provide a machine config file with the enabled **systemd** unit, as shown in the following example:

### Example output

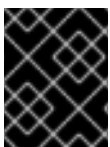
```
variant: rhcos
version: 1.1.0
systemd:
  units:
    - name: custom-bootupd-auto.service
      enabled: true
      contents: |
        [Unit]
        Description=Bootupd automatic update

        [Service]
        ExecStart=/usr/bin/bootupctl update
        RemainAfterExit=yes

        [Install]
        WantedBy=multi-user.target
```

## 18.6.17. Installing the OpenShift CLI by downloading the binary

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.



### IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

### Installing the OpenShift CLI on Linux

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

## Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

```
$ tar xvf <file>
```

5. Place the **oc** binary in a directory that is on your **PATH**.  
To check your **PATH**, execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

## Installing the OpenShift CLI on Windows

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

## Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

## Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

## Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.

3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your PATH.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

### 18.6.18. Waiting for the bootstrap process to complete

The OpenShift Container Platform bootstrap process begins after the cluster nodes first boot into the persistent RHCOS environment that has been installed to disk. The configuration information provided through the Ignition config files is used to initialize the bootstrap process and install OpenShift Container Platform on the machines. You must wait for the bootstrap process to complete.

#### Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have obtained the installation program and generated the Ignition config files for your cluster.
- You installed RHCOS on your cluster machines and provided the Ignition config files that the OpenShift Container Platform installation program generated.
- Your machines have direct internet access or have an HTTP or HTTPS proxy available.

#### Procedure

1. Monitor the bootstrap process:

```
$ ./openshift-install --dir <installation_directory> wait-for bootstrap-complete \ 1  
--log-level=info 2
```

1 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

#### Example output

```
INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...  
INFO API v1.22.1 up  
INFO Waiting up to 30m0s for bootstrapping to complete...  
INFO It is now safe to remove the bootstrap resources
```

The command succeeds when the Kubernetes API server signals that it has been bootstrapped on the control plane machines.

2. After bootstrap process is complete, remove the bootstrap machine from the load balancer.



### IMPORTANT

You must remove the bootstrap machine from the load balancer at this point. You can also remove or reformat the bootstrap machine itself.

## 18.6.19. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

### Example output

```
system:admin
```

## 18.6.20. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

### Prerequisites

- You added machines to your cluster.

### Procedure



1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

### Example output

```
NAME      STATUS    ROLES    AGE    VERSION
master-0  Ready    master   63m    v1.22.1
master-1  Ready    master   63m    v1.22.1
master-2  Ready    master   64m    v1.22.1
```

The output lists all of the machines that you created.



### NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

2. Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

### Example output

```
NAME      AGE    REQUESTOR                                     CONDITION
csr-8b2br  15m    system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper  Pending
csr-8vnps  15m    system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper  Pending
...
```

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

3. If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:



### NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.

**NOTE**

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrap** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{\n"}\n{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```

**NOTE**

Some Operators might not become available until some CSRs are approved.

- Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

**Example output**

```
NAME      AGE   REQUESTOR                                     CONDITION
csr-bfd72 5m26s system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv 5m26s system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

- If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{\n"}\n{{end}}\n{{end}}' | xargs oc adm certificate approve
```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

### Example output

```
NAME      STATUS  ROLES  AGE  VERSION
master-0  Ready   master 73m  v1.22.1
master-1  Ready   master 73m  v1.22.1
master-2  Ready   master 74m  v1.22.1
worker-0  Ready   worker 11m  v1.22.1
worker-1  Ready   worker 11m  v1.22.1
```



### NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

### Additional information

- For more information on CSRs, see [Certificate Signing Requests](#).

## 18.6.21. Initial Operator configuration

After the control plane initializes, you must immediately configure some Operators so that they all become available.

### Prerequisites

- Your control plane has initialized.

### Procedure

1. Watch the cluster components come online:

```
$ watch -n5 oc get clusteroperators
```

### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
authentication	4.9.0	True	False	False	19m
baremetal	4.9.0	True	False	False	37m
cloud-credential	4.9.0	True	False	False	40m
cluster-autoscaler	4.9.0	True	False	False	37m
config-operator	4.9.0	True	False	False	38m

console	4.9.0	True	False	False	26m
csi-snapshot-controller	4.9.0	True	False	False	37m
dns	4.9.0	True	False	False	37m
etcd	4.9.0	True	False	False	36m
image-registry	4.9.0	True	False	False	31m
ingress	4.9.0	True	False	False	30m
insights	4.9.0	True	False	False	31m
kube-apiserver	4.9.0	True	False	False	26m
kube-controller-manager	4.9.0	True	False	False	36m
kube-scheduler	4.9.0	True	False	False	36m
kube-storage-version-migrator	4.9.0	True	False	False	37m
machine-api	4.9.0	True	False	False	29m
machine-approver	4.9.0	True	False	False	37m
machine-config	4.9.0	True	False	False	36m
marketplace	4.9.0	True	False	False	37m
monitoring	4.9.0	True	False	False	29m
network	4.9.0	True	False	False	38m
node-tuning	4.9.0	True	False	False	37m
openshift-apiserver	4.9.0	True	False	False	32m
openshift-controller-manager	4.9.0	True	False	False	30m
openshift-samples	4.9.0	True	False	False	32m
operator-lifecycle-manager	4.9.0	True	False	False	37m
operator-lifecycle-manager-catalog	4.9.0	True	False	False	37m
operator-lifecycle-manager-packageserver	4.9.0	True	False	False	32m
service-ca	4.9.0	True	False	False	38m
storage	4.9.0	True	False	False	37m

2. Configure the Operators that are not available.

### 18.6.21.1. Image registry removed during installation

On platforms that do not provide shareable object storage, the OpenShift Image Registry Operator bootstraps itself as **Removed**. This allows **openshift-installer** to complete installations on these platform types.

After installation, you must edit the Image Registry Operator configuration to switch the **managementState** from **Removed** to **Managed**.



#### NOTE

The Prometheus console provides an **ImageRegistryRemoved** alert, for example:

"Image Registry has been removed. **ImageStreamTags**, **BuildConfigs** and **DeploymentConfigs** which reference **ImageStreamTags** may not work as expected. Please configure storage and update the config to **Managed** state by editing `configs.imageregistry.operator.openshift.io`."

### 18.6.21.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

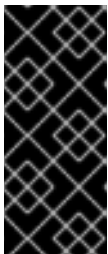
Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

### 18.6.21.2.1. Configuring registry storage for VMware vSphere

As a cluster administrator, following installation you must configure your registry to use storage.

#### Prerequisites

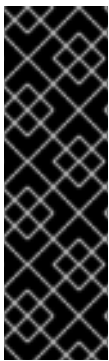
- Cluster administrator permissions.
- A cluster on VMware vSphere.
- Persistent storage provisioned for your cluster, such as Red Hat OpenShift Container Storage.



#### IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have "100Gi" capacity.



#### IMPORTANT

Testing shows issues with using the NFS server on RHEL as storage backend for core services. This includes the OpenShift Container Registry and Quay, Prometheus for monitoring storage, and Elasticsearch for logging storage. Therefore, using RHEL NFS to back PVs used by core services is not recommended.

Other NFS implementations on the marketplace might not have these issues. Contact the individual NFS implementation vendor for more information on any testing that was possibly completed against these OpenShift Container Platform core components.

#### Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.



#### NOTE

When using shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

### Example output

```
No resources found in openshift-image-registry namespace
```



#### NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

### Example output

```
storage:
  pvc:
    claim: 1
```

- 1 Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** persistent volume claim (PVC). The PVC is generated based on the default storage class. However, be aware that the default storage class might provide ReadWriteOnce (RWO) volumes, such as a RADOS Block Device (RBD), which can cause issues when replicating to more than one replica.

4. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED
image-registry	4.7	True	False	False 6h50m

#### 18.6.21.2.2. Configuring storage for the image registry in non-production clusters

You must configure storage for the Image Registry Operator. For non-production clusters, you can set the image registry to an empty directory. If you do so, all images are lost if you restart the registry.

#### Procedure

- To set the image registry storage to an empty directory:

```
$ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec": {"storage":{"emptyDir":{}}}'
```

**WARNING**

Configure this option for only non-production clusters.

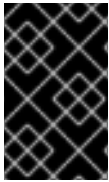
If you run this command before the Image Registry Operator initializes its components, the **oc patch** command fails with the following error:

```
Error from server (NotFound): configs.imageregistry.operator.openshift.io "cluster" not found
```

Wait a few minutes and run the command again.

### 18.6.21.2.3. Configuring block registry storage for VMware vSphere

To allow the image registry to use block storage types such as vSphere Virtual Machine Disk (VMDK) during upgrades as a cluster administrator, you can use the **Recreate** rollout strategy.

**IMPORTANT**

Block storage volumes are supported but not recommended for use with image registry on production clusters. An installation where the registry is configured on block storage is not highly available because the registry cannot have more than one replica.

#### Procedure

1. To set the image registry storage as a block storage type, patch the registry so that it uses the **Recreate** rollout strategy and runs with only **1** replica:

```
$ oc patch config.imageregistry.operator.openshift.io/cluster --type=merge -p '{"spec": {"rolloutStrategy": "Recreate", "replicas": 1}}'
```

2. Provision the PV for the block storage device, and create a PVC for that volume. The requested block volume uses the ReadWriteOnce (RWO) access mode.

- a. Create a **pvc.yaml** file with the following contents to define a VMware vSphere **PersistentVolumeClaim** object:

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: image-registry-storage 1
  namespace: openshift-image-registry 2
spec:
  accessModes:
  - ReadWriteOnce 3
  resources:
    requests:
      storage: 100Gi 4
```

- 1 A unique name that represents the **PersistentVolumeClaim** object.

- 2 The namespace for the **PersistentVolumeClaim** object, which is **openshift-image-registry**.
- 3 The access mode of the persistent volume claim. With **ReadWriteOnce**, the volume can be mounted with read and write permissions by a single node.
- 4 The size of the persistent volume claim.

b. Create the **PersistentVolumeClaim** object from the file:

```
$ oc create -f pvc.yaml -n openshift-image-registry
```

3. Edit the registry configuration so that it references the correct PVC:

```
$ oc edit config.imageregistry.operator.openshift.io -o yaml
```

### Example output

```
storage:
  pvc:
    claim: 1
```

- 1 Creating a custom PVC allows you to leave the **claim** field blank for the default automatic creation of an **image-registry-storage** PVC.

For instructions about configuring registry storage so that it references the correct PVC, see [Configuring the registry for vSphere](#).

## 18.6.22. Completing installation on user-provisioned infrastructure

After you complete the Operator configuration, you can finish installing the cluster on infrastructure that you provide.

### Prerequisites

- Your control plane has initialized.
- You have completed the initial Operator configuration.

### Procedure

1. Confirm that all the cluster components are online with the following command:

```
$ watch -n5 oc get clusteroperators
```

### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED
authentication	4.9.0	True	False	False 19m
baremetal	4.9.0	True	False	False 37m



cloud-credential	4.9.0	True	False	False	40m
cluster-autoscaler	4.9.0	True	False	False	37m
config-operator	4.9.0	True	False	False	38m
console	4.9.0	True	False	False	26m
csi-snapshot-controller	4.9.0	True	False	False	37m
dns	4.9.0	True	False	False	37m
etcd	4.9.0	True	False	False	36m
image-registry	4.9.0	True	False	False	31m
ingress	4.9.0	True	False	False	30m
insights	4.9.0	True	False	False	31m
kube-apiserver	4.9.0	True	False	False	26m
kube-controller-manager	4.9.0	True	False	False	36m
kube-scheduler	4.9.0	True	False	False	36m
kube-storage-version-migrator	4.9.0	True	False	False	37m
machine-api	4.9.0	True	False	False	29m
machine-approver	4.9.0	True	False	False	37m
machine-config	4.9.0	True	False	False	36m
marketplace	4.9.0	True	False	False	37m
monitoring	4.9.0	True	False	False	29m
network	4.9.0	True	False	False	38m
node-tuning	4.9.0	True	False	False	37m
openshift-apiserver	4.9.0	True	False	False	32m
openshift-controller-manager	4.9.0	True	False	False	30m
openshift-samples	4.9.0	True	False	False	32m
operator-lifecycle-manager	4.9.0	True	False	False	37m
operator-lifecycle-manager-catalog	4.9.0	True	False	False	37m
operator-lifecycle-manager-packageserver	4.9.0	True	False	False	32m
service-ca	4.9.0	True	False	False	38m
storage	4.9.0	True	False	False	37m

Alternatively, the following command notifies you when all of the clusters are available. It also retrieves and displays credentials:

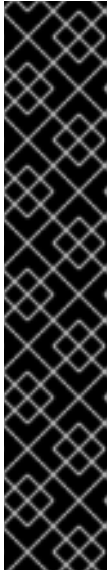
```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

### Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

The command succeeds when the Cluster Version Operator finishes deploying the OpenShift Container Platform cluster from Kubernetes API server.



## IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

### 2. Confirm that the Kubernetes API server is communicating with the pods.

- To view a list of all pods, use the following command:

```
$ oc get pods --all-namespaces
```

#### Example output

```

NAMESPACE           NAME                                     READY  STATUS
RESTARTS  AGE
openshift-apiserver-operator  openshift-apiserver-operator-85cb746d55-zqhs8  1/1
Running   1      9m
openshift-apiserver          apiserver-67b9g                                1/1  Running  0
3m
openshift-apiserver          apiserver-ljcmx                                1/1  Running  0
1m
openshift-apiserver          apiserver-z25h4                                1/1  Running  0
2m
openshift-authentication-operator  authentication-operator-69d5d8bf84-vh2n8      1/1
Running   0      5m
...

```

- View the logs for a pod that is listed in the output of the previous command by using the following command:

```
$ oc logs <pod_name> -n <namespace> 1
```

- 1** Specify the pod name and namespace, as shown in the output of the previous command.

If the pod logs display, the Kubernetes API server can communicate with the cluster machines.

- For an installation with Fibre Channel Protocol (FCP), additional steps are required to enable multipathing. Do not enable multipathing during installation. See "Enabling multipathing with kernel arguments on RHCOS" in the *Post-installation machine configuration tasks* documentation for more information.

You can add extra compute machines after the cluster installation is completed by following [Adding compute machines to vSphere](#).

### 18.6.23. Backing up VMware vSphere volumes

OpenShift Container Platform provisions new volumes as independent persistent disks to freely attach and detach the volume on any node in the cluster. As a consequence, it is not possible to back up volumes that use snapshots, or to restore volumes from snapshots. See [Snapshot Limitations](#) for more information.

#### Procedure

To create a backup of persistent volumes:

1. Stop the application that is using the persistent volume.
2. Clone the persistent volume.
3. Restart the application.
4. Create a backup of the cloned volume.
5. Delete the cloned volume.

### 18.6.24. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

#### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

### 18.6.25. Next steps

- [Customize your cluster](#).
- If necessary, you can [opt out of remote health reporting](#).
- [Set up your registry and configure registry storage](#).
- Optional: [View the events from the vSphere Problem Detector Operator](#) to determine if the cluster has permission or storage configuration issues.

## 18.7. INSTALLING A CLUSTER ON VMC WITH USER-PROVISIONED INFRASTRUCTURE AND NETWORK CUSTOMIZATIONS

In OpenShift Container Platform version 4.9, you can install a cluster on your VMware vSphere instance using infrastructure you provision with customized network configuration options by deploying it to [VMware Cloud \(VMC\) on AWS](#).

Once you configure your VMC environment for OpenShift Container Platform deployment, you use the OpenShift Container Platform installation program from the bastion management host, co-located in the VMC environment. The installation program and control plane automates the process of deploying and managing the resources needed for the OpenShift Container Platform cluster.

By customizing your network configuration, your cluster can coexist with existing IP address allocations in your environment and integrate with existing VXLAN configurations. You must set most of the network configuration parameters during installation, and you can modify only **kubeProxy** configuration parameters in a running cluster.

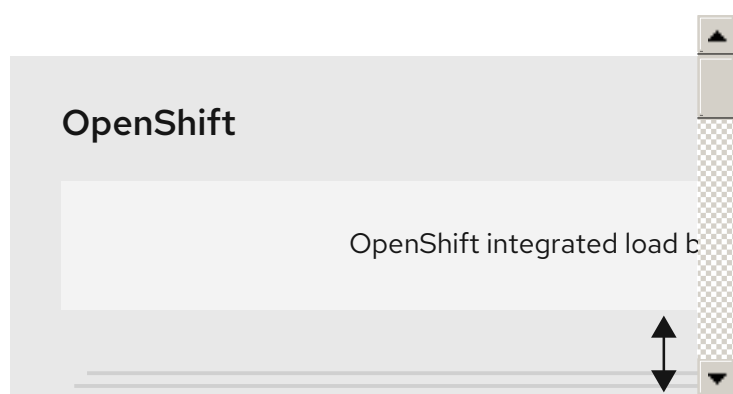


#### NOTE

OpenShift Container Platform supports deploying a cluster to a single VMware vCenter only. Deploying a cluster with machines/machine sets on multiple vCenters is not supported.

### 18.7.1. Setting up VMC for vSphere

You can install OpenShift Container Platform on VMware Cloud (VMC) on AWS hosted vSphere clusters to enable applications to be deployed and managed both on-premise and off-premise, across the hybrid cloud.



You must configure several options in your VMC environment prior to installing OpenShift Container Platform on VMware vSphere. Ensure your VMC environment has the following prerequisites:

- Create a non-exclusive, DHCP-enabled, NSX-T network segment and subnet. Other virtual machines (VMs) can be hosted on the subnet, but at least eight IP addresses must be available for the OpenShift Container Platform deployment.
- Configure the following firewall rules:
  - An ANY:ANY firewall rule between the OpenShift Container Platform compute network and the internet. This is used by nodes and applications to download container images.
  - An ANY:ANY firewall rule between the installation host and the software-defined data center (SDDC) management network on port 443. This allows you to upload the Red Hat Enterprise Linux CoreOS (RHCOS) OVA during deployment.
  - An HTTPS firewall rule between the OpenShift Container Platform compute network and vCenter. This connection allows OpenShift Container Platform to communicate with vCenter for provisioning and managing nodes, persistent volume claims (PVCs), and other resources.
- You must have the following information to deploy OpenShift Container Platform:

- The OpenShift Container Platform cluster name, such as **vmc-prod-1**.
- The base DNS name, such as **companyname.com**.
- If not using the default, the pod network CIDR and services network CIDR must be identified, which are set by default to **10.128.0.0/14** and **172.30.0.0/16**, respectively. These CIDRs are used for pod-to-pod and pod-to-service communication and are not accessible externally; however, they must not overlap with existing subnets in your organization.
- The following vCenter information:
  - vCenter hostname, username, and password
  - Datacenter name, such as **SDDC-Datacenter**
  - Cluster name, such as **Cluster-1**
  - Network name
  - Datastore name, such as **WorkloadDatastore**

**NOTE**

It is recommended to move your vSphere cluster to the VMC **Compute-ResourcePool** resource pool after your cluster installation is finished.

- A Linux-based host deployed to VMC as a bastion.
  - The bastion host can be Red Hat Enterprise Linux (RHEL) or any another Linux-based host; it must have internet connectivity and the ability to upload an OVA to the ESXi hosts.
  - Download and install the OpenShift CLI tools to the bastion host.
    - The **openshift-install** installation program
    - The OpenShift CLI (**oc**) tool

**NOTE**

You cannot use the VMware NSX Container Plugin for Kubernetes (NCP), and NSX is not used as the OpenShift SDN. The version of NSX currently available with VMC is incompatible with the version of NCP certified with OpenShift Container Platform.

However, the NSX DHCP service is used for virtual machine IP management with the full-stack automated OpenShift Container Platform deployment and with nodes provisioned, either manually or automatically, by the Machine API integration with vSphere. Additionally, NSX firewall rules are created to enable access with the OpenShift Container Platform cluster and between the bastion host and the VMC vSphere hosts.

**18.7.1.1. VMC Sizer tool**

VMware Cloud on AWS is built on top of AWS bare metal infrastructure; this is the same bare metal infrastructure which runs AWS native services. When a VMware cloud on AWS software-defined data center (SDDC) is deployed, you consume these physical server nodes and run the VMware ESXi

hypervisor in a single tenant fashion. This means the physical infrastructure is not accessible to anyone else using VMC. It is important to consider how many physical hosts you will need to host your virtual infrastructure.

To determine this, VMware provides the [VMC on AWS Sizer](#). With this tool, you can define the resources you intend to host on VMC:

- Types of workloads
- Total number of virtual machines
- Specification information such as:
  - Storage requirements
  - vCPUs
  - vRAM
  - Overcommit ratios

With these details, the sizer tool can generate a report, based on VMware best practices, and recommend your cluster configuration and the number of hosts you will need.

### 18.7.2. vSphere prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You provisioned [block registry storage](#). For more information on persistent storage, see [Understanding persistent storage](#).
- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.

### 18.7.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



## IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

### 18.7.4. VMware vSphere infrastructure requirements

You must install the OpenShift Container Platform cluster on a VMware vSphere version 6 or 7 instance that meets the requirements for the components that you use.

**Table 18.58. Version requirements for vSphere virtual environments**

Virtual environment product	Required version
VM hardware version	13 or later
vSphere ESXi hosts	6.5 or later
vCenter host	6.5 or later



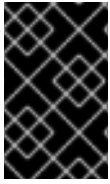
## IMPORTANT

Installing a cluster on VMware vSphere version 6.7U2 or earlier and virtual hardware version 13 is now deprecated. These versions are still fully supported, but support will be removed in a future version of OpenShift Container Platform. Hardware version 15 is now the default for vSphere virtual machines in OpenShift Container Platform. To update the hardware version for your vSphere nodes, see the "Updating hardware on nodes running in vSphere" article.

**Table 18.59. Minimum supported vSphere version for VMware components**

Component	Minimum supported versions	Description
Hypervisor	vSphere 6.5 and later with HW version 13	This version is the minimum version that Red Hat Enterprise Linux CoreOS (RHCOS) supports. See the <a href="#">Red Hat Enterprise Linux 8 supported hypervisors list</a> .
Storage with in-tree drivers	vSphere 6.5 and later	This plugin creates vSphere storage by using the in-tree storage drivers for vSphere included in OpenShift Container Platform.

If you use a vSphere version 6.5 instance, consider upgrading to 6.7U3 or 7.0 before you install OpenShift Container Platform.



## IMPORTANT

You must ensure that the time on your ESXi hosts is synchronized before you install OpenShift Container Platform. See [Edit Time Configuration for a Host](#) in the VMware documentation.

### Additional resources

- To update the hardware version for your vSphere nodes, see [Updating hardware on nodes running in vSphere](#).

## 18.7.5. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

### 18.7.5.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

**Table 18.60. Minimum required hosts**

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.



## IMPORTANT

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 7.9, or RHEL 8.4.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See [Red Hat Enterprise Linux technology capabilities and limits](#).



### 18.7.5.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

**Table 18.61. Minimum resource requirements**

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 7.9, or RHEL 8.4 [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio:  $(\text{threads per core} \times \text{cores}) \times \text{sockets} = \text{vCPUs}$ .
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.

### 18.7.5.3. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

### 18.7.5.4. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **iniramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.

It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.



#### NOTE

If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

#### 18.7.5.4.1. Setting the cluster node hostnames through DHCP

On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

#### 18.7.5.4.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.



#### IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

**Table 18.62. Ports used for all-machine to all-machine communications**

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	<b>1936</b>	Metrics

Protocol	Port	Description
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> and the Cluster Version Operator on port <b>9099</b> .
	<b>10250-10259</b>	The default ports that Kubernetes reserves
	<b>10256</b>	openshift-sdn
UDP	<b>4789</b>	VXLAN and Geneve
	<b>6081</b>	VXLAN and Geneve
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> .
	<b>500</b>	IPsec IKE packets
	<b>4500</b>	IPsec NAT-T packets
TCP/UDP	<b>30000-32767</b>	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 18.63. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	<b>6443</b>	Kubernetes API

Table 18.64. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	<b>2379-2380</b>	etcd server and peer ports

### NTP configuration for user-provisioned infrastructure

OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service*.

If a DHCP server provides NTP server information, the chrony time service on the Red Hat Enterprise Linux CoreOS (RHCOS) machines read the information and can sync the clock with the NTP servers.

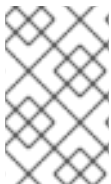
### 18.7.5.5. User-provisioned DNS requirements

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API
- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines

Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.




#### NOTE

It is recommended to use a DHCP server to provide the hostnames to each cluster node. See the *DHCP recommendations for user-provisioned infrastructure* section for more information.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, **<cluster\_name>** is the cluster name and **<base\_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster\_name>.<base\_domain>..**

**Table 18.65. Required DNS records**

Component	Record	Description
Kubernetes API	<b>api.&lt;cluster_name&gt;.&lt;base_domain&gt;..</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
	<b>api-int.&lt;cluster_name&gt;.&lt;base_domain&gt;..</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster.
		 <p><b>IMPORTANT</b></p> <p>The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.</p>

Component	Record	Description
Routes	<b>*.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	<p>A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.</p> <p>For example, <b>console-openshift-console.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;</b> is used as a wildcard route to the OpenShift Container Platform console.</p>
Bootstrap machine	<b>bootstrap.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.
Control plane machines	<b>&lt;master&gt;&lt;n&gt;.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.
Compute machines	<b>&lt;worker&gt;&lt;n&gt;.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.



## NOTE

In OpenShift Container Platform 4.4 and later, you do not need to specify etcd host and SRV records in your DNS configuration.

## TIP

You can use the **dig** command to verify name and reverse name resolution. See the section on *Validating DNS resolution for user-provisioned infrastructure* for detailed validation steps.

### 18.7.5.5.1. Example DNS configuration for user-provisioned clusters

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is **ocp4** and the base domain is **example.com**.

#### Example DNS A record configuration for a user-provisioned cluster

The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

### Example 18.16. Sample DNS zone database

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H ; refresh (3 hours)
  30M ; retry (30 minutes)
  2W ; expiry (2 weeks)
  1W ) ; minimum (1 week)
IN NS ns1.example.com.
IN MX 10 smtp.example.com.
;
;
ns1.example.com. IN A 192.168.1.5
smtp.example.com. IN A 192.168.1.5
;
helper.example.com. IN A 192.168.1.5
helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com. IN A 192.168.1.5 1
api-int.ocp4.example.com. IN A 192.168.1.5 2
;
*.apps.ocp4.example.com. IN A 192.168.1.5 3
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 4
;
master0.ocp4.example.com. IN A 192.168.1.97 5
master1.ocp4.example.com. IN A 192.168.1.98 6
master2.ocp4.example.com. IN A 192.168.1.99 7
;
worker0.ocp4.example.com. IN A 192.168.1.11 8
worker1.ocp4.example.com. IN A 192.168.1.7 9
;
;EOF
```

- 1 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.
- 2 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.
- 3 Provides name resolution for the wildcard routes. The record refers to the IP address of the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

**NOTE**

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

- 4 Provides name resolution for the bootstrap machine.
- 5 6 7 Provides name resolution for the control plane machines.
- 8 9 Provides name resolution for the compute machines.

**Example DNS PTR record configuration for a user-provisioned cluster**

The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

**Example 18.17. Sample DNS zone database for reverse records**

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H ; refresh (3 hours)
  30M ; retry (30 minutes)
  2W ; expiry (2 weeks)
  1W ) ; minimum (1 week)
IN NS ns1.example.com.
;
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. 2
;
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. 3
;
97.1.168.192.in-addr.arpa. IN PTR master0.ocp4.example.com. 4
98.1.168.192.in-addr.arpa. IN PTR master1.ocp4.example.com. 5
99.1.168.192.in-addr.arpa. IN PTR master2.ocp4.example.com. 6
;
11.1.168.192.in-addr.arpa. IN PTR worker0.ocp4.example.com. 7
7.1.168.192.in-addr.arpa. IN PTR worker1.ocp4.example.com. 8
;
;EOF
```

- 1 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.
- 2 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.
- 3 Provides reverse DNS resolution for the bootstrap machine.
- 4 5 6 Provides reverse DNS resolution for the control plane machines.

**7 8** Provides reverse DNS resolution for the compute machines.



#### NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard.

### 18.7.5.6. Load balancing requirements for user-provisioned infrastructure

Before you install OpenShift Container Platform, you must provision the API and application ingress load balancing infrastructure. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.



#### NOTE

If you want to deploy the API and application ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer.** Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:
  - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the API routes.
  - A stateless load balancing algorithm. The options vary based on the load balancer implementation.



#### NOTE

Session persistence is not required for the API load balancer to function properly.

Configure the following ports on both the front and back of the load balancers:

**Table 18.66. API load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
<b>6443</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the <b>/readyz</b> endpoint for the API server health check probe.	X	X	Kubernetes API server



Port	Back-end machines (pool members)	Internal	External	Description
<b>22623</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server



## NOTE

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the `/readyz` endpoint to the removal of the API server instance from the pool. Within the time frame after `/readyz` returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application ingress load balancer:** Provides an ingress point for application traffic flowing in from outside the cluster. Configure the following conditions:
  - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the ingress routes.
  - A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

## TIP

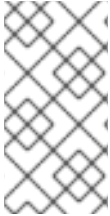
If the true IP address of the client can be seen by the application ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

Configure the following ports on both the front and back of the load balancers:

**Table 18.67. Application ingress load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
<b>443</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic
<b>80</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic

Port	Back-end machines (pool members)	Internal	External	Description
1936	The worker nodes that run the Ingress Controller pods, by default. You must configure the <b>/healthz/ready</b> endpoint for the ingress health check probe.	X	X	HTTP traffic

**NOTE**

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

**NOTE**

A working configuration for the Ingress router is required for an OpenShift Container Platform cluster. You must configure the Ingress router after the control plane initializes.

#### 18.7.5.6.1. Example load balancer configuration for user-provisioned clusters

This section provides an example API and application ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an **/etc/haproxy/haproxy.cfg** configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing one load balancing solution over another.

**NOTE**

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

#### Example 18.18. Sample API and application ingress load balancer configuration

```
global
log      127.0.0.1 local2
pidfile  /var/run/haproxy.pid
maxconn  4000
daemon
defaults
mode     http
log      global
option   dontlognull
option   http-server-close
option   redispatch
retries  3
timeout http-request 10s
timeout queue      1m
timeout connect    10s
```

```

timeout client      1m
timeout server     1m
timeout http-keep-alive 10s
timeout check      10s
maxconn            3000
frontend stats
bind *:1936
mode              http
log               global
maxconn 10
stats enable
stats hide-version
stats refresh 30s
stats show-node
stats show-desc Stats for ocp4 cluster 1
stats auth admin:ocp4
stats uri /stats
listen api-server-6443 2
bind *:6443
mode tcp
server bootstrap bootstrap.ocp4.example.com:6443 check inter 1s backup 3
server master0 master0.ocp4.example.com:6443 check inter 1s
server master1 master1.ocp4.example.com:6443 check inter 1s
server master2 master2.ocp4.example.com:6443 check inter 1s
listen machine-config-server-22623 4
bind *:22623
mode tcp
server bootstrap bootstrap.ocp4.example.com:22623 check inter 1s backup 5
server master0 master0.ocp4.example.com:22623 check inter 1s
server master1 master1.ocp4.example.com:22623 check inter 1s
server master2 master2.ocp4.example.com:22623 check inter 1s
listen ingress-router-443 6
bind *:443
mode tcp
balance source
server worker0 worker0.ocp4.example.com:443 check inter 1s
server worker1 worker1.ocp4.example.com:443 check inter 1s
listen ingress-router-80 7
bind *:80
mode tcp
balance source
server worker0 worker0.ocp4.example.com:80 check inter 1s
server worker1 worker1.ocp4.example.com:80 check inter 1s

```

- 1** In the example, the cluster name is **ocp4**.
- 2** Port **6443** handles the Kubernetes API traffic and points to the control plane machines.
- 3** **5** The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.
- 4** Port **22623** handles the machine config server traffic and points to the control plane machines.
- 6** Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

- 7 Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



#### NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

#### TIP

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltp** on the HAProxy node.



#### NOTE

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running **setsebool -P haproxy\_connect\_any=1**.

### 18.7.6. Preparing the user-provisioned infrastructure

Before you install OpenShift Container Platform on user-provisioned infrastructure, you must prepare the underlying infrastructure.

This section provides details about the high-level steps required to set up your cluster infrastructure in preparation for an OpenShift Container Platform installation. This includes configuring IP networking and network connectivity for your cluster nodes, enabling the required ports through your firewall, and setting up the required DNS and load balancing infrastructure.

After preparation, your cluster infrastructure must meet the requirements outlined in the *Requirements for a cluster with user-provisioned infrastructure* section.

#### Prerequisites

- You have reviewed the [OpenShift Container Platform 4.x Tested Integrations](#) page.
- You have reviewed the infrastructure requirements detailed in the *Requirements for a cluster with user-provisioned infrastructure* section.

#### Procedure

1. If you are using DHCP to provide the IP networking configuration to your cluster nodes, configure your DHCP service.
  - a. Add persistent IP addresses for the nodes to your DHCP server configuration. In your configuration, match the MAC address of the relevant network interface to the intended IP address for each node.

- b. When you use DHCP to configure IP addressing for the cluster machines, the machines also obtain the DNS server information through DHCP. Define the persistent DNS server address that is used by the cluster nodes through your DHCP server configuration.

**NOTE**

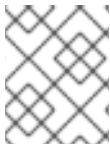
If you are not using a DHCP service, you must provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

- c. Define the hostnames of your cluster nodes in your DHCP server configuration. See the *Setting the cluster node hostnames through DHCP* section for details about hostname considerations.

**NOTE**

If you are not using a DHCP service, the cluster nodes obtain their hostname through a reverse DNS lookup.

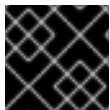
2. Ensure that your network infrastructure provides the required network connectivity between the cluster components. See the *Networking requirements for user-provisioned infrastructure* section for details about the requirements.
3. Configure your firewall to enable the ports required for the OpenShift Container Platform cluster components to communicate. See *Networking requirements for user-provisioned infrastructure* section for details about the ports that are required.
4. Setup the required DNS infrastructure for your cluster.
  - a. Configure DNS name resolution for the Kubernetes API, the application wildcard, the bootstrap machine, the control plane machines, and the compute machines.
  - b. Configure reverse DNS resolution for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.  
See the *User-provisioned DNS requirements* section for more information about the OpenShift Container Platform DNS requirements.
5. Validate your DNS configuration.
  - a. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses in the responses correspond to the correct components.
  - b. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names in the responses correspond to the correct components.  
See the *Validating DNS resolution for user-provisioned infrastructure* section for detailed DNS validation steps.
6. Provision the required API and application ingress load balancing infrastructure. See the *Load balancing requirements for user-provisioned infrastructure* section for more information about the requirements.

**NOTE**

Some load balancing solutions require the DNS name resolution for the cluster nodes to be in place before the load balancing is initialized.

**18.7.7. Validating DNS resolution for user-provisioned infrastructure**

You can validate your DNS configuration before installing OpenShift Container Platform on user-provisioned infrastructure.

**IMPORTANT**

The validation steps detailed in this section must succeed before you install your cluster.

**Prerequisites**

- You have configured the required DNS records for your user-provisioned infrastructure.

**Procedure**

- From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses contained in the responses correspond to the correct components.
  - Perform a lookup against the Kubernetes API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api.<cluster_name>.<base_domain> 1
```

- Replace **<nameserver\_ip>** with the IP address of the nameserver, **<cluster\_name>** with your cluster name, and **<base\_domain>** with your base domain name.

**Example output**

```
api.ocp4.example.com. 0 IN A 192.168.1.5
```

- Perform a lookup against the Kubernetes internal API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api-int.<cluster_name>.<base_domain>
```

**Example output**

```
api-int.ocp4.example.com. 0 IN A 192.168.1.5
```

- Test an example **\*.apps.<cluster\_name>.<base\_domain>** DNS wildcard lookup. All of the application wildcard lookups must resolve to the IP address of the application ingress load balancer:

```
$ dig +noall +answer @<nameserver_ip> random.apps.<cluster_name>.<base_domain>
```

**Example output**

```
random.apps.ocp4.example.com. 0 IN A 192.168.1.5
```



### NOTE

In the example outputs, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

You can replace **random** with another wildcard value. For example, you can query the route to the OpenShift Container Platform console:

```
$ dig +noall +answer @<nameserver_ip> console-openshift-console.apps.<cluster_name>.<base_domain>
```

### Example output

```
console-openshift-console.apps.ocp4.example.com. 0 IN A 192.168.1.5
```

- d. Run a lookup against the bootstrap DNS record name. Check that the result points to the IP address of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> bootstrap.<cluster_name>.<base_domain>
```

### Example output

```
bootstrap.ocp4.example.com. 0 IN A 192.168.1.96
```

- e. Use this method to perform lookups against the DNS record names for the control plane and compute nodes. Check that the results correspond to the IP addresses of each node.
2. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names contained in the responses correspond to the correct components.

- a. Perform a reverse lookup against the IP address of the API load balancer. Check that the response includes the record names for the Kubernetes API and the Kubernetes internal API:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.5
```

### Example output

```
5.1.168.192.in-addr.arpa. 0 IN PTR api-int.ocp4.example.com. 1  
5.1.168.192.in-addr.arpa. 0 IN PTR api.ocp4.example.com. 2
```

**1** Provides the record name for the Kubernetes internal API.

**2** Provides the record name for the Kubernetes API.

**NOTE**

A PTR record is not required for the OpenShift Container Platform application wildcard. No validation step is needed for reverse DNS resolution against the IP address of the application ingress load balancer.

- b. Perform a reverse lookup against the IP address of the bootstrap node. Check that the result points to the DNS record name of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.96
```

**Example output**

```
96.1.168.192.in-addr.arpa. 0 IN PTR bootstrap.ocp4.example.com.
```

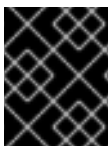
- c. Use this method to perform reverse lookups against the IP addresses for the control plane and compute nodes. Check that the results correspond to the DNS record names of each node.

**18.7.8. Generating a key pair for cluster node SSH access**

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.

**IMPORTANT**

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

**NOTE**

You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

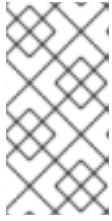
**Procedure**

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```



- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.



#### NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

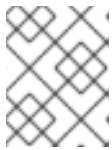
2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.



#### NOTE

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

#### Example output

```
Agent pid 31874
```



#### NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1 Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

#### Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

### Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program.

## 18.7.9. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on a local computer.

### Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space

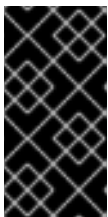
### Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



#### IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.



#### IMPORTANT

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#) . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

## 18.7.10. Manually creating the installation configuration file

For user-provisioned installations of OpenShift Container Platform, you manually generate your installation configuration file.

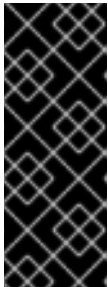
## Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

## Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```



### IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation\_directory>**.



### NOTE

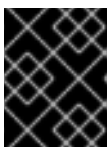
You must name this configuration file **install-config.yaml**.



### NOTE

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation\_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



### IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

### 18.7.10.1. Sample **install-config.yaml** file for VMware vSphere

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```
apiVersion: v1
```

```

baseDomain: example.com 1
compute:
- hyperthreading: Enabled 2 3
  name: worker
  replicas: 0 4
controlPlane:
  hyperthreading: Enabled 5 6
  name: master
  replicas: 3 7
metadata:
  name: test 8
platform:
  vsphere:
    vcenter: your.vcenter.server 9
    username: username 10
    password: password 11
    datacenter: datacenter 12
    defaultDatastore: datastore 13
    folder: "/<datacenter_name>/vm/<folder_name>/<subfolder_name>" 14
  fips: false 15
  pullSecret: '{"auths": ...}' 16
  sshKey: 'ssh-ed25519 AAAA...' 17

```

- 1 The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.
- 2 5 The **controlPlane** section is a single mapping, but the compute section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. Although both sections currently define a single machine pool, it is possible that future versions of OpenShift Container Platform will support defining multiple compute pools during installation. Only one control plane pool is used.
- 3 6 Whether to enable or disable simultaneous multithreading, or **hyperthreading**. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores. You can disable it by setting the parameter value to **Disabled**. If you disable simultaneous multithreading in some cluster machines, you must disable it in all cluster machines.



### IMPORTANT

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance. Your machines must use at least 8 CPUs and 32 GB of RAM if you disable simultaneous multithreading.

- 4 You must set the value of the **replicas** parameter to **0**. This parameter controls the number of workers that the cluster creates and manages for you, which are functions that the cluster does not perform when you use user-provisioned infrastructure. You must manually deploy worker machines for the cluster to use before you finish installing OpenShift Container Platform.
- 7 The number of control plane machines that you add to the cluster. Because the cluster uses this values as the number of etcd endpoints in the cluster, the value must match the number of control plane machines that you deploy.

- 8 The cluster name that you specified in your DNS records.
- 9 The fully-qualified hostname or IP address of the vCenter server.
- 10 The name of the user for accessing the server. This user must have at least the roles and privileges that are required for [static or dynamic persistent volume provisioning](#) in vSphere.
- 11 The password associated with the vSphere user.
- 12 The vSphere datacenter.
- 13 The default vSphere datastore to use.
- 14 Optional: For installer-provisioned infrastructure, the absolute path of an existing folder where the installation program creates the virtual machines, for example, `/<datacenter_name>/vm/<folder_name>/<subfolder_name>`. If you do not provide this value, the installation program creates a top-level folder in the datacenter virtual machine folder that is named with the infrastructure ID. If you are providing the infrastructure for the cluster, omit this parameter.
- 15 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.



### IMPORTANT

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

- 16 The pull secret that you obtained from [OpenShift Cluster Manager](#). This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.
- 17 The public portion of the default SSH key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).

#### 18.7.10.2. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

#### Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



## NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

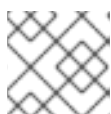
## Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
  -----BEGIN CERTIFICATE-----
  <MY_TRUSTED_CA_CERT>
  -----END CERTIFICATE-----
...

```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations. You must include vCenter's IP address and the IP range that you use for its machines.
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

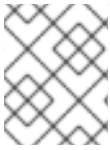


## NOTE

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

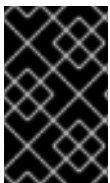


## NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

### 18.7.11. Specifying advanced network configuration

You can use advanced network configuration for your cluster network provider to integrate your cluster into your existing network environment. You can specify advanced network configuration only before you install the cluster.



## IMPORTANT

Customizing your network configuration by modifying the OpenShift Container Platform manifest files created by the installation program is not supported. Applying a manifest file that you create, as in the following procedure, is supported.

### Prerequisites

- You have created the **install-config.yaml** file and completed any modifications to it.

### Procedure

- Change to the directory that contains the installation program and create the manifests:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

- 1** **<installation\_directory>** specifies the name of the directory that contains the **install-config.yaml** file for your cluster.

- Create a stub manifest file for the advanced network configuration that is named **cluster-network-03-config.yml** in the **<installation\_directory>/manifests/** directory:

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
```

- Specify the advanced network configuration for your cluster in the **cluster-network-03-config.yml** file, such as in the following examples:

#### Specify a different VXLAN port for the OpenShift SDN network provider

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
```

```

defaultNetwork:
  openshiftSDNConfig:
    vxlanPort: 4800

```

### Enable IPsec for the OVN-Kubernetes network provider

```

apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    ovnKubernetesConfig:
      ipsecConfig: {}

```

- Optional: Back up the **manifests/cluster-network-03-config.yml** file. The installation program consumes the **manifests/** directory when you create the Ignition config files.
- Remove the Kubernetes manifest files that define the control plane machines and compute machineSets:

```

$ rm -f openshift/99_openshift-cluster-api_master-machines-*.yaml openshift/99_openshift-cluster-api_worker-machineset-*.yaml

```

Because you create and manage these resources yourself, you do not have to initialize them.

- You can preserve the MachineSet files to create compute machines by using the machine API, but you must update references to them to match your environment.

## 18.7.12. Cluster Network Operator configuration

The configuration for the cluster network is specified as part of the Cluster Network Operator (CNO) configuration and stored in a custom resource (CR) object that is named **cluster**. The CR specifies the fields for the **Network** API in the **operator.openshift.io** API group.

The CNO configuration inherits the following fields during cluster installation from the **Network** API in the **Network.config.openshift.io** API group and these fields cannot be changed:

### **clusterNetwork**

IP address pools from which pod IP addresses are allocated.

### **serviceNetwork**

IP address pool for services.

### **defaultNetwork.type**

Cluster network provider, such as OpenShift SDN or OVN-Kubernetes.

You can specify the cluster network provider configuration for your cluster by setting the fields for the **defaultNetwork** object in the CNO object named **cluster**.

### 18.7.12.1. Cluster Network Operator configuration object

The fields for the Cluster Network Operator (CNO) are described in the following table:

**Table 18.68. Cluster Network Operator configuration object**




Field	Type	Description
<b>metadata.name</b>	<b>string</b>	The name of the CNO object. This name is always <b>cluster</b> .
<b>spec.clusterNetwork</b>	<b>array</b>	<p>A list specifying the blocks of IP addresses from which pod IP addresses are allocated and the subnet prefix length assigned to each individual node in the cluster. For example:</p> <pre>spec:   clusterNetwork:   - cidr: 10.128.0.0/19     hostPrefix: 23   - cidr: 10.128.32.0/19     hostPrefix: 23</pre> <p>You can customize this field only in the <b>install-config.yaml</b> file before you create the manifests. The value is read-only in the manifest file.</p>
<b>spec.serviceNetwork</b>	<b>array</b>	<p>A block of IP addresses for services. The OpenShift SDN and OVN-Kubernetes Container Network Interface (CNI) network providers support only a single IP address block for the service network. For example:</p> <pre>spec:   serviceNetwork:   - 172.30.0.0/14</pre> <p>You can customize this field only in the <b>install-config.yaml</b> file before you create the manifests. The value is read-only in the manifest file.</p>
<b>spec.defaultNetwork</b>	<b>object</b>	Configures the Container Network Interface (CNI) cluster network provider for the cluster network.
<b>spec.kubeProxy</b> <b>Config</b>	<b>object</b>	The fields for this object specify the kube-proxy configuration. If you are using the OVN-Kubernetes cluster network provider, the kube-proxy configuration has no effect.

### defaultNetwork object configuration

The values for the **defaultNetwork** object are defined in the following table:

Table 18.69. **defaultNetwork** object

Field	Type	Description
-------	------	-------------

Field	Type	Description
<b>type</b>	<b>string</b>	<p>Either <b>OpenShiftSDN</b> or <b>OVNKubernetes</b>. The cluster network provider is selected during installation. This value cannot be changed after cluster installation.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>NOTE</b></p> <p>OpenShift Container Platform uses the OpenShift SDN Container Network Interface (CNI) cluster network provider by default.</p> </div> </div>
<b>openshiftSDNConfig</b>	<b>object</b>	This object is only valid for the OpenShift SDN cluster network provider.
<b>ovnKubernetesConfig</b>	<b>object</b>	This object is only valid for the OVN-Kubernetes cluster network provider.

### Configuration for the OpenShift SDN CNI cluster network provider

The following table describes the configuration fields for the OpenShift SDN Container Network Interface (CNI) cluster network provider.

**Table 18.70. openshiftSDNConfig object**

Field	Type	Description
<b>mode</b>	<b>string</b>	<p>Configures the network isolation mode for OpenShift SDN. The default value is <b>NetworkPolicy</b>.</p> <p>The values <b>Multitenant</b> and <b>Subnet</b> are available for backwards compatibility with OpenShift Container Platform 3.x but are not recommended. This value cannot be changed after cluster installation.</p>

Field	Type	Description
<b>mtu</b>	<b>integer</b>	<p>The maximum transmission unit (MTU) for the VXLAN overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU.</p> <p>If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes.</p> <p>If your cluster requires different MTU values for different nodes, you must set this value to <b>50</b> less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of <b>9001</b>, and some have an MTU of <b>1500</b>, you must set this value to <b>1450</b>.</p> <p>This value cannot be changed after cluster installation.</p>
<b>vxlanPort</b>	<b>integer</b>	<p>The port to use for all VXLAN packets. The default value is <b>4789</b>. This value cannot be changed after cluster installation.</p> <p>If you are running in a virtualized environment with existing nodes that are part of another VXLAN network, then you might be required to change this. For example, when running an OpenShift SDN overlay on top of VMware NSX-T, you must select an alternate port for the VXLAN, because both SDNs use the same default VXLAN port number.</p> <p>On Amazon Web Services (AWS), you can select an alternate port for the VXLAN between port <b>9000</b> and port <b>9999</b>.</p>

### Example OpenShift SDN configuration

```

defaultNetwork:
  type: OpenShiftSDN
  openshiftSDNConfig:
    mode: NetworkPolicy
    mtu: 1450
    vxlanPort: 4789

```

### Configuration for the OVN-Kubernetes CNI cluster network provider

The following table describes the configuration fields for the OVN-Kubernetes CNI cluster network provider.

Table 18.71. `ovnKubernetesConfig` object

Field	Type	Description
-------	------	-------------

Field	Type	Description
<b>mtu</b>	<b>integer</b>	<p>The maximum transmission unit (MTU) for the Geneve (Generic Network Virtualization Encapsulation) overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU.</p> <p>If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes.</p> <p>If your cluster requires different MTU values for different nodes, you must set this value to <b>100</b> less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of <b>9001</b>, and some have an MTU of <b>1500</b>, you must set this value to <b>1400</b>.</p> <p>This value cannot be changed after cluster installation.</p>
<b>genevePort</b>	<b>integer</b>	The port to use for all Geneve packets. The default value is <b>6081</b> . This value cannot be changed after cluster installation.
<b>ipsecConfig</b>	<b>object</b>	Specify an empty object to enable IPsec encryption. This value cannot be changed after cluster installation.
<b>policyAuditConfig</b>	<b>object</b>	Specify a configuration object for customizing network policy audit logging. If unset, the defaults audit log settings are used.

Table 18.72. **policyAuditConfig** object

Field	Type	Description
<b>rateLimit</b>	integer	The maximum number of messages to generate every second per node. The default value is <b>20</b> messages per second.
<b>maxFileSize</b>	integer	The maximum size for the audit log in bytes. The default value is <b>50000000</b> or 50 MB.

Field	Type	Description
<b>destination</b>	string	<p>One of the following additional audit log targets:</p> <p><b>libc</b> The libc <b>syslog()</b> function of the journald process on the host.</p> <p><b>udp:&lt;host&gt;:&lt;port&gt;</b> A syslog server. Replace <b>&lt;host&gt;:&lt;port&gt;</b> with the host and port of the syslog server.</p> <p><b>unix:&lt;file&gt;</b> A Unix Domain Socket file specified by <b>&lt;file&gt;</b>.</p> <p><b>null</b> Do not send the audit logs to any additional target.</p>
<b>syslogFacility</b>	string	The syslog facility, such as <b>kern</b> , as defined by RFC5424. The default value is <b>local0</b> .


### Example OVN-Kubernetes configuration

```
defaultNetwork:
  type: OVNKubernetes
  ovnKubernetesConfig:
    mtu: 1400
    genevePort: 6081
    ipsecConfig: {}
```

### kubeProxyConfig object configuration

The values for the **kubeProxyConfig** object are defined in the following table:

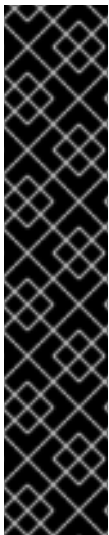
Table 18.73. **kubeProxyConfig** object

Field	Type	Description
<b>iptablesSyncPeriod</b>	<b>string</b>	<p>The refresh period for <b>iptables</b> rules. The default value is <b>30s</b>. Valid suffixes include <b>s</b>, <b>m</b>, and <b>h</b> and are described in the <a href="#">Go time package</a> documentation.</p> <div style="display: flex; align-items: flex-start;"> <div style="flex: 1;">  </div> <div style="flex: 2;"> <p><b>NOTE</b></p> <p>Because of performance improvements introduced in OpenShift Container Platform 4.3 and greater, adjusting the <b>iptablesSyncPeriod</b> parameter is no longer necessary.</p> </div> </div>

Field	Type	Description
<b>proxyArguments.iptables-min-sync-period</b>	<b>array</b>	<p>The minimum duration before refreshing <b>iptables</b> rules. This field ensures that the refresh does not happen too frequently. Valid suffixes include <b>s</b>, <b>m</b>, and <b>h</b> and are described in the <a href="#">Go time package</a>. The default value is:</p> <pre>kubeProxyConfig:   proxyArguments:     iptables-min-sync-period:       - 0s</pre>

### 18.7.13. Creating the Ignition config files

Because you must manually start the cluster machines, you must generate the Ignition config files that the cluster needs to make its machines.



#### IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

#### Prerequisites

- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster. For a restricted network installation, these files are on your mirror host.

#### Procedure

- Obtain the Ignition config files:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

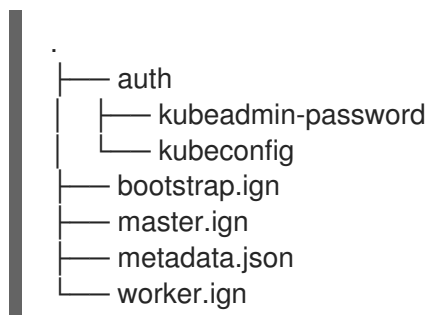
- 1** For **<installation\_directory>**, specify the directory name to store the files that the installation program creates.



## IMPORTANT

If you created an **install-config.yaml** file, specify the directory that contains it. Otherwise, specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

The following files are generated in the directory:



### 18.7.14. Extracting the infrastructure name

The Ignition config files contain a unique cluster identifier that you can use to uniquely identify your cluster in VMware Cloud on AWS. If you plan to use the cluster identifier as the name of your virtual machine folder, you must extract it.

#### Prerequisites

- You obtained the OpenShift Container Platform installation program and the pull secret for your cluster.
- You generated the Ignition config files for your cluster.
- You installed the **jq** package.

#### Procedure

- To extract and view the infrastructure name from the Ignition config file metadata, run the following command:

```
$ jq -r .infraID <installation_directory>/metadata.json 1
```

- 1 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

#### Example output

```
openshift-vw9j6 1
```

- 1 The output of this command is your cluster name and a random string.

## 18.7.15. Installing RHCOS and starting the OpenShift Container Platform bootstrap process

To install OpenShift Container Platform on user-provisioned infrastructure on VMware vSphere, you must install Red Hat Enterprise Linux CoreOS (RHCOS) on vSphere hosts. When you install RHCOS, you must provide the Ignition config file that was generated by the OpenShift Container Platform installation program for the type of machine you are installing. If you have configured suitable networking, DNS, and load balancing infrastructure, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS machines have rebooted.

### Prerequisites

- You have obtained the Ignition config files for your cluster.
- You have access to an HTTP server that you can access from your computer and that the machines that you create can access.
- You have created a [vSphere cluster](#).

### Procedure

1. Upload the bootstrap Ignition config file, which is named **<installation\_directory>/bootstrap.ign**, that the installation program created to your HTTP server. Note the URL of this file.
2. Save the following secondary Ignition config file for your bootstrap node to your computer as **<installation\_directory>/merge-bootstrap.ign**:

```
{
  "ignition": {
    "config": {
      "merge": [
        {
          "source": "<bootstrap_ignition_config_url>", 1
          "verification": {}
        }
      ]
    },
    "timeouts": {},
    "version": "3.2.0"
  },
  "networkd": {},
  "passwd": {},
  "storage": {},
  "systemd": {}
}
```

- 1 Specify the URL of the bootstrap Ignition config file that you hosted.

When you create the virtual machine (VM) for the bootstrap machine, you use this Ignition config file.

3. Locate the following Ignition config files that the installation program created:
  - **<installation\_directory>/master.ign**

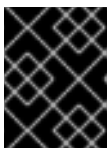


- `<installation_directory>/worker.ign`
  - `<installation_directory>/merge-bootstrap.ign`
4. Convert the Ignition config files to Base64 encoding. Later in this procedure, you must add these files to the extra configuration parameter **guestinfo.ignition.config.data** in your VM. For example, if you use a Linux operating system, you can use the **base64** command to encode the files.

```
$ base64 -w0 <installation_directory>/master.ign > <installation_directory>/master.64
```

```
$ base64 -w0 <installation_directory>/worker.ign > <installation_directory>/worker.64
```

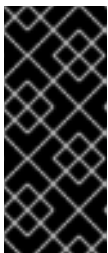
```
$ base64 -w0 <installation_directory>/merge-bootstrap.ign > <installation_directory>/merge-bootstrap.64
```



### IMPORTANT

If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

5. Obtain the RHCOS OVA image. Images are available from the [RHCOS image mirror](#) page.

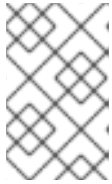


### IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download an image with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image version that matches your OpenShift Container Platform version if it is available.

The filename contains the OpenShift Container Platform version number in the format **rhcos-vmware.<architecture>.ova**.

6. In the vSphere Client, create a folder in your datacenter to store your VMs.
- a. Click the **VMs and Templates** view.
  - b. Right-click the name of your datacenter.
  - c. Click **New Folder** → **New VM and Template Folder**
  - d. In the window that is displayed, enter the folder name. If you did not specify an existing folder in the **install-config.yaml** file, then create a folder with the same name as the infrastructure ID. You use this folder name so vCenter dynamically provisions storage in the appropriate location for its Workspace configuration.
7. In the vSphere Client, create a template for the OVA image and then clone the template as needed.

**NOTE**

In the following steps, you create a template and then clone the template for all of your cluster machines. You then provide the location for the Ignition config file for that cloned machine type when you provision the VMs.

- a. From the **Hosts and Clusters** tab, right-click your cluster name and select **Deploy OVF Template**.
- b. On the **Select an OVF** tab, specify the name of the RHCOS OVA file that you downloaded.
- c. On the **Select a name and folder** tab, set a **Virtual machine name** for your template, such as **Template-RHCOS**. Click the name of your vSphere cluster and select the folder you created in the previous step.
- d. On the **Select a compute resource** tab, click the name of your vSphere cluster.
- e. On the **Select storage** tab, configure the storage options for your VM.
  - Select **Thin Provision** or **Thick Provision**, based on your storage preferences.
  - Select the datastore that you specified in your **install-config.yaml** file.
- f. On the **Select network** tab, specify the network that you configured for the cluster, if available.
- g. When creating the OVF template, do not specify values on the **Customize template** tab or configure the template any further.

**IMPORTANT**

Do not start the original VM template. The VM template must remain off and must be cloned for new RHCOS machines. Starting the VM template configures the VM template as a VM on the platform, which prevents it from being used as a template that machine sets can apply configurations to.

8. Optional: Update the configured virtual hardware version in the VM template, if necessary. Follow [Upgrading a virtual machine to the latest hardware version](#) in the VMware documentation for more information.

**IMPORTANT**

It is recommended that you update the hardware version of the VM template to version 15 before creating VMs from it, if necessary. Using hardware version 13 for your cluster nodes running on vSphere is now deprecated. If your imported template defaults to hardware version 13, you must ensure that your ESXi host is on 6.7U3 or later before upgrading the VM template to hardware version 15. If your vSphere version is less than 6.7U3, you can skip this upgrade step; however, a future version of OpenShift Container Platform is scheduled to remove support for hardware version 13 and vSphere versions less than 6.7U3.

9. After the template deploys, deploy a VM for a machine in the cluster.
  - a. Right-click the template name and click **Clone** → **Clone to Virtual Machine**

- b. On the **Select a name and folder** tab, specify a name for the VM. You might include the machine type in the name, such as **control-plane-0** or **compute-1**.
- c. On the **Select a name and folder** tab, select the name of the folder that you created for the cluster.
- d. On the **Select a compute resource** tab, select the name of a host in your datacenter.
- e. Optional: On the **Select storage** tab, customize the storage options.
- f. On the **Select clone options**, select **Customize this virtual machine's hardware**.
- g. On the **Customize hardware** tab, click **VM Options** → **Advanced**.
  - Optional: Override default DHCP networking in vSphere. To enable static IP networking:

- i. Set your static IP configuration:

```
$ export IPCFG="ip=<ip>::<gateway>:<netmask>:<hostname>:<iface>:none
nameserver=svr1 [nameserver=svr2 [nameserver=svr3 [...]]]"
```

#### Example command

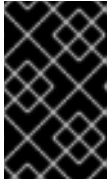
```
$ export IPCFG="ip=192.168.100.101::192.168.100.254:255.255.255.0::none
nameserver=8.8.8.8"
```

- ii. Set the **guestinfo.afterburn.initrd.network-kargs** property before booting a VM from an OVA in vSphere:

```
$ govc vm.change -vm "<vm_name>" -e "guestinfo.afterburn.initrd.network-
kargs=${IPCFG}"
```

- Optional: In the event of cluster performance issues, from the **Latency Sensitivity** list, select **High**. Ensure that your VM's CPU and memory reservation have the following values:
  - Memory reservation value must be equal to its configured memory size.
  - CPU reservation value must be at least the number of low latency virtual CPUs multiplied by the measured physical CPU speed.
- Click **Edit Configuration**, and on the **Configuration Parameters** window, search the list of available parameters for steal clock accounting (**stealclock.enable**). If it is available, set its value to **TRUE**. Enabling steal clock accounting can help with troubleshooting cluster issues.
- Click **Add Configuration Params**. Define the following parameter names and values:
  - **guestinfo.ignition.config.data**: Locate the base-64 encoded files that you created previously in this procedure, and paste the contents of the base64-encoded Ignition config file for this machine type.
  - **guestinfo.ignition.config.data.encoding**: Specify **base64**.
  - **disk.EnableUUID**: Specify **TRUE**.

- **stealclock.enable**: If this parameter was not defined, add it and specify **TRUE**.
- h. In the **Virtual Hardware** panel of the **Customize hardware** tab, modify the specified values as required. Ensure that the amount of RAM, CPU, and disk storage meets the minimum requirements for the machine type.
  - i. Complete the configuration and power on the VM.
10. Create the rest of the machines for your cluster by following the preceding steps for each machine.



### IMPORTANT

You must create the bootstrap and control plane machines at this time. Because some pods are deployed on compute machines by default, also create at least two compute machines before you install the cluster.

## 18.7.16. Adding more compute machines to a cluster in vSphere

You can add more compute machines to a user-provisioned OpenShift Container Platform cluster on VMware vSphere.

### Prerequisites

- Obtain the base64-encoded Ignition file for your compute machines.
- You have access to the vSphere template that you created for your cluster.

### Procedure

1. After the template deploys, deploy a VM for a machine in the cluster.
  - a. Right-click the template's name and click **Clone** → **Clone to Virtual Machine**
  - b. On the **Select a name and folder** tab, specify a name for the VM. You might include the machine type in the name, such as **compute-1**.
  - c. On the **Select a name and folder** tab, select the name of the folder that you created for the cluster.
  - d. On the **Select a compute resource** tab, select the name of a host in your datacenter.
  - e. Optional: On the **Select storage** tab, customize the storage options.
  - f. On the **Select clone options**, select **Customize this virtual machine's hardware**
  - g. On the **Customize hardware** tab, click **VM Options** → **Advanced**.
    - From the **Latency Sensitivity** list, select **High**.
    - Click **Edit Configuration**, and on the **Configuration Parameters** window, click **Add Configuration Params**. Define the following parameter names and values:
      - **guestinfo.ignition.config.data**: Paste the contents of the base64-encoded compute Ignition config file for this machine type.

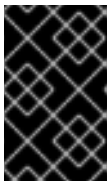
- **guestinfo.ignition.config.data.encoding**: Specify **base64**.
  - **disk.EnableUUID**: Specify **TRUE**.
- h. In the **Virtual Hardware** panel of the **Customize hardware** tab, modify the specified values as required. Ensure that the amount of RAM, CPU, and disk storage meets the minimum requirements for the machine type. Also, make sure to select the correct network under **Add network adapter** if there are multiple networks available.
  - i. Complete the configuration and power on the VM.
2. Continue to create more compute machines for your cluster.

### 18.7.17. Disk partitioning

In most cases, data partitions are originally created by installing RHCOS, rather than by installing another operating system. In such cases, the OpenShift Container Platform installer should be allowed to configure your disk partitions.

However, there are two cases where you might want to intervene to override the default partitioning when installing an OpenShift Container Platform node:

- **Create separate partitions**: For greenfield installations on an empty disk, you might want to add separate storage to a partition. This is officially supported for making **/var** or a subdirectory of **/var**, such as **/var/lib/etcd**, a separate partition, but not both.



#### IMPORTANT

For disk sizes larger than 100GB, and especially disk sizes larger than 1TB, create a separate **/var** partition. See "Creating a separate **/var** partition" and this [Red Hat Knowledgebase article](#) for more information.



#### IMPORTANT

Kubernetes supports only two file system partitions. If you add more than one partition to the original configuration, Kubernetes cannot monitor all of them.

- **Retain existing partitions**: For a brownfield installation where you are reinstalling OpenShift Container Platform on an existing node and want to retain data partitions installed from your previous operating system, there are both boot arguments and options to **coreos-installer** that allow you to retain existing data partitions.

### Creating a separate **/var** partition

In general, disk partitioning for OpenShift Container Platform should be left to the installer. However, there are cases where you might want to create separate partitions in a part of the filesystem that you expect to grow.

OpenShift Container Platform supports the addition of a single partition to attach storage to either the **/var** partition or a subdirectory of **/var**. For example:

- **/var/lib/containers**: Holds container-related content that can grow as more images and containers are added to a system.
- **/var/lib/etcd**: Holds data that you might want to keep separate for purposes such as performance optimization of etcd storage.

- **/var**: Holds data that you might want to keep separate for purposes such as auditing.



## IMPORTANT

For disk sizes larger than 100GB, and especially larger than 1TB, create a separate **/var** partition.

Storing the contents of a **/var** directory separately makes it easier to grow storage for those areas as needed and reinstall OpenShift Container Platform at a later date and keep that data intact. With this method, you will not have to pull all your containers again, nor will you have to copy massive log files when you update systems.

Because **/var** must be in place before a fresh installation of Red Hat Enterprise Linux CoreOS (RHCOS), the following procedure sets up the separate **/var** partition by creating a machine config manifest that is inserted during the **openshift-install** preparation phases of an OpenShift Container Platform installation.

### Procedure

1. Create a directory to hold the OpenShift Container Platform installation files:

```
$ mkdir $HOME/clusterconfig
```

2. Run **openshift-install** to create a set of files in the **manifest** and **openshift** subdirectories. Answer the system questions as you are prompted:

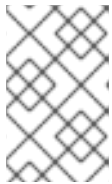
```
$ openshift-install create manifests --dir $HOME/clusterconfig
? SSH Public Key ...
$ ls $HOME/clusterconfig/openshift/
99_kubeadmin-password-secret.yaml
99_openshift-cluster-api_master-machines-0.yaml
99_openshift-cluster-api_master-machines-1.yaml
99_openshift-cluster-api_master-machines-2.yaml
...
```

3. Create a Butane config that configures the additional partition. For example, name the file **`$HOME/clusterconfig/98-var-partition.bu`**, change the disk device name to the name of the storage device on the **worker** systems, and set the storage size as appropriate. This example places the **/var** directory on a separate partition:

```
variant: openshift
version: 4.9.0
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 98-var-partition
storage:
  disks:
    - device: /dev/<device_name> 1
      partitions:
        - label: var
          start_mib: <partition_start_offset> 2
          size_mib: <partition_size> 3
  filesystems:
```

```
- device: /dev/disk/by-partlabel/var
  path: /var
  format: xfs
  mount_options: [defaults, prjquota] 4
  with_mount_unit: true
```

- 1 The storage device name of the disk that you want to partition.
- 2 When adding a data partition to the boot disk, a minimum value of 25000 mebibytes is recommended. The root file system is automatically resized to fill all available space up to the specified offset. If no value is specified, or if the specified value is smaller than the recommended minimum, the resulting root file system will be too small, and future reinstalls of RHCOS might overwrite the beginning of the data partition.
- 3 The size of the data partition in mebibytes.
- 4 The **prjquota** mount option must be enabled for filesystems used for container storage.



#### NOTE

When creating a separate **/var** partition, you cannot use different instance types for worker nodes, if the different instance types do not have the same device name.

4. Create a manifest from the Butane config and save it to the **clusterconfig/openshift** directory. For example, run the following command:

```
$ butane $HOME/clusterconfig/98-var-partition.bu -o $HOME/clusterconfig/openshift/98-var-partition.yaml
```

5. Run **openshift-install** again to create Ignition configs from a set of files in the **manifest** and **openshift** subdirectories:

```
$ openshift-install create ignition-configs --dir $HOME/clusterconfig
$ ls $HOME/clusterconfig/
auth bootstrap.ign master.ign metadata.json worker.ign
```

Now you can use the Ignition config files as input to the vSphere installation procedures to install Red Hat Enterprise Linux CoreOS (RHCOS) systems.

### 18.7.18. Updating the bootloader using bootupd

To update the bootloader by using **bootupd**, you must either install **bootupd** on RHCOS machines manually or provide a machine config with the enabled **systemd** unit. Unlike **grubby** or other bootloader tools, **bootupd** does not manage kernel space configuration such as passing kernel arguments.

After you have installed **bootupd**, you can manage it remotely from the OpenShift Container Platform cluster.



## NOTE

It is recommended that you use **bootupd** only on bare metal or virtualized hypervisor installations, such as for protection against the BootHole vulnerability.

## Manual install method

You can manually install **bootupd** by using the **bootctl** command-line tool.

1. Inspect the system status:

```
# bootupctl status
```

### Example output

```
Component EFI
Installed: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
Update: At latest version
```

2. RHCOS images created without **bootupd** installed on them require an explicit adoption phase. If the system status is **Adoptable**, perform the adoption:

```
# bootupctl adopt-and-update
```

### Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

3. If an update is available, apply the update so that the changes take effect on the next reboot:

```
# bootupctl update
```

### Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

## Machine config method

Another way to enable **bootupd** is by providing a machine config.

- Provide a machine config file with the enabled **systemd** unit, as shown in the following example:

### Example output

```
variant: rhcos
version: 1.1.0
systemd:
units:
- name: custom-bootupd-auto.service
  enabled: true
  contents: |
    [Unit]
    Description=Bootupd automatic update
```



```
[Service]
ExecStart=/usr/bin/bootupctl update
RemainAfterExit=yes
```

```
[Install]
WantedBy=multi-user.target
```

### 18.7.19. Waiting for the bootstrap process to complete

The OpenShift Container Platform bootstrap process begins after the cluster nodes first boot into the persistent RHCOS environment that has been installed to disk. The configuration information provided through the Ignition config files is used to initialize the bootstrap process and install OpenShift Container Platform on the machines. You must wait for the bootstrap process to complete.

#### Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have obtained the installation program and generated the Ignition config files for your cluster.
- You installed RHCOS on your cluster machines and provided the Ignition config files that the OpenShift Container Platform installation program generated.
- Your machines have direct internet access or have an HTTP or HTTPS proxy available.

#### Procedure

1. Monitor the bootstrap process:

```
$ ./openshift-install --dir <installation_directory> wait-for bootstrap-complete \ 1
--log-level=info 2
```

- 1 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

- 2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

#### Example output

```
INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...
INFO API v1.22.1 up
INFO Waiting up to 30m0s for bootstrapping to complete...
INFO It is now safe to remove the bootstrap resources
```

The command succeeds when the Kubernetes API server signals that it has been bootstrapped on the control plane machines.

2. After bootstrap process is complete, remove the bootstrap machine from the load balancer.



## IMPORTANT

You must remove the bootstrap machine from the load balancer at this point. You can also remove or reformat the bootstrap machine itself.

### 18.7.20. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

#### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

#### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

#### Example output

```
system:admin
```

### 18.7.21. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

#### Prerequisites

- You added machines to your cluster.

#### Procedure

1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

#### Example output

NAME	STATUS	ROLES	AGE	VERSION
master-0	Ready	master	63m	v1.22.1
master-1	Ready	master	63m	v1.22.1
master-2	Ready	master	64m	v1.22.1

The output lists all of the machines that you created.



#### NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

- Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

#### Example output

NAME	AGE	REQUESTOR	CONDITION
csr-8b2br	15m	system:serviceaccount:openshift-machine-config-operator:node-bootstrapper	Pending
csr-8vnps	15m	system:serviceaccount:openshift-machine-config-operator:node-bootstrapper	Pending
...			

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

- If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:



#### NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.

**NOTE**

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrap** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{\n"}\n{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```

**NOTE**

Some Operators might not become available until some CSRs are approved.

4. Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

**Example output**

```
NAME      AGE   REQUESTOR                                     CONDITION
csr-bfd72 5m26s system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv 5m26s system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

5. If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

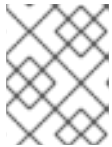
```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{\n"}\n{{end}}\n' | xargs oc adm certificate approve
```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

### Example output

```
NAME      STATUS  ROLES  AGE  VERSION
master-0  Ready   master 73m  v1.22.1
master-1  Ready   master 73m  v1.22.1
master-2  Ready   master 74m  v1.22.1
worker-0  Ready   worker 11m  v1.22.1
worker-1  Ready   worker 11m  v1.22.1
```



### NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

### Additional information

- For more information on CSRs, see [Certificate Signing Requests](#).

## 18.7.22. Initial Operator configuration

After the control plane initializes, you must immediately configure some Operators so that they all become available.

### Prerequisites

- Your control plane has initialized.

### Procedure

1. Watch the cluster components come online:

```
$ watch -n5 oc get clusteroperators
```

### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
authentication	4.9.0	True	False	False	19m
baremetal	4.9.0	True	False	False	37m
cloud-credential	4.9.0	True	False	False	40m
cluster-autoscaler	4.9.0	True	False	False	37m
config-operator	4.9.0	True	False	False	38m

console	4.9.0	True	False	False	26m
csi-snapshot-controller	4.9.0	True	False	False	37m
dns	4.9.0	True	False	False	37m
etcd	4.9.0	True	False	False	36m
image-registry	4.9.0	True	False	False	31m
ingress	4.9.0	True	False	False	30m
insights	4.9.0	True	False	False	31m
kube-apiserver	4.9.0	True	False	False	26m
kube-controller-manager	4.9.0	True	False	False	36m
kube-scheduler	4.9.0	True	False	False	36m
kube-storage-version-migrator	4.9.0	True	False	False	37m
machine-api	4.9.0	True	False	False	29m
machine-approver	4.9.0	True	False	False	37m
machine-config	4.9.0	True	False	False	36m
marketplace	4.9.0	True	False	False	37m
monitoring	4.9.0	True	False	False	29m
network	4.9.0	True	False	False	38m
node-tuning	4.9.0	True	False	False	37m
openshift-apiserver	4.9.0	True	False	False	32m
openshift-controller-manager	4.9.0	True	False	False	30m
openshift-samples	4.9.0	True	False	False	32m
operator-lifecycle-manager	4.9.0	True	False	False	37m
operator-lifecycle-manager-catalog	4.9.0	True	False	False	37m
operator-lifecycle-manager-packageserver	4.9.0	True	False	False	32m
service-ca	4.9.0	True	False	False	38m
storage	4.9.0	True	False	False	37m

2. Configure the Operators that are not available.

### 18.7.22.1. Image registry removed during installation

On platforms that do not provide shareable object storage, the OpenShift Image Registry Operator bootstraps itself as **Removed**. This allows **openshift-installer** to complete installations on these platform types.

After installation, you must edit the Image Registry Operator configuration to switch the **managementState** from **Removed** to **Managed**.



#### NOTE

The Prometheus console provides an **ImageRegistryRemoved** alert, for example:

"Image Registry has been removed. **ImageStreamTags**, **BuildConfigs** and **DeploymentConfigs** which reference **ImageStreamTags** may not work as expected. Please configure storage and update the config to **Managed** state by editing `configs.imageregistry.operator.openshift.io`."

### 18.7.22.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

### 18.7.22.2.1. Configuring block registry storage for VMware vSphere

To allow the image registry to use block storage types such as vSphere Virtual Machine Disk (VMDK) during upgrades as a cluster administrator, you can use the **Recreate** rollout strategy.



#### IMPORTANT

Block storage volumes are supported but not recommended for use with image registry on production clusters. An installation where the registry is configured on block storage is not highly available because the registry cannot have more than one replica.

#### Procedure

1. To set the image registry storage as a block storage type, patch the registry so that it uses the **Recreate** rollout strategy and runs with only **1** replica:

```
$ oc patch config.imageregistry.operator.openshift.io/cluster --type=merge -p '{"spec": {"rolloutStrategy": "Recreate", "replicas": 1}}'
```

2. Provision the PV for the block storage device, and create a PVC for that volume. The requested block volume uses the ReadWriteOnce (RWO) access mode.
  - a. Create a **pvc.yaml** file with the following contents to define a VMware vSphere **PersistentVolumeClaim** object:

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: image-registry-storage 1
  namespace: openshift-image-registry 2
spec:
  accessModes:
    - ReadWriteOnce 3
  resources:
    requests:
      storage: 100Gi 4
```

- 1 A unique name that represents the **PersistentVolumeClaim** object.
- 2 The namespace for the **PersistentVolumeClaim** object, which is **openshift-image-registry**.
- 3 The access mode of the persistent volume claim. With **ReadWriteOnce**, the volume can be mounted with read and write permissions by a single node.
- 4 The size of the persistent volume claim.

- b. Create the **PersistentVolumeClaim** object from the file:

```
$ oc create -f pvc.yaml -n openshift-image-registry
```

3. Edit the registry configuration so that it references the correct PVC:

```
$ oc edit config.imageregistry.operator.openshift.io -o yaml
```

### Example output

```
storage:
  pvc:
    claim: 1
```

- 1 Creating a custom PVC allows you to leave the **claim** field blank for the default automatic creation of an **image-registry-storage** PVC.

For instructions about configuring registry storage so that it references the correct PVC, see [Configuring the registry for vSphere](#).

## 18.7.23. Completing installation on user-provisioned infrastructure

After you complete the Operator configuration, you can finish installing the cluster on infrastructure that you provide.

### Prerequisites

- Your control plane has initialized.
- You have completed the initial Operator configuration.

### Procedure

1. Confirm that all the cluster components are online with the following command:

```
$ watch -n5 oc get clusteroperators
```

### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
authentication	4.9.0	True	False	False	19m
baremetal	4.9.0	True	False	False	37m
cloud-credential	4.9.0	True	False	False	40m
cluster-autoscaler	4.9.0	True	False	False	37m
config-operator	4.9.0	True	False	False	38m
console	4.9.0	True	False	False	26m
csi-snapshot-controller	4.9.0	True	False	False	37m
dns	4.9.0	True	False	False	37m
etcd	4.9.0	True	False	False	36m
image-registry	4.9.0	True	False	False	31m
ingress	4.9.0	True	False	False	30m



insights	4.9.0	True	False	False	31m
kube-apiserver	4.9.0	True	False	False	26m
kube-controller-manager	4.9.0	True	False	False	36m
kube-scheduler	4.9.0	True	False	False	36m
kube-storage-version-migrator	4.9.0	True	False	False	37m
machine-api	4.9.0	True	False	False	29m
machine-approver	4.9.0	True	False	False	37m
machine-config	4.9.0	True	False	False	36m
marketplace	4.9.0	True	False	False	37m
monitoring	4.9.0	True	False	False	29m
network	4.9.0	True	False	False	38m
node-tuning	4.9.0	True	False	False	37m
openshift-apiserver	4.9.0	True	False	False	32m
openshift-controller-manager	4.9.0	True	False	False	30m
openshift-samples	4.9.0	True	False	False	32m
operator-lifecycle-manager	4.9.0	True	False	False	37m
operator-lifecycle-manager-catalog	4.9.0	True	False	False	37m
operator-lifecycle-manager-packageserver	4.9.0	True	False	False	32m
service-ca	4.9.0	True	False	False	38m
storage	4.9.0	True	False	False	37m

Alternatively, the following command notifies you when all of the clusters are available. It also retrieves and displays credentials:

```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

### Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

The command succeeds when the Cluster Version Operator finishes deploying the OpenShift Container Platform cluster from Kubernetes API server.

### IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Confirm that the Kubernetes API server is communicating with the pods.

a. To view a list of all pods, use the following command:

```
$ oc get pods --all-namespaces
```

#### Example output

```

NAMESPACE           NAME                                     READY  STATUS
RESTARTS  AGE
openshift-apiserver-operator  openshift-apiserver-operator-85cb746d55-zqhs8  1/1
Running   1    9m
openshift-apiserver          apiserver-67b9g                                1/1  Running  0
3m
openshift-apiserver          apiserver-ljcmx                                1/1  Running  0
1m
openshift-apiserver          apiserver-z25h4                                1/1  Running  0
2m
openshift-authentication-operator  authentication-operator-69d5d8bf84-vh2n8    1/1
Running   0    5m
...

```

b. View the logs for a pod that is listed in the output of the previous command by using the following command:

```
$ oc logs <pod_name> -n <namespace> 1
```

**1** Specify the pod name and namespace, as shown in the output of the previous command.

If the pod logs display, the Kubernetes API server can communicate with the cluster machines.

3. For an installation with Fibre Channel Protocol (FCP), additional steps are required to enable multipathing. Do not enable multipathing during installation. See "Enabling multipathing with kernel arguments on RHCOS" in the *Post-installation machine configuration tasks* documentation for more information.

You can add extra compute machines after the cluster installation is completed by following [Adding compute machines to vSphere](#).

### 18.7.24. Backing up VMware vSphere volumes

OpenShift Container Platform provisions new volumes as independent persistent disks to freely attach and detach the volume on any node in the cluster. As a consequence, it is not possible to back up volumes that use snapshots, or to restore volumes from snapshots. See [Snapshot Limitations](#) for more information.

#### Procedure

To create a backup of persistent volumes:

1. Stop the application that is using the persistent volume.

2. Clone the persistent volume.
3. Restart the application.
4. Create a backup of the cloned volume.
5. Delete the cloned volume.

### 18.7.25. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

#### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

### 18.7.26. Next steps

- [Customize your cluster](#).
- If necessary, you can [opt out of remote health reporting](#) .
- [Set up your registry and configure registry storage](#) .
- Optional: [View the events from the vSphere Problem Detector Operator](#) to determine if the cluster has permission or storage configuration issues.

## 18.8. INSTALLING A CLUSTER ON VMC IN A RESTRICTED NETWORK WITH USER-PROVISIONED INFRASTRUCTURE

In OpenShift Container Platform version 4.9, you can install a cluster on VMware vSphere infrastructure that you provision in a restricted network by deploying it to [VMware Cloud \(VMC\) on AWS](#).

Once you configure your VMC environment for OpenShift Container Platform deployment, you use the OpenShift Container Platform installation program from the bastion management host, co-located in the VMC environment. The installation program and control plane automates the process of deploying and managing the resources needed for the OpenShift Container Platform cluster.

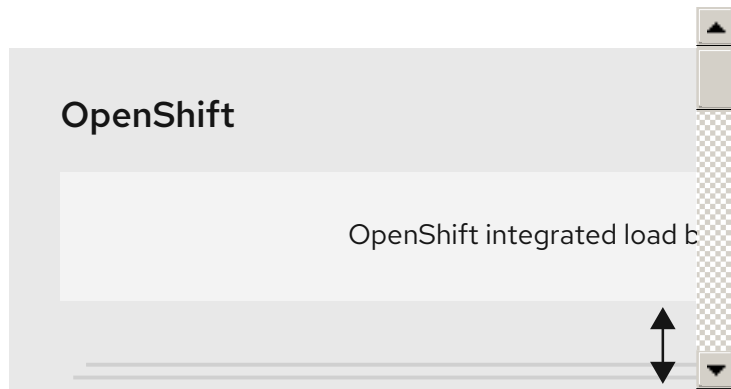


#### NOTE

OpenShift Container Platform supports deploying a cluster to a single VMware vCenter only. Deploying a cluster with machines/machine sets on multiple vCenters is not supported.

### 18.8.1. Setting up VMC for vSphere

You can install OpenShift Container Platform on VMware Cloud (VMC) on AWS hosted vSphere clusters to enable applications to be deployed and managed both on-premise and off-premise, across the hybrid cloud.



You must configure several options in your VMC environment prior to installing OpenShift Container Platform on VMware vSphere. Ensure your VMC environment has the following prerequisites:

- Create a non-exclusive, DHCP-enabled, NSX-T network segment and subnet. Other virtual machines (VMs) can be hosted on the subnet, but at least eight IP addresses must be available for the OpenShift Container Platform deployment.
- Configure the following firewall rules:
  - An ANY:ANY firewall rule between the installation host and the software-defined data center (SDDC) management network on port 443. This allows you to upload the Red Hat Enterprise Linux CoreOS (RHCOS) OVA during deployment.
  - An HTTPS firewall rule between the OpenShift Container Platform compute network and vCenter. This connection allows OpenShift Container Platform to communicate with vCenter for provisioning and managing nodes, persistent volume claims (PVCs), and other resources.
- You must have the following information to deploy OpenShift Container Platform:
  - The OpenShift Container Platform cluster name, such as **vmc-prod-1**.
  - The base DNS name, such as **companyname.com**.
  - If not using the default, the pod network CIDR and services network CIDR must be identified, which are set by default to **10.128.0.0/14** and **172.30.0.0/16**, respectively. These CIDRs are used for pod-to-pod and pod-to-service communication and are not accessible externally; however, they must not overlap with existing subnets in your organization.
  - The following vCenter information:
    - vCenter hostname, username, and password
    - Datacenter name, such as **SDDC-Datacenter**
    - Cluster name, such as **Cluster-1**
    - Network name
    - Datastore name, such as **WorkloadDatastore**

**NOTE**

It is recommended to move your vSphere cluster to the VMC **Compute-ResourcePool** resource pool after your cluster installation is finished.

- A Linux-based host deployed to VMC as a bastion.
  - The bastion host can be Red Hat Enterprise Linux (RHEL) or any another Linux-based host; it must have internet connectivity and the ability to upload an OVA to the ESXi hosts.
  - Download and install the OpenShift CLI tools to the bastion host.
    - The **openshift-install** installation program
    - The OpenShift CLI (**oc**) tool

**NOTE**

You cannot use the VMware NSX Container Plugin for Kubernetes (NCP), and NSX is not used as the OpenShift SDN. The version of NSX currently available with VMC is incompatible with the version of NCP certified with OpenShift Container Platform.

However, the NSX DHCP service is used for virtual machine IP management with the full-stack automated OpenShift Container Platform deployment and with nodes provisioned, either manually or automatically, by the Machine API integration with vSphere. Additionally, NSX firewall rules are created to enable access with the OpenShift Container Platform cluster and between the bastion host and the VMC vSphere hosts.

**18.8.1.1. VMC Sizer tool**

VMware Cloud on AWS is built on top of AWS bare metal infrastructure; this is the same bare metal infrastructure which runs AWS native services. When a VMware cloud on AWS software-defined data center (SDDC) is deployed, you consume these physical server nodes and run the VMware ESXi hypervisor in a single tenant fashion. This means the physical infrastructure is not accessible to anyone else using VMC. It is important to consider how many physical hosts you will need to host your virtual infrastructure.

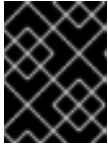
To determine this, VMware provides the [VMC on AWS Sizer](#). With this tool, you can define the resources you intend to host on VMC:

- Types of workloads
- Total number of virtual machines
- Specification information such as:
  - Storage requirements
  - vCPUs
  - vRAM
  - Overcommit ratios

With these details, the sizer tool can generate a report, based on VMware best practices, and recommend your cluster configuration and the number of hosts you will need.

## 18.8.2. vSphere prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You [created a registry on your mirror host](#) and obtain the **imageContentSources** data for your version of OpenShift Container Platform.



### IMPORTANT

Because the installation media is on the mirror host, you can use that computer to complete all installation steps.

- You provisioned [block registry storage](#). For more information on persistent storage, see [Understanding persistent storage](#).
- If you use a firewall and plan to use the Telemetry service, you [configured the firewall to allow the sites](#) that your cluster requires access to.



### NOTE

Be sure to also review this site list if you are configuring a proxy.

## 18.8.3. About installations in restricted networks

In OpenShift Container Platform 4.9, you can perform an installation that does not require an active connection to the internet to obtain software components. Restricted network installations can be completed using installer-provisioned infrastructure or user-provisioned infrastructure, depending on the cloud platform to which you are installing the cluster.

If you choose to perform a restricted network installation on a cloud platform, you still require access to its cloud APIs. Some cloud functions, like Amazon Web Service's Route 53 DNS and IAM services, require internet access. Depending on your network, you might require less internet access for an installation on bare metal hardware or on VMware vSphere.

To complete a restricted network installation, you must create a registry that mirrors the contents of the OpenShift Container Platform registry and contains the installation media. You can create this registry on a mirror host, which can access both the internet and your closed network, or by using other methods that meet your restrictions.



### IMPORTANT

Because of the complexity of the configuration for user-provisioned installations, consider completing a standard user-provisioned infrastructure installation before you attempt a restricted network installation using user-provisioned infrastructure. Completing this test installation might make it easier to isolate and troubleshoot any issues that might arise during your installation in a restricted network.

### 18.8.3.1. Additional limits

Clusters in restricted networks have the following additional limitations and restrictions:

- The **ClusterVersion** status includes an **Unable to retrieve available updates** error.
- By default, you cannot use the contents of the Developer Catalog because you cannot access the required image stream tags.

#### 18.8.4. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to obtain the images that are necessary to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



#### IMPORTANT

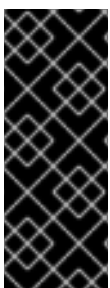
If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

#### 18.8.5. VMware vSphere infrastructure requirements

You must install the OpenShift Container Platform cluster on a VMware vSphere version 6 or 7 instance that meets the requirements for the components that you use.

**Table 18.74. Version requirements for vSphere virtual environments**

Virtual environment product	Required version
VM hardware version	13 or later
vSphere ESXi hosts	6.5 or later
vCenter host	6.5 or later



#### IMPORTANT

Installing a cluster on VMware vSphere version 6.7U2 or earlier and virtual hardware version 13 is now deprecated. These versions are still fully supported, but support will be removed in a future version of OpenShift Container Platform. Hardware version 15 is now the default for vSphere virtual machines in OpenShift Container Platform. To update the hardware version for your vSphere nodes, see the "Updating hardware on nodes running in vSphere" article.

**Table 18.75. Minimum supported vSphere version for VMware components**

Component	Minimum supported versions	Description
Hypervisor	vSphere 6.5 and later with HW version 13	This version is the minimum version that Red Hat Enterprise Linux CoreOS (RHCOS) supports. See the <a href="#">Red Hat Enterprise Linux 8 supported hypervisors list</a> .
Storage with in-tree drivers	vSphere 6.5 and later	This plugin creates vSphere storage by using the in-tree storage drivers for vSphere included in OpenShift Container Platform.

If you use a vSphere version 6.5 instance, consider upgrading to 6.7U3 or 7.0 before you install OpenShift Container Platform.

**IMPORTANT**

You must ensure that the time on your ESXi hosts is synchronized before you install OpenShift Container Platform. See [Edit Time Configuration for a Host](#) in the VMware documentation.

**Additional resources**

- To update the hardware version for your vSphere nodes, see [Updating hardware on nodes running in vSphere](#).

**18.8.6. Requirements for a cluster with user-provisioned infrastructure**

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

**18.8.6.1. Required machines for cluster installation**

The smallest OpenShift Container Platform clusters require the following hosts:

**Table 18.76. Minimum required hosts**

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.



Hosts	Description
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.



### IMPORTANT

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 7.9, or RHEL 8.4.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See [Red Hat Enterprise Linux technology capabilities and limits](#).

#### 18.8.6.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

**Table 18.77. Minimum resource requirements**

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 7.9, or RHEL 8.4 [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio:  $(\text{threads per core} \times \text{cores}) \times \text{sockets} = \text{vCPUs}$ .
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks.

Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.

### 18.8.6.3. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

### 18.8.6.4. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.

It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.



#### NOTE

If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

#### 18.8.6.4.1. Setting the cluster node hostnames through DHCP

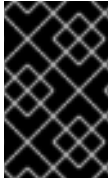
On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

### 18.8.6.4.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.



#### IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

**Table 18.78. Ports used for all-machine to all-machine communications**

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	<b>1936</b>	Metrics
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> and the Cluster Version Operator on port <b>9099</b> .
	<b>10250-10259</b>	The default ports that Kubernetes reserves
	<b>10256</b>	openshift-sdn
UDP	<b>4789</b>	VXLAN and Geneve
	<b>6081</b>	VXLAN and Geneve
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> .
	<b>500</b>	IPsec IKE packets
	<b>4500</b>	IPsec NAT-T packets
TCP/UDP	<b>30000-32767</b>	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

**Table 18.79. Ports used for all-machine to control plane communications**

Protocol	Port	Description
TCP	<b>6443</b>	Kubernetes API

**Table 18.80. Ports used for control plane machine to control plane machine communications**

Protocol	Port	Description
TCP	<b>2379-2380</b>	etcd server and peer ports

**NTP configuration for user-provisioned infrastructure**

OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service*.

If a DHCP server provides NTP server information, the chrony time service on the Red Hat Enterprise Linux CoreOS (RHCOS) machines read the information and can sync the clock with the NTP servers.

**18.8.6.5. User-provisioned DNS requirements**

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API
- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines

Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.


**NOTE**

It is recommended to use a DHCP server to provide the hostnames to each cluster node. See the *DHCP recommendations for user-provisioned infrastructure* section for more information.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, **<cluster\_name>** is the cluster name and **<base\_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster\_name>.<base\_domain>.**

**Table 18.81. Required DNS records**

Component	Record	Description
-----------	--------	-------------

Component	Record	Description
Kubernetes API	<b>api.&lt;cluster_name&gt;.&lt;base_domain&gt;</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
	<b>api-int.&lt;cluster_name&gt;.&lt;base_domain&gt;</b>	<p>A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster.</p> <div style="display: flex; align-items: flex-start;">  <div> <p><b>IMPORTANT</b></p> <p>The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.</p> </div> </div>
Routes	<b>*.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;</b>	<p>A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.</p> <p>For example, <b>console-openshift-console.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;</b> is used as a wildcard route to the OpenShift Container Platform console.</p>
Bootstrap machine	<b>bootstrap.&lt;cluster_name&gt;.&lt;base_domain&gt;</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.
Control plane machines	<b>&lt;master&gt;&lt;n&gt;.&lt;cluster_name&gt;.&lt;base_domain&gt;</b>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.
Compute machines	<b>&lt;worker&gt;&lt;n&gt;.&lt;cluster_name&gt;.&lt;base_domain&gt;</b>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.



#### NOTE

In OpenShift Container Platform 4.4 and later, you do not need to specify etcd host and SRV records in your DNS configuration.

**TIP**

You can use the **dig** command to verify name and reverse name resolution. See the section on *Validating DNS resolution for user-provisioned infrastructure* for detailed validation steps.

**18.8.6.5.1. Example DNS configuration for user-provisioned clusters**

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is **ocp4** and the base domain is **example.com**.

**Example DNS A record configuration for a user-provisioned cluster**

The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

**Example 18.19. Sample DNS zone database**

```
$TTL 1W
@ IN SOA ns1.example.com. root (
    2019070700 ; serial
    3H ; refresh (3 hours)
    30M ; retry (30 minutes)
    2W ; expiry (2 weeks)
    1W ) ; minimum (1 week)
IN NS ns1.example.com.
IN MX 10 smtp.example.com.
;
;
ns1.example.com. IN A 192.168.1.5
smtp.example.com. IN A 192.168.1.5
;
helper.example.com. IN A 192.168.1.5
helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com. IN A 192.168.1.5 1
api-int.ocp4.example.com. IN A 192.168.1.5 2
;
*.apps.ocp4.example.com. IN A 192.168.1.5 3
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 4
;
master0.ocp4.example.com. IN A 192.168.1.97 5
master1.ocp4.example.com. IN A 192.168.1.98 6
master2.ocp4.example.com. IN A 192.168.1.99 7
;
worker0.ocp4.example.com. IN A 192.168.1.11 8
worker1.ocp4.example.com. IN A 192.168.1.7 9
;
;EOF
```

- 1 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.

- 2 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.
- 3 Provides name resolution for the wildcard routes. The record refers to the IP address of the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



#### NOTE

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

- 4 Provides name resolution for the bootstrap machine.
- 5 6 7 Provides name resolution for the control plane machines.
- 8 9 Provides name resolution for the compute machines.

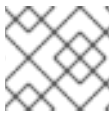
### Example DNS PTR record configuration for a user-provisioned cluster

The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

#### Example 18.20. Sample DNS zone database for reverse records

```
$TTL 1W
@ IN SOA ns1.example.com. root (
  2019070700 ; serial
  3H ; refresh (3 hours)
  30M ; retry (30 minutes)
  2W ; expiry (2 weeks)
  1W ) ; minimum (1 week)
IN NS ns1.example.com.
;
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. 2
;
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. 3
;
97.1.168.192.in-addr.arpa. IN PTR master0.ocp4.example.com. 4
98.1.168.192.in-addr.arpa. IN PTR master1.ocp4.example.com. 5
99.1.168.192.in-addr.arpa. IN PTR master2.ocp4.example.com. 6
;
11.1.168.192.in-addr.arpa. IN PTR worker0.ocp4.example.com. 7
7.1.168.192.in-addr.arpa. IN PTR worker1.ocp4.example.com. 8
;
;EOF
```

- 1 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.
- 2 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.
- 3 Provides reverse DNS resolution for the bootstrap machine.
- 4 5 6 Provides reverse DNS resolution for the control plane machines.
- 7 8 Provides reverse DNS resolution for the compute machines.

**NOTE**

A PTR record is not required for the OpenShift Container Platform application wildcard.

### 18.8.6.6. Load balancing requirements for user-provisioned infrastructure

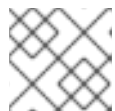
Before you install OpenShift Container Platform, you must provision the API and application ingress load balancing infrastructure. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

**NOTE**

If you want to deploy the API and application ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer.** Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:
  - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the API routes.
  - A stateless load balancing algorithm. The options vary based on the load balancer implementation.

**NOTE**

Session persistence is not required for the API load balancer to function properly.

Configure the following ports on both the front and back of the load balancers:

**Table 18.82. API load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
------	----------------------------------	----------	----------	-------------



Port	Back-end machines (pool members)	Internal	External	Description
<b>6443</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the <b>/readyz</b> endpoint for the API server health check probe.	X	X	Kubernetes API server
<b>22623</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server



### NOTE

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the **/readyz** endpoint to the removal of the API server instance from the pool. Within the time frame after **/readyz** returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application ingress load balancer.** Provides an ingress point for application traffic flowing in from outside the cluster. Configure the following conditions:
  - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the ingress routes.
  - A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

### TIP

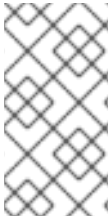
If the true IP address of the client can be seen by the application ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

Configure the following ports on both the front and back of the load balancers:

**Table 18.83. Application ingress load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
------	----------------------------------	----------	----------	-------------

Port	Back-end machines (pool members)	Internal	External	Description
<b>443</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic
<b>80</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic
<b>1936</b>	The worker nodes that run the Ingress Controller pods, by default. You must configure the <b>/healthz/ready</b> endpoint for the ingress health check probe.	X	X	HTTP traffic

**NOTE**

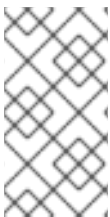
If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

**NOTE**

A working configuration for the Ingress router is required for an OpenShift Container Platform cluster. You must configure the Ingress router after the control plane initializes.

#### 18.8.6.6.1. Example load balancer configuration for user-provisioned clusters

This section provides an example API and application ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an **/etc/haproxy/haproxy.cfg** configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing one load balancing solution over another.

**NOTE**

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

#### Example 18.21. Sample API and application ingress load balancer configuration

```
global
log      127.0.0.1 local2
pidfile  /var/run/haproxy.pid
maxconn  4000
daemon
defaults
mode     http
```

```

log                global
option             dontlognull
option http-server-close
option             redispatch
retries            3
timeout http-request 10s
timeout queue      1m
timeout connect    10s
timeout client     1m
timeout server     1m
timeout http-keep-alive 10s
timeout check      10s
maxconn            3000
frontend stats
bind *:1936
mode              http
log               global
maxconn 10
stats enable
stats hide-version
stats refresh 30s
stats show-node
stats show-desc Stats for ocp4 cluster 1
stats auth admin:ocp4
stats uri /stats
listen api-server-6443 2
bind *:6443
mode tcp
server bootstrap bootstrap.ocp4.example.com:6443 check inter 1s backup 3
server master0 master0.ocp4.example.com:6443 check inter 1s
server master1 master1.ocp4.example.com:6443 check inter 1s
server master2 master2.ocp4.example.com:6443 check inter 1s
listen machine-config-server-22623 4
bind *:22623
mode tcp
server bootstrap bootstrap.ocp4.example.com:22623 check inter 1s backup 5
server master0 master0.ocp4.example.com:22623 check inter 1s
server master1 master1.ocp4.example.com:22623 check inter 1s
server master2 master2.ocp4.example.com:22623 check inter 1s
listen ingress-router-443 6
bind *:443
mode tcp
balance source
server worker0 worker0.ocp4.example.com:443 check inter 1s
server worker1 worker1.ocp4.example.com:443 check inter 1s
listen ingress-router-80 7
bind *:80
mode tcp
balance source
server worker0 worker0.ocp4.example.com:80 check inter 1s
server worker1 worker1.ocp4.example.com:80 check inter 1s

```

**1** In the example, the cluster name is **ocp4**.

**2** Port **6443** handles the Kubernetes API traffic and points to the control plane machines.

- 3 5 The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.
- 4 Port **22623** handles the machine config server traffic and points to the control plane machines.
- 6 Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.
- 7 Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

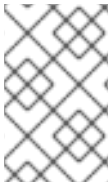


#### NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

#### TIP

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltp** on the HAProxy node.



#### NOTE

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running **setsebool -P haproxy\_connect\_any=1**.

### 18.8.7. Preparing the user-provisioned infrastructure

Before you install OpenShift Container Platform on user-provisioned infrastructure, you must prepare the underlying infrastructure.

This section provides details about the high-level steps required to set up your cluster infrastructure in preparation for an OpenShift Container Platform installation. This includes configuring IP networking and network connectivity for your cluster nodes, enabling the required ports through your firewall, and setting up the required DNS and load balancing infrastructure.

After preparation, your cluster infrastructure must meet the requirements outlined in the *Requirements for a cluster with user-provisioned infrastructure* section.

#### Prerequisites

- You have reviewed the [OpenShift Container Platform 4.x Tested Integrations](#) page.
- You have reviewed the infrastructure requirements detailed in the *Requirements for a cluster with user-provisioned infrastructure* section.

#### Procedure

1. If you are using DHCP to provide the IP networking configuration to your cluster nodes, configure your DHCP service.
  - a. Add persistent IP addresses for the nodes to your DHCP server configuration. In your configuration, match the MAC address of the relevant network interface to the intended IP address for each node.
  - b. When you use DHCP to configure IP addressing for the cluster machines, the machines also obtain the DNS server information through DHCP. Define the persistent DNS server address that is used by the cluster nodes through your DHCP server configuration.

**NOTE**

If you are not using a DHCP service, you must provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

- c. Define the hostnames of your cluster nodes in your DHCP server configuration. See the *Setting the cluster node hostnames through DHCP* section for details about hostname considerations.

**NOTE**

If you are not using a DHCP service, the cluster nodes obtain their hostname through a reverse DNS lookup.

2. Ensure that your network infrastructure provides the required network connectivity between the cluster components. See the *Networking requirements for user-provisioned infrastructure* section for details about the requirements.
3. Configure your firewall to enable the ports required for the OpenShift Container Platform cluster components to communicate. See *Networking requirements for user-provisioned infrastructure* section for details about the ports that are required.
4. Setup the required DNS infrastructure for your cluster.
  - a. Configure DNS name resolution for the Kubernetes API, the application wildcard, the bootstrap machine, the control plane machines, and the compute machines.
  - b. Configure reverse DNS resolution for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.  
See the *User-provisioned DNS requirements* section for more information about the OpenShift Container Platform DNS requirements.
5. Validate your DNS configuration.
  - a. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses in the responses correspond to the correct components.
  - b. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names in the responses correspond to the correct components.

See the *Validating DNS resolution for user-provisioned infrastructure* section for detailed DNS validation steps.

6. Provision the required API and application ingress load balancing infrastructure. See the *Load balancing requirements for user-provisioned infrastructure* section for more information about the requirements.

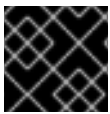


#### NOTE

Some load balancing solutions require the DNS name resolution for the cluster nodes to be in place before the load balancing is initialized.

### 18.8.8. Validating DNS resolution for user-provisioned infrastructure

You can validate your DNS configuration before installing OpenShift Container Platform on user-provisioned infrastructure.



#### IMPORTANT

The validation steps detailed in this section must succeed before you install your cluster.

#### Prerequisites

- You have configured the required DNS records for your user-provisioned infrastructure.

#### Procedure

1. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses contained in the responses correspond to the correct components.
  - a. Perform a lookup against the Kubernetes API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api.<cluster_name>.<base_domain> 1
```

- 1 Replace **<nameserver\_ip>** with the IP address of the nameserver, **<cluster\_name>** with your cluster name, and **<base\_domain>** with your base domain name.

#### Example output

```
api.ocp4.example.com. 0 IN A 192.168.1.5
```

- b. Perform a lookup against the Kubernetes internal API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api-int.<cluster_name>.<base_domain>
```

#### Example output

```
api-int.ocp4.example.com. 0 IN A 192.168.1.5
```

- c. Test an example `*.apps.<cluster_name>.<base_domain>` DNS wildcard lookup. All of the application wildcard lookups must resolve to the IP address of the application ingress load balancer:

```
$ dig +noall +answer @<nameserver_ip> random.apps.<cluster_name>.<base_domain>
```

### Example output

```
random.apps.ocp4.example.com. 0 IN A 192.168.1.5
```



### NOTE

In the example outputs, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

You can replace **random** with another wildcard value. For example, you can query the route to the OpenShift Container Platform console:

```
$ dig +noall +answer @<nameserver_ip> console-openshift-console.apps.<cluster_name>.<base_domain>
```

### Example output

```
console-openshift-console.apps.ocp4.example.com. 0 IN A 192.168.1.5
```

- d. Run a lookup against the bootstrap DNS record name. Check that the result points to the IP address of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> bootstrap.<cluster_name>.<base_domain>
```

### Example output

```
bootstrap.ocp4.example.com. 0 IN A 192.168.1.96
```

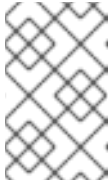
- e. Use this method to perform lookups against the DNS record names for the control plane and compute nodes. Check that the results correspond to the IP addresses of each node.
2. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names contained in the responses correspond to the correct components.
- a. Perform a reverse lookup against the IP address of the API load balancer. Check that the response includes the record names for the Kubernetes API and the Kubernetes internal API:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.5
```

### Example output

```
5.1.168.192.in-addr.arpa. 0 IN PTR api-int.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. 0 IN PTR api.ocp4.example.com. 2
```

- 1 Provides the record name for the Kubernetes internal API.
- 2 Provides the record name for the Kubernetes API.



#### NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard. No validation step is needed for reverse DNS resolution against the IP address of the application ingress load balancer.

- b. Perform a reverse lookup against the IP address of the bootstrap node. Check that the result points to the DNS record name of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.96
```

#### Example output

```
96.1.168.192.in-addr.arpa. 0 IN PTR bootstrap.ocp4.example.com.
```

- c. Use this method to perform reverse lookups against the IP addresses for the control plane and compute nodes. Check that the results correspond to the DNS record names of each node.

### 18.8.9. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.



#### IMPORTANT

Do not skip this procedure in production environments, where disaster recovery and debugging is required.



#### NOTE

You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

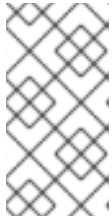


## Procedure

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.



### NOTE

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.



### NOTE

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

### Example output

```
Agent pid 31874
```



### NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

■

```
$ ssh-add <path>/<file_name> 1
```

- 1 Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

### Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

### Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program. If you install a cluster on infrastructure that you provision, you must provide the key to the installation program.

## 18.8.10. Manually creating the installation configuration file

For user-provisioned installations of OpenShift Container Platform, you manually generate your installation configuration file.

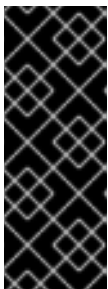
### Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain the **imageContentSources** section from the output of the command to mirror the repository.
- Obtain the contents of the certificate for your mirror registry.

### Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```



### IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation\_directory>**.

**NOTE**

You must name this configuration file **install-config.yaml**.

- Unless you use a registry that RHCOS trusts by default, such as **docker.io**, you must provide the contents of the certificate for your mirror repository in the **additionalTrustBundle** section. In most cases, you must provide the certificate for your mirror.
- You must include the **imageContentSources** section from the output of the command to mirror the repository.

**NOTE**

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation\_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.

**IMPORTANT**

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

### 18.8.10.1. Sample **install-config.yaml** file for VMware vSphere

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```

apiVersion: v1
baseDomain: example.com 1
compute:
- hyperthreading: Enabled 2 3
  name: worker
  replicas: 0 4
controlPlane:
  hyperthreading: Enabled 5 6
  name: master
  replicas: 3 7
metadata:
  name: test 8
platform:
  vsphere:
    vcenter: your.vcenter.server 9
    username: username 10
    password: password 11
    datacenter: datacenter 12
    defaultDatastore: datastore 13
    folder: "/<datacenter_name>/vm/<folder_name>/<subfolder_name>" 14
  fips: false 15
pullSecret: '{"auths":{"<local_registry>":{"auth": "<credentials>","email": "you@example.com"}}}' 16

```



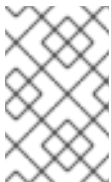
- 14 Optional: For installer-provisioned infrastructure, the absolute path of an existing folder where the installation program creates the virtual machines, for example,
- 15 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.



### IMPORTANT

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

- 16 For **<local\_registry>**, specify the registry domain name, and optionally the port, that your mirror registry uses to serve content. For example **registry.example.com** or **registry.example.com:5000**. For **<credentials>**, specify the base64-encoded user name and password for your mirror registry.
- 17 The public portion of the default SSH key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).



### NOTE

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

- 18 Provide the contents of the certificate file that you used for your mirror registry.
- 19 Provide the **imageContentSources** section from the output of the command to mirror the repository.

#### 18.8.10.2. Configuring the cluster-wide proxy during installation

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

#### Prerequisites

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.



## NOTE

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

## Procedure

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
  additionalTrustBundle: | 4
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
  ...
```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all destinations. You must include vCenter's IP address and the IP range that you use for its machines.
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.



## NOTE

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.



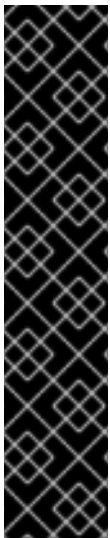
## NOTE

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

### 18.8.11. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.



## IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

## Prerequisites

- You obtained the OpenShift Container Platform installation program. For a restricted network installation, these files are on your mirror host.
- You created the **install-config.yaml** installation configuration file.

## Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

- 1** For **<installation\_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

2. Remove the Kubernetes manifest files that define the control plane machines and compute machine sets:

```
$ rm -f openshift/99_openshift-cluster-api_master-machines-*.yaml openshift/99_openshift-
cluster-api_worker-machineset-*.yaml
```

Because you create and manage these resources yourself, you do not have to initialize them.

- You can preserve the machine set files to create compute machines by using the machine API, but you must update references to them to match your environment.
3. Check that the **mastersSchedulable** parameter in the `<installation_directory>/manifests/cluster-scheduler-02-config.yml` Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:
    - a. Open the `<installation_directory>/manifests/cluster-scheduler-02-config.yml` file.
    - b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.
    - c. Save and exit the file.
  4. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

- 1** For `<installation_directory>`, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the `./<installation_directory>/auth` directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

### 18.8.12. Extracting the infrastructure name

The Ignition config files contain a unique cluster identifier that you can use to uniquely identify your cluster in VMware Cloud on AWS. If you plan to use the cluster identifier as the name of your virtual machine folder, you must extract it.

#### Prerequisites

- You obtained the OpenShift Container Platform installation program and the pull secret for your cluster.
- You generated the Ignition config files for your cluster.
- You installed the **jq** package.



## Procedure

- To extract and view the infrastructure name from the Ignition config file metadata, run the following command:

```
$ jq -r .infraID <installation_directory>/metadata.json 1
```

- For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

## Example output

```
openshift-vw9j6 1
```

- The output of this command is your cluster name and a random string.

### 18.8.13. Installing RHCOS and starting the OpenShift Container Platform bootstrap process

To install OpenShift Container Platform on user-provisioned infrastructure on VMware vSphere, you must install Red Hat Enterprise Linux CoreOS (RHCOS) on vSphere hosts. When you install RHCOS, you must provide the Ignition config file that was generated by the OpenShift Container Platform installation program for the type of machine you are installing. If you have configured suitable networking, DNS, and load balancing infrastructure, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS machines have rebooted.

## Prerequisites

- You have obtained the Ignition config files for your cluster.
- You have access to an HTTP server that you can access from your computer and that the machines that you create can access.
- You have created a [vSphere cluster](#).

## Procedure

- Upload the bootstrap Ignition config file, which is named **<installation\_directory>/bootstrap.ign**, that the installation program created to your HTTP server. Note the URL of this file.
- Save the following secondary Ignition config file for your bootstrap node to your computer as **<installation\_directory>/merge-bootstrap.ign**:

```
{
  "ignition": {
    "config": {
      "merge": [
        {
          "source": "<bootstrap_ignition_config_url>", 1
          "verification": {}
        }
      ]
    }
  }
}
```

```

    },
    "timeouts": {},
    "version": "3.2.0"
  },
  "networkd": {},
  "passwd": {},
  "storage": {},
  "systemd": {}
}

```

- 1 Specify the URL of the bootstrap Ignition config file that you hosted.

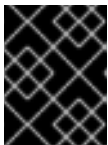
When you create the virtual machine (VM) for the bootstrap machine, you use this Ignition config file.

3. Locate the following Ignition config files that the installation program created:
  - **<installation\_directory>/master.ign**
  - **<installation\_directory>/worker.ign**
  - **<installation\_directory>/merge-bootstrap.ign**
4. Convert the Ignition config files to Base64 encoding. Later in this procedure, you must add these files to the extra configuration parameter **guestinfo.ignition.config.data** in your VM. For example, if you use a Linux operating system, you can use the **base64** command to encode the files.

```
$ base64 -w0 <installation_directory>/master.ign > <installation_directory>/master.64
```

```
$ base64 -w0 <installation_directory>/worker.ign > <installation_directory>/worker.64
```

```
$ base64 -w0 <installation_directory>/merge-bootstrap.ign > <installation_directory>/merge-bootstrap.64
```



### IMPORTANT

If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

5. Obtain the RHCOS OVA image. Images are available from the [RHCOS image mirror](#) page.

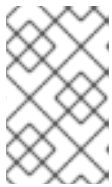


### IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download an image with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image version that matches your OpenShift Container Platform version if it is available.

The filename contains the OpenShift Container Platform version number in the format **rhcos-vmware.<architecture>.ova**.

6. In the vSphere Client, create a folder in your datacenter to store your VMs.
  - a. Click the **VMs and Templates** view.
  - b. Right-click the name of your datacenter.
  - c. Click **New Folder → New VM and Template Folder**.
  - d. In the window that is displayed, enter the folder name. If you did not specify an existing folder in the **install-config.yaml** file, then create a folder with the same name as the infrastructure ID. You use this folder name so vCenter dynamically provisions storage in the appropriate location for its Workspace configuration.
7. In the vSphere Client, create a template for the OVA image and then clone the template as needed.

**NOTE**

In the following steps, you create a template and then clone the template for all of your cluster machines. You then provide the location for the Ignition config file for that cloned machine type when you provision the VMs.

- a. From the **Hosts and Clusters** tab, right-click your cluster name and select **Deploy OVF Template**.
- b. On the **Select an OVF** tab, specify the name of the RHCOS OVA file that you downloaded.
- c. On the **Select a name and folder** tab, set a **Virtual machine name** for your template, such as **Template-RHCOS**. Click the name of your vSphere cluster and select the folder you created in the previous step.
- d. On the **Select a compute resource** tab, click the name of your vSphere cluster.
- e. On the **Select storage** tab, configure the storage options for your VM.
  - Select **Thin Provision** or **Thick Provision**, based on your storage preferences.
  - Select the datastore that you specified in your **install-config.yaml** file.
- f. On the **Select network** tab, specify the network that you configured for the cluster, if available.
- g. When creating the OVF template, do not specify values on the **Customize template** tab or configure the template any further.

**IMPORTANT**

Do not start the original VM template. The VM template must remain off and must be cloned for new RHCOS machines. Starting the VM template configures the VM template as a VM on the platform, which prevents it from being used as a template that machine sets can apply configurations to.

8. Optional: Update the configured virtual hardware version in the VM template, if necessary. Follow [Upgrading a virtual machine to the latest hardware version](#) in the VMware documentation for more information.



## IMPORTANT

It is recommended that you update the hardware version of the VM template to version 15 before creating VMs from it, if necessary. Using hardware version 13 for your cluster nodes running on vSphere is now deprecated. If your imported template defaults to hardware version 13, you must ensure that your ESXi host is on 6.7U3 or later before upgrading the VM template to hardware version 15. If your vSphere version is less than 6.7U3, you can skip this upgrade step; however, a future version of OpenShift Container Platform is scheduled to remove support for hardware version 13 and vSphere versions less than 6.7U3.

9. After the template deploys, deploy a VM for a machine in the cluster.
  - a. Right-click the template name and click **Clone** → **Clone to Virtual Machine**
  - b. On the **Select a name and folder** tab, specify a name for the VM. You might include the machine type in the name, such as **control-plane-0** or **compute-1**.
  - c. On the **Select a name and folder** tab, select the name of the folder that you created for the cluster.
  - d. On the **Select a compute resource** tab, select the name of a host in your datacenter.
  - e. Optional: On the **Select storage** tab, customize the storage options.
  - f. On the **Select clone options**, select **Customize this virtual machine's hardware**
  - g. On the **Customize hardware** tab, click **VM Options** → **Advanced**.
    - Optional: Override default DHCP networking in vSphere. To enable static IP networking:
      - i. Set your static IP configuration:

```
$ export IPCFG="ip=<ip>::<gateway>:<netmask>:<hostname>:<iface>:none
nameserver=svr1 [nameserver=svr2 [nameserver=svr3 [...]]]"
```

### Example command

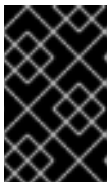
```
$ export IPCFG="ip=192.168.100.101::192.168.100.254:255.255.255.0::none
nameserver=8.8.8.8"
```

- ii. Set the **guestinfo.afterburn.initrd.network-kargs** property before booting a VM from an OVA in vSphere:

```
$ govc vm.change -vm "<vm_name>" -e "guestinfo.afterburn.initrd.network-
kargs=${IPCFG}"
```

- Optional: In the event of cluster performance issues, from the **Latency Sensitivity** list, select **High**. Ensure that your VM's CPU and memory reservation have the following values:
  - Memory reservation value must be equal to its configured memory size.
  - CPU reservation value must be at least the number of low latency virtual CPUs multiplied by the measured physical CPU speed.

- Click **Edit Configuration**, and on the **Configuration Parameters** window, search the list of available parameters for steal clock accounting (**stealclock.enable**). If it is available, set its value to **TRUE**. Enabling steal clock accounting can help with troubleshooting cluster issues.
  - Click **Add Configuration Params**. Define the following parameter names and values:
    - **guestinfo.ignition.config.data**: Locate the base-64 encoded files that you created previously in this procedure, and paste the contents of the base64-encoded Ignition config file for this machine type.
    - **guestinfo.ignition.config.data.encoding**: Specify **base64**.
    - **disk.EnableUUID**: Specify **TRUE**.
    - **stealclock.enable**: If this parameter was not defined, add it and specify **TRUE**.
  - h. In the **Virtual Hardware** panel of the **Customize hardware** tab, modify the specified values as required. Ensure that the amount of RAM, CPU, and disk storage meets the minimum requirements for the machine type.
  - i. Complete the configuration and power on the VM.
10. Create the rest of the machines for your cluster by following the preceding steps for each machine.



### IMPORTANT

You must create the bootstrap and control plane machines at this time. Because some pods are deployed on compute machines by default, also create at least two compute machines before you install the cluster.

## 18.8.14. Adding more compute machines to a cluster in vSphere

You can add more compute machines to a user-provisioned OpenShift Container Platform cluster on VMware vSphere.

### Prerequisites

- Obtain the base64-encoded Ignition file for your compute machines.
- You have access to the vSphere template that you created for your cluster.

### Procedure

1. After the template deploys, deploy a VM for a machine in the cluster.
  - a. Right-click the template's name and click **Clone** → **Clone to Virtual Machine**
  - b. On the **Select a name and folder** tab, specify a name for the VM. You might include the machine type in the name, such as **compute-1**.
  - c. On the **Select a name and folder** tab, select the name of the folder that you created for the cluster.
  - d. On the **Select a compute resource** tab, select the name of a host in your datacenter.

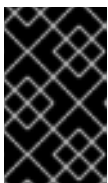
- e. Optional: On the **Select storage** tab, customize the storage options.
  - f. On the **Select clone options**, select **Customize this virtual machine's hardware**
  - g. On the **Customize hardware** tab, click **VM Options → Advanced**.
    - From the **Latency Sensitivity** list, select **High**.
    - Click **Edit Configuration**, and on the **Configuration Parameters** window, click **Add Configuration Params**. Define the following parameter names and values:
      - **guestinfo.ignition.config.data**: Paste the contents of the base64-encoded compute Ignition config file for this machine type.
      - **guestinfo.ignition.config.data.encoding**: Specify **base64**.
      - **disk.EnableUUID**: Specify **TRUE**.
  - h. In the **Virtual Hardware** panel of the **Customize hardware** tab, modify the specified values as required. Ensure that the amount of RAM, CPU, and disk storage meets the minimum requirements for the machine type. Also, make sure to select the correct network under **Add network adapter** if there are multiple networks available.
  - i. Complete the configuration and power on the VM.
2. Continue to create more compute machines for your cluster.

### 18.8.15. Disk partitioning

In most cases, data partitions are originally created by installing RHCOS, rather than by installing another operating system. In such cases, the OpenShift Container Platform installer should be allowed to configure your disk partitions.

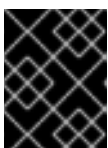
However, there are two cases where you might want to intervene to override the default partitioning when installing an OpenShift Container Platform node:

- **Create separate partitions:** For greenfield installations on an empty disk, you might want to add separate storage to a partition. This is officially supported for making **/var** or a subdirectory of **/var**, such as **/var/lib/etcd**, a separate partition, but not both.



#### IMPORTANT

For disk sizes larger than 100GB, and especially disk sizes larger than 1TB, create a separate **/var** partition. See "Creating a separate **/var** partition" and this [Red Hat Knowledgebase article](#) for more information.



#### IMPORTANT

Kubernetes supports only two file system partitions. If you add more than one partition to the original configuration, Kubernetes cannot monitor all of them.

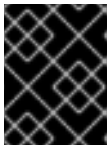
- **Retain existing partitions:** For a brownfield installation where you are reinstalling OpenShift Container Platform on an existing node and want to retain data partitions installed from your previous operating system, there are both boot arguments and options to **coreos-installer** that allow you to retain existing data partitions.

## Creating a separate `/var` partition

In general, disk partitioning for OpenShift Container Platform should be left to the installer. However, there are cases where you might want to create separate partitions in a part of the filesystem that you expect to grow.

OpenShift Container Platform supports the addition of a single partition to attach storage to either the `/var` partition or a subdirectory of `/var`. For example:

- `/var/lib/containers`: Holds container-related content that can grow as more images and containers are added to a system.
- `/var/lib/etcd`: Holds data that you might want to keep separate for purposes such as performance optimization of etcd storage.
- `/var`: Holds data that you might want to keep separate for purposes such as auditing.



### IMPORTANT

For disk sizes larger than 100GB, and especially larger than 1TB, create a separate `/var` partition.

Storing the contents of a `/var` directory separately makes it easier to grow storage for those areas as needed and reinstall OpenShift Container Platform at a later date and keep that data intact. With this method, you will not have to pull all your containers again, nor will you have to copy massive log files when you update systems.

Because `/var` must be in place before a fresh installation of Red Hat Enterprise Linux CoreOS (RHCOS), the following procedure sets up the separate `/var` partition by creating a machine config manifest that is inserted during the **openshift-install** preparation phases of an OpenShift Container Platform installation.

### Procedure

1. Create a directory to hold the OpenShift Container Platform installation files:

```
$ mkdir $HOME/clusterconfig
```

2. Run **openshift-install** to create a set of files in the **manifest** and **openshift** subdirectories. Answer the system questions as you are prompted:

```
$ openshift-install create manifests --dir $HOME/clusterconfig
? SSH Public Key ...
$ ls $HOME/clusterconfig/openshift/
99_kubeadmin-password-secret.yaml
99_openshift-cluster-api_master-machines-0.yaml
99_openshift-cluster-api_master-machines-1.yaml
99_openshift-cluster-api_master-machines-2.yaml
...
```

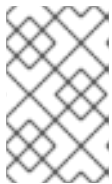
3. Create a Butane config that configures the additional partition. For example, name the file **`$HOME/clusterconfig/98-var-partition.bu`**, change the disk device name to the name of the storage device on the **worker** systems, and set the storage size as appropriate. This example places the `/var` directory on a separate partition:

```

variant: openshift
version: 4.9.0
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 98-var-partition
storage:
  disks:
    - device: /dev/<device_name> ❶
      partitions:
        - label: var
          start_mib: <partition_start_offset> ❷
          size_mib: <partition_size> ❸
      filesystems:
        - device: /dev/disk/by-partlabel/var
          path: /var
          format: xfs
          mount_options: [defaults, prjquota] ❹
          with_mount_unit: true

```

- ❶ The storage device name of the disk that you want to partition.
- ❷ When adding a data partition to the boot disk, a minimum value of 25000 mebibytes is recommended. The root file system is automatically resized to fill all available space up to the specified offset. If no value is specified, or if the specified value is smaller than the recommended minimum, the resulting root file system will be too small, and future reinstalls of RHCOS might overwrite the beginning of the data partition.
- ❸ The size of the data partition in mebibytes.
- ❹ The **prjquota** mount option must be enabled for filesystems used for container storage.



#### NOTE

When creating a separate **/var** partition, you cannot use different instance types for worker nodes, if the different instance types do not have the same device name.

4. Create a manifest from the Butane config and save it to the **clusterconfig/openshift** directory. For example, run the following command:

```
$ butane $HOME/clusterconfig/98-var-partition.bu -o $HOME/clusterconfig/openshift/98-var-partition.yaml
```

5. Run **openshift-install** again to create Ignition configs from a set of files in the **manifest** and **openshift** subdirectories:

```
$ openshift-install create ignition-configs --dir $HOME/clusterconfig
$ ls $HOME/clusterconfig/
auth bootstrap.ign master.ign metadata.json worker.ign
```

Now you can use the Ignition config files as input to the vSphere installation procedures to install Red Hat Enterprise Linux CoreOS (RHCOS) systems.



## 18.8.16. Updating the bootloader using bootupd

To update the bootloader by using **bootupd**, you must either install **bootupd** on RHCOS machines manually or provide a machine config with the enabled **systemd** unit. Unlike **grubby** or other bootloader tools, **bootupd** does not manage kernel space configuration such as passing kernel arguments.

After you have installed **bootupd**, you can manage it remotely from the OpenShift Container Platform cluster.



### NOTE

It is recommended that you use **bootupd** only on bare metal or virtualized hypervisor installations, such as for protection against the BootHole vulnerability.

### Manual install method

You can manually install **bootupd** by using the **bootctl** command-line tool.

1. Inspect the system status:

```
# bootupctl status
```

#### Example output

```
Component EFI
  Installed: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
  Update: At latest version
```

2. RHCOS images created without **bootupd** installed on them require an explicit adoption phase. If the system status is **Adoptable**, perform the adoption:

```
# bootupctl adopt-and-update
```

#### Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

3. If an update is available, apply the update so that the changes take effect on the next reboot:

```
# bootupctl update
```

#### Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

### Machine config method

Another way to enable **bootupd** is by providing a machine config.

- Provide a machine config file with the enabled **systemd** unit, as shown in the following example:

#### Example output

```

variant: rhcos
version: 1.1.0
systemd:
  units:
    - name: custom-bootupd-auto.service
      enabled: true
      contents: |
        [Unit]
        Description=Bootupd automatic update

        [Service]
        ExecStart=/usr/bin/bootupctl update
        RemainAfterExit=yes

        [Install]
        WantedBy=multi-user.target

```

### 18.8.17. Waiting for the bootstrap process to complete

The OpenShift Container Platform bootstrap process begins after the cluster nodes first boot into the persistent RHCOS environment that has been installed to disk. The configuration information provided through the Ignition config files is used to initialize the bootstrap process and install OpenShift Container Platform on the machines. You must wait for the bootstrap process to complete.

#### Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have obtained the installation program and generated the Ignition config files for your cluster.
- You installed RHCOS on your cluster machines and provided the Ignition config files that the OpenShift Container Platform installation program generated.

#### Procedure

1. Monitor the bootstrap process:

```

$ ./openshift-install --dir <installation_directory> wait-for bootstrap-complete \ 1
--log-level=info 2

```

1 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

#### Example output

```

INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...
INFO API v1.22.1 up
INFO Waiting up to 30m0s for bootstrapping to complete...

```

**INFO** It is now safe to remove the bootstrap resources

The command succeeds when the Kubernetes API server signals that it has been bootstrapped on the control plane machines.

2. After bootstrap process is complete, remove the bootstrap machine from the load balancer.



### IMPORTANT

You must remove the bootstrap machine from the load balancer at this point. You can also remove or reformat the bootstrap machine itself.

## 18.8.18. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

### Example output

```
system:admin
```

## 18.8.19. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

### Prerequisites

- You added machines to your cluster.

## Procedure

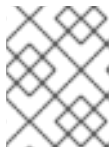
1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

### Example output

```
NAME      STATUS    ROLES    AGE   VERSION
master-0  Ready    master   63m   v1.22.1
master-1  Ready    master   63m   v1.22.1
master-2  Ready    master   64m   v1.22.1
```

The output lists all of the machines that you created.



### NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

2. Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

### Example output

```
NAME      AGE   REQUESTOR                                     CONDITION
csr-8b2br  15m   system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper  Pending
csr-8vnps  15m   system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper  Pending
...
```

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

3. If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:



### NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.

**NOTE**

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrap** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{\n"}\n{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```

**NOTE**

Some Operators might not become available until some CSRs are approved.

4. Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

**Example output**

```
NAME      AGE   REQUESTOR                                     CONDITION
csr-bfd72 5m26s system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv 5m26s system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

5. If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{\n"}\n{{end}}' | xargs oc adm certificate approve
```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

### Example output

```
NAME      STATUS  ROLES  AGE  VERSION
master-0  Ready   master 73m  v1.22.1
master-1  Ready   master 73m  v1.22.1
master-2  Ready   master 74m  v1.22.1
worker-0  Ready   worker 11m  v1.22.1
worker-1  Ready   worker 11m  v1.22.1
```



### NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

### Additional information

- For more information on CSRs, see [Certificate Signing Requests](#).

## 18.8.20. Initial Operator configuration

After the control plane initializes, you must immediately configure some Operators so that they all become available.

### Prerequisites

- Your control plane has initialized.

### Procedure

1. Watch the cluster components come online:

```
$ watch -n5 oc get clusteroperators
```

### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
authentication	4.9.0	True	False	False	19m
baremetal	4.9.0	True	False	False	37m
cloud-credential	4.9.0	True	False	False	40m
cluster-autoscaler	4.9.0	True	False	False	37m
config-operator	4.9.0	True	False	False	38m

console	4.9.0	True	False	False	26m
csi-snapshot-controller	4.9.0	True	False	False	37m
dns	4.9.0	True	False	False	37m
etcd	4.9.0	True	False	False	36m
image-registry	4.9.0	True	False	False	31m
ingress	4.9.0	True	False	False	30m
insights	4.9.0	True	False	False	31m
kube-apiserver	4.9.0	True	False	False	26m
kube-controller-manager	4.9.0	True	False	False	36m
kube-scheduler	4.9.0	True	False	False	36m
kube-storage-version-migrator	4.9.0	True	False	False	37m
machine-api	4.9.0	True	False	False	29m
machine-approver	4.9.0	True	False	False	37m
machine-config	4.9.0	True	False	False	36m
marketplace	4.9.0	True	False	False	37m
monitoring	4.9.0	True	False	False	29m
network	4.9.0	True	False	False	38m
node-tuning	4.9.0	True	False	False	37m
openshift-apiserver	4.9.0	True	False	False	32m
openshift-controller-manager	4.9.0	True	False	False	30m
openshift-samples	4.9.0	True	False	False	32m
operator-lifecycle-manager	4.9.0	True	False	False	37m
operator-lifecycle-manager-catalog	4.9.0	True	False	False	37m
operator-lifecycle-manager-packageserver	4.9.0	True	False	False	32m
service-ca	4.9.0	True	False	False	38m
storage	4.9.0	True	False	False	37m

2. Configure the Operators that are not available.

### 18.8.20.1. Disabling the default OperatorHub sources

Operator catalogs that source content provided by Red Hat and community projects are configured for OperatorHub by default during an OpenShift Container Platform installation. In a restricted network environment, you must disable the default catalogs as a cluster administrator.

#### Procedure

- Disable the sources for the default catalogs by adding **disableAllDefaultSources: true** to the **OperatorHub** object:

```
$ oc patch OperatorHub cluster --type json \
  -p [{"op": "add", "path": "/spec/disableAllDefaultSources", "value": true}]
```

#### TIP

Alternatively, you can use the web console to manage catalog sources. From the **Administration** → **Cluster Settings** → **Configuration** → **OperatorHub** page, click the **Sources** tab, where you can create, delete, disable, and enable individual sources.

### 18.8.20.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

### 18.8.20.2.1. Configuring registry storage for VMware vSphere

As a cluster administrator, following installation you must configure your registry to use storage.

#### Prerequisites

- Cluster administrator permissions.
- A cluster on VMware vSphere.
- Persistent storage provisioned for your cluster, such as Red Hat OpenShift Container Storage.



#### IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have "100Gi" capacity.



#### IMPORTANT

Testing shows issues with using the NFS server on RHEL as storage backend for core services. This includes the OpenShift Container Registry and Quay, Prometheus for monitoring storage, and Elasticsearch for logging storage. Therefore, using RHEL NFS to back PVs used by core services is not recommended.

Other NFS implementations on the marketplace might not have these issues. Contact the individual NFS implementation vendor for more information on any testing that was possibly completed against these OpenShift Container Platform core components.

#### Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.



#### NOTE

When using shared storage, review your security settings to prevent outside access.

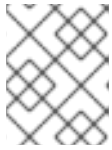
2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```



## Example output

```
No resources found in openshift-image-registry namespace
```



### NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

## Example output

```
storage:
  pvc:
    claim: 1
```

- 1 Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** persistent volume claim (PVC). The PVC is generated based on the default storage class. However, be aware that the default storage class might provide ReadWriteOnce (RWO) volumes, such as a RADOS Block Device (RBD), which can cause issues when replicating to more than one replica.

4. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

## Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED
image-registry	4.7	True	False	False 6h50m

### 18.8.20.2.2. Configuring storage for the image registry in non-production clusters

You must configure storage for the Image Registry Operator. For non-production clusters, you can set the image registry to an empty directory. If you do so, all images are lost if you restart the registry.

#### Procedure

- To set the image registry storage to an empty directory:

```
$ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec": {"storage":{"emptyDir":{}}}'
```

**WARNING**

Configure this option for only non-production clusters.

If you run this command before the Image Registry Operator initializes its components, the **oc patch** command fails with the following error:

```
Error from server (NotFound): configs.imageregistry.operator.openshift.io "cluster" not found
```

Wait a few minutes and run the command again.

**18.8.20.2.3. Configuring block registry storage for VMware vSphere**

To allow the image registry to use block storage types such as vSphere Virtual Machine Disk (VMDK) during upgrades as a cluster administrator, you can use the **Recreate** rollout strategy.

**IMPORTANT**

Block storage volumes are supported but not recommended for use with image registry on production clusters. An installation where the registry is configured on block storage is not highly available because the registry cannot have more than one replica.

**Procedure**

1. To set the image registry storage as a block storage type, patch the registry so that it uses the **Recreate** rollout strategy and runs with only **1** replica:

```
$ oc patch config.imageregistry.operator.openshift.io/cluster --type=merge -p '{"spec": {"rolloutStrategy": "Recreate", "replicas": 1}}'
```

2. Provision the PV for the block storage device, and create a PVC for that volume. The requested block volume uses the ReadWriteOnce (RWO) access mode.

- a. Create a **pvc.yaml** file with the following contents to define a VMware vSphere **PersistentVolumeClaim** object:

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: image-registry-storage 1
  namespace: openshift-image-registry 2
spec:
  accessModes:
  - ReadWriteOnce 3
  resources:
    requests:
      storage: 100Gi 4
```

- 1 A unique name that represents the **PersistentVolumeClaim** object.

- 2 The namespace for the **PersistentVolumeClaim** object, which is **openshift-image-registry**.
- 3 The access mode of the persistent volume claim. With **ReadWriteOnce**, the volume can be mounted with read and write permissions by a single node.
- 4 The size of the persistent volume claim.

b. Create the **PersistentVolumeClaim** object from the file:

```
$ oc create -f pvc.yaml -n openshift-image-registry
```

3. Edit the registry configuration so that it references the correct PVC:

```
$ oc edit config.imageregistry.operator.openshift.io -o yaml
```

### Example output

```
storage:
  pvc:
    claim: 1
```

- 1 Creating a custom PVC allows you to leave the **claim** field blank for the default automatic creation of an **image-registry-storage** PVC.

For instructions about configuring registry storage so that it references the correct PVC, see [Configuring registry storage for VMware vSphere](#).

## 18.8.21. Completing installation on user-provisioned infrastructure

After you complete the Operator configuration, you can finish installing the cluster on infrastructure that you provide.

### Prerequisites

- Your control plane has initialized.
- You have completed the initial Operator configuration.

### Procedure

1. Confirm that all the cluster components are online with the following command:

```
$ watch -n5 oc get clusteroperators
```

### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED
authentication	4.9.0	True	False	False 19m
baremetal	4.9.0	True	False	False 37m

cloud-credential	4.9.0	True	False	False	40m
cluster-autoscaler	4.9.0	True	False	False	37m
config-operator	4.9.0	True	False	False	38m
console	4.9.0	True	False	False	26m
csi-snapshot-controller	4.9.0	True	False	False	37m
dns	4.9.0	True	False	False	37m
etcd	4.9.0	True	False	False	36m
image-registry	4.9.0	True	False	False	31m
ingress	4.9.0	True	False	False	30m
insights	4.9.0	True	False	False	31m
kube-apiserver	4.9.0	True	False	False	26m
kube-controller-manager	4.9.0	True	False	False	36m
kube-scheduler	4.9.0	True	False	False	36m
kube-storage-version-migrator	4.9.0	True	False	False	37m
machine-api	4.9.0	True	False	False	29m
machine-approver	4.9.0	True	False	False	37m
machine-config	4.9.0	True	False	False	36m
marketplace	4.9.0	True	False	False	37m
monitoring	4.9.0	True	False	False	29m
network	4.9.0	True	False	False	38m
node-tuning	4.9.0	True	False	False	37m
openshift-apiserver	4.9.0	True	False	False	32m
openshift-controller-manager	4.9.0	True	False	False	30m
openshift-samples	4.9.0	True	False	False	32m
operator-lifecycle-manager	4.9.0	True	False	False	37m
operator-lifecycle-manager-catalog	4.9.0	True	False	False	37m
operator-lifecycle-manager-packageserver	4.9.0	True	False	False	32m
service-ca	4.9.0	True	False	False	38m
storage	4.9.0	True	False	False	37m

Alternatively, the following command notifies you when all of the clusters are available. It also retrieves and displays credentials:

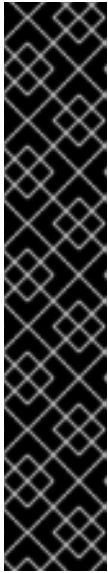
```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

### Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

The command succeeds when the Cluster Version Operator finishes deploying the OpenShift Container Platform cluster from Kubernetes API server.



## IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Confirm that the Kubernetes API server is communicating with the pods.

- a. To view a list of all pods, use the following command:

```
$ oc get pods --all-namespaces
```

### Example output

```

NAMESPACE           NAME                                     READY  STATUS
RESTARTS  AGE
openshift-apiserver-operator  openshift-apiserver-operator-85cb746d55-zqhs8  1/1
Running   1      9m
openshift-apiserver          apiserver-67b9g                                1/1  Running  0
3m
openshift-apiserver          apiserver-ljcmx                                1/1  Running  0
1m
openshift-apiserver          apiserver-z25h4                                1/1  Running  0
2m
openshift-authentication-operator  authentication-operator-69d5d8bf84-vh2n8  1/1
Running   0      5m
...

```

- b. View the logs for a pod that is listed in the output of the previous command by using the following command:

```
$ oc logs <pod_name> -n <namespace> ❶
```

- ❶ Specify the pod name and namespace, as shown in the output of the previous command.

If the pod logs display, the Kubernetes API server can communicate with the cluster machines.

3. For an installation with Fibre Channel Protocol (FCP), additional steps are required to enable multipathing. Do not enable multipathing during installation. See "Enabling multipathing with kernel arguments on RHCOS" in the *Post-installation machine configuration tasks* documentation for more information.

4. Register your cluster on the [Cluster registration](#) page.

You can add extra compute machines after the cluster installation is completed by following [Adding compute machines to vSphere](#).

### 18.8.22. Backing up VMware vSphere volumes

OpenShift Container Platform provisions new volumes as independent persistent disks to freely attach and detach the volume on any node in the cluster. As a consequence, it is not possible to back up volumes that use snapshots, or to restore volumes from snapshots. See [Snapshot Limitations](#) for more information.

#### Procedure

To create a backup of persistent volumes:

1. Stop the application that is using the persistent volume.
2. Clone the persistent volume.
3. Restart the application.
4. Create a backup of the cloned volume.
5. Delete the cloned volume.

### 18.8.23. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

#### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

### 18.8.24. Next steps

- [Customize your cluster](#).
- [Configure image streams](#) for the Cluster Samples Operator and the **must-gather** tool.
- Learn how to [use Operator Lifecycle Manager \(OLM\) on restricted networks](#).
- If the mirror registry that you used to install your cluster has a trusted CA, add it to the cluster by [configuring additional trust stores](#).
- If necessary, you can [opt out of remote health reporting](#).
- Optional: [View the events from the vSphere Problem Detector Operator](#) to determine if the cluster has permission or storage configuration issues.

## 18.9. UNINSTALLING A CLUSTER ON VMC

You can remove a cluster installed on VMware vSphere infrastructure that you deployed to [VMware Cloud \(VMC\) on AWS](#) by using installer-provisioned infrastructure.

### 18.9.1. Removing a cluster that uses installer-provisioned infrastructure

You can remove a cluster that uses installer-provisioned infrastructure from your cloud.



#### NOTE

After uninstallation, check your cloud provider for any resources not removed properly, especially with User Provisioned Infrastructure (UPI) clusters. There might be resources that the installer did not create or that the installer is unable to access.

#### Prerequisites

- Have a copy of the installation program that you used to deploy the cluster.
- Have the files that the installation program generated when you created your cluster.

#### Procedure

1. From the directory that contains the installation program on the computer that you used to install the cluster, run the following command:

```

$ ./openshift-install destroy cluster \
--dir <installation_directory> --log-level info 1 2

```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

- 2** To view different details, specify **warn**, **debug**, or **error** instead of **info**.



#### NOTE

You must specify the directory that contains the cluster definition files for your cluster. The installation program requires the **metadata.json** file in this directory to delete the cluster.

2. Optional: Delete the **<installation\_directory>** directory and the OpenShift Container Platform installation program.

## CHAPTER 19. INSTALLING ON ANY PLATFORM

### 19.1. INSTALLING A CLUSTER ON ANY PLATFORM

In OpenShift Container Platform version 4.9, you can install a cluster on any infrastructure that you provision, including virtualization and cloud environments.



#### IMPORTANT

Review the information in the [guidelines for deploying OpenShift Container Platform on non-tested platforms](#) before you attempt to install an OpenShift Container Platform cluster in virtualized or cloud environments.

#### 19.1.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update](#) processes.
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.



#### NOTE

Be sure to also review this site list if you are configuring a proxy.

#### 19.1.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.9, you require access to the internet to install your cluster.

You must have internet access to:

- Access [OpenShift Cluster Manager](#) to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster.
- Access [Quay.io](#) to obtain the packages that are required to install your cluster.
- Obtain the packages that are required to perform cluster updates.



#### IMPORTANT

If your cluster cannot have direct internet access, you can perform a restricted network installation on some types of infrastructure that you provision. During that process, you download the required content and use it to populate a mirror registry with the installation packages. With some installation types, the environment that you install your cluster in will not require internet access. Before you update the cluster, you update the content of the mirror registry.

#### 19.1.3. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.



This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

### 19.1.3.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

**Table 19.1. Minimum required hosts**

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.



#### IMPORTANT

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 7.9, or RHEL 8.4.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 8 and inherits all of its hardware certifications and requirements. See [Red Hat Enterprise Linux technology capabilities and limits](#).

### 19.1.3.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

**Table 19.2. Minimum resource requirements**

Machine	Operating System	vCPU [1]	Virtual RAM	Storage	IOPS [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 7.9, or RHEL 8.4 [3]	2	8 GB	100 GB	300

1. One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or hyperthreading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio:  $(\text{threads per core} \times \text{cores}) \times \text{sockets} = \text{vCPUs}$ .
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.

### 19.1.3.3. Certificate signing requests management

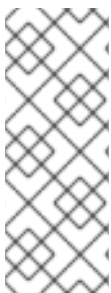
Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine-approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

### 19.1.3.4. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.

It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.



#### NOTE

If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

#### 19.1.3.4.1. Setting the cluster node hostnames through DHCP

On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

#### 19.1.3.4.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.



#### IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

**Table 19.3. Ports used for all-machine to all-machine communications**

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	<b>1936</b>	Metrics
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> and the Cluster Version Operator on port <b>9099</b> .
	<b>10250-10259</b>	The default ports that Kubernetes reserves
	<b>10256</b>	openshift-sdn
UDP	<b>4789</b>	VXLAN and Geneve
	<b>6081</b>	VXLAN and Geneve
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> .
	<b>500</b>	IPsec IKE packets
	<b>4500</b>	IPsec NAT-T packets

Protocol	Port	Description
TCP/UDP	<b>30000-32767</b>	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 19.4. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	<b>6443</b>	Kubernetes API

Table 19.5. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	<b>2379-2380</b>	etcd server and peer ports

### NTP configuration for user-provisioned infrastructure

OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service*.

If a DHCP server provides NTP server information, the chrony time service on the Red Hat Enterprise Linux CoreOS (RHCOS) machines read the information and can sync the clock with the NTP servers.

### Additional resources

- [Configuring chrony time service](#)

### 19.1.3.5. User-provisioned DNS requirements

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API
- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines

Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.


DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.

**NOTE**

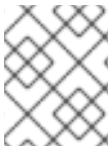
It is recommended to use a DHCP server to provide the hostnames to each cluster node. See the *DHCP recommendations for user-provisioned infrastructure* section for more information.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, **<cluster\_name>** is the cluster name and **<base\_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster\_name>.<base\_domain>.**

**Table 19.6. Required DNS records**

Component	Record	Description
Kubernetes API	<b>api.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
	<b>api-int.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster.
		 <p><b>IMPORTANT</b></p> <p>The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.</p>
Routes	<b>*.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	<p>A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.</p> <p>For example, <b>console-openshift-console.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;</b> is used as a wildcard route to the OpenShift Container Platform console.</p>
Bootstrap machine	<b>bootstrap.&lt;cluster_name&gt;.&lt;base_domain&gt;.</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.

Component	Record	Description
Control plane machines	<b>&lt;master&gt;&lt;n&gt;.</b> <b>&lt;cluster_name&gt;.</b> <b>&lt;base_domain&gt;.</b>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.
Compute machines	<b>&lt;worker&gt;&lt;n&gt;.</b> <b>&lt;cluster_name&gt;.</b> <b>&lt;base_domain&gt;.</b>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.

**NOTE**

In OpenShift Container Platform 4.4 and later, you do not need to specify etcd host and SRV records in your DNS configuration.

**TIP**

You can use the **dig** command to verify name and reverse name resolution. See the section on *Validating DNS resolution for user-provisioned infrastructure* for detailed validation steps.

**19.1.3.5.1. Example DNS configuration for user-provisioned clusters**

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is **ocp4** and the base domain is **example.com**.

**Example DNS A record configuration for a user-provisioned cluster**

The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

**Example 19.1. Sample DNS zone database**

```
$TTL 1W
@ IN SOA ns1.example.com. root (
    2019070700 ; serial
    3H ; refresh (3 hours)
    30M ; retry (30 minutes)
    2W ; expiry (2 weeks)
    1W ) ; minimum (1 week)
IN NS ns1.example.com.
IN MX 10 smtp.example.com.
;
;
ns1.example.com. IN A 192.168.1.5
smtp.example.com. IN A 192.168.1.5
;
helper.example.com. IN A 192.168.1.5
```

```

helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com. IN A 192.168.1.5 1
api-int.ocp4.example.com. IN A 192.168.1.5 2
;
*.apps.ocp4.example.com. IN A 192.168.1.5 3
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 4
;
master0.ocp4.example.com. IN A 192.168.1.97 5
master1.ocp4.example.com. IN A 192.168.1.98 6
master2.ocp4.example.com. IN A 192.168.1.99 7
;
worker0.ocp4.example.com. IN A 192.168.1.11 8
worker1.ocp4.example.com. IN A 192.168.1.7 9
;
;EOF

```

- 1 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.
- 2 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.
- 3 Provides name resolution for the wildcard routes. The record refers to the IP address of the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



#### NOTE

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

- 4 Provides name resolution for the bootstrap machine.
- 5 6 7 Provides name resolution for the control plane machines.
- 8 9 Provides name resolution for the compute machines.

### Example DNS PTR record configuration for a user-provisioned cluster

The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

#### Example 19.2. Sample DNS zone database for reverse records

```

$TTL 1W
@ IN SOA ns1.example.com. root (
2019070700 ; serial

```

```

3H ; refresh (3 hours)
30M ; retry (30 minutes)
2W ; expiry (2 weeks)
1W ) ; minimum (1 week)
IN NS ns1.example.com.
;
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. 1
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. 2
;
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. 3
;
97.1.168.192.in-addr.arpa. IN PTR master0.ocp4.example.com. 4
98.1.168.192.in-addr.arpa. IN PTR master1.ocp4.example.com. 5
99.1.168.192.in-addr.arpa. IN PTR master2.ocp4.example.com. 6
;
11.1.168.192.in-addr.arpa. IN PTR worker0.ocp4.example.com. 7
7.1.168.192.in-addr.arpa. IN PTR worker1.ocp4.example.com. 8
;
;EOF

```

- 1 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.
- 2 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.
- 3 Provides reverse DNS resolution for the bootstrap machine.
- 4 5 6 Provides reverse DNS resolution for the control plane machines.
- 7 8 Provides reverse DNS resolution for the compute machines.

**NOTE**

A PTR record is not required for the OpenShift Container Platform application wildcard.

### 19.1.3.6. Load balancing requirements for user-provisioned infrastructure

Before you install OpenShift Container Platform, you must provision the API and application ingress load balancing infrastructure. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

**NOTE**

If you want to deploy the API and application ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer.** Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:



- Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the API routes.
- A stateless load balancing algorithm. The options vary based on the load balancer implementation.

**NOTE**

Session persistence is not required for the API load balancer to function properly.

Configure the following ports on both the front and back of the load balancers:

**Table 19.7. API load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
<b>6443</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the <b>/readyz</b> endpoint for the API server health check probe.	X	X	Kubernetes API server
<b>22623</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server

**NOTE**

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the **/readyz** endpoint to the removal of the API server instance from the pool. Within the time frame after **/readyz** returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application ingress load balancer.** Provides an ingress point for application traffic flowing in from outside the cluster. Configure the following conditions:
  - Layer 4 load balancing only. This can be referred to as Raw TCP, SSL Passthrough, or SSL Bridge mode. If you use SSL Bridge mode, you must enable Server Name Indication (SNI) for the ingress routes.
  - A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

**TIP**

If the true IP address of the client can be seen by the application ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

Configure the following ports on both the front and back of the load balancers:

**Table 19.8. Application ingress load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
<b>443</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic
<b>80</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic
<b>1936</b>	The worker nodes that run the Ingress Controller pods, by default. You must configure the <b>/healthz/ready</b> endpoint for the ingress health check probe.	X	X	HTTP traffic

**NOTE**

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

**NOTE**

A working configuration for the Ingress router is required for an OpenShift Container Platform cluster. You must configure the Ingress router after the control plane initializes.

### 19.1.3.6.1. Example load balancer configuration for user-provisioned clusters

This section provides an example API and application ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an **/etc/haproxy/haproxy.cfg** configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing one load balancing solution over another.

**NOTE**

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

## Example 19.3. Sample API and application ingress load balancer configuration

```

global
log      127.0.0.1 local2
pidfile  /var/run/haproxy.pid
maxconn  4000
daemon

defaults
mode      http
log       global
option    dontlognull
option    http-server-close
option    redispatch
retries   3
timeout   http-request 10s
timeout   queue        1m
timeout   connect      10s
timeout   client        1m
timeout   server        1m
timeout   http-keep-alive 10s
timeout   check         10s
maxconn   3000

frontend stats
bind *:1936
mode      http
log       global
maxconn  10
stats enable
stats hide-version
stats refresh 30s
stats show-node
stats show-desc Stats for ocp4 cluster 1
stats auth admin:ocp4
stats uri /stats

listen api-server-6443 2
bind *:6443
mode tcp
server bootstrap bootstrap.ocp4.example.com:6443 check inter 1s backup 3
server master0 master0.ocp4.example.com:6443 check inter 1s
server master1 master1.ocp4.example.com:6443 check inter 1s
server master2 master2.ocp4.example.com:6443 check inter 1s

listen machine-config-server-22623 4
bind *:22623
mode tcp
server bootstrap bootstrap.ocp4.example.com:22623 check inter 1s backup 5
server master0 master0.ocp4.example.com:22623 check inter 1s
server master1 master1.ocp4.example.com:22623 check inter 1s
server master2 master2.ocp4.example.com:22623 check inter 1s

listen ingress-router-443 6
bind *:443
mode tcp
balance source
server worker0 worker0.ocp4.example.com:443 check inter 1s
server worker1 worker1.ocp4.example.com:443 check inter 1s

listen ingress-router-80 7

```

```
bind *:80
mode tcp
balance source
server worker0 worker0.ocp4.example.com:80 check inter 1s
server worker1 worker1.ocp4.example.com:80 check inter 1s
```

- 1 In the example, the cluster name is **ocp4**.
- 2 Port **6443** handles the Kubernetes API traffic and points to the control plane machines.
- 3 5 The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.
- 4 Port **22623** handles the machine config server traffic and points to the control plane machines.
- 6 Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.
- 7 Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



#### NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

#### TIP

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltp** on the HAProxy node.



#### NOTE

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running **setsebool -P haproxy\_connect\_any=1**.

### 19.1.4. Preparing the user-provisioned infrastructure

Before you install OpenShift Container Platform on user-provisioned infrastructure, you must prepare the underlying infrastructure.

This section provides details about the high-level steps required to set up your cluster infrastructure in preparation for an OpenShift Container Platform installation. This includes configuring IP networking and network connectivity for your cluster nodes, enabling the required ports through your firewall, and setting up the required DNS and load balancing infrastructure.

After preparation, your cluster infrastructure must meet the requirements outlined in the *Requirements for a cluster with user-provisioned infrastructure* section.

## Prerequisites

- You have reviewed the [OpenShift Container Platform 4.x Tested Integrations](#) page.
- You have reviewed the infrastructure requirements detailed in the *Requirements for a cluster with user-provisioned infrastructure* section.

## Procedure

1. If you are using DHCP to provide the IP networking configuration to your cluster nodes, configure your DHCP service.
  - a. Add persistent IP addresses for the nodes to your DHCP server configuration. In your configuration, match the MAC address of the relevant network interface to the intended IP address for each node.
  - b. When you use DHCP to configure IP addressing for the cluster machines, the machines also obtain the DNS server information through DHCP. Define the persistent DNS server address that is used by the cluster nodes through your DHCP server configuration.



### NOTE

If you are not using a DHCP service, you must provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

- c. Define the hostnames of your cluster nodes in your DHCP server configuration. See the *Setting the cluster node hostnames through DHCP* section for details about hostname considerations.



### NOTE

If you are not using a DHCP service, the cluster nodes obtain their hostname through a reverse DNS lookup.

2. Ensure that your network infrastructure provides the required network connectivity between the cluster components. See the *Networking requirements for user-provisioned infrastructure* section for details about the requirements.
3. Configure your firewall to enable the ports required for the OpenShift Container Platform cluster components to communicate. See *Networking requirements for user-provisioned infrastructure* section for details about the ports that are required.
4. Setup the required DNS infrastructure for your cluster.
  - a. Configure DNS name resolution for the Kubernetes API, the application wildcard, the bootstrap machine, the control plane machines, and the compute machines.
  - b. Configure reverse DNS resolution for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.  
See the *User-provisioned DNS requirements* section for more information about the OpenShift Container Platform DNS requirements.

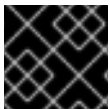
5. Validate your DNS configuration.
  - a. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses in the responses correspond to the correct components.
  - b. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names in the responses correspond to the correct components.  
See the *Validating DNS resolution for user-provisioned infrastructure* section for detailed DNS validation steps.
6. Provision the required API and application ingress load balancing infrastructure. See the *Load balancing requirements for user-provisioned infrastructure* section for more information about the requirements.

**NOTE**

Some load balancing solutions require the DNS name resolution for the cluster nodes to be in place before the load balancing is initialized.

### 19.1.5. Validating DNS resolution for user-provisioned infrastructure

You can validate your DNS configuration before installing OpenShift Container Platform on user-provisioned infrastructure.

**IMPORTANT**

The validation steps detailed in this section must succeed before you install your cluster.

#### Prerequisites

- You have configured the required DNS records for your user-provisioned infrastructure.

#### Procedure

1. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses contained in the responses correspond to the correct components.
  - a. Perform a lookup against the Kubernetes API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api.<cluster_name>.<base_domain> 1
```

- 1** Replace **<nameserver\_ip>** with the IP address of the nameserver, **<cluster\_name>** with your cluster name, and **<base\_domain>** with your base domain name.

#### Example output

```
api.ocp4.example.com. 0 IN A 192.168.1.5
```

- b. Perform a lookup against the Kubernetes internal API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api-int.<cluster_name>.<base_domain>
```

#### Example output

```
api-int.ocp4.example.com. 0 IN A 192.168.1.5
```

- c. Test an example **\*.apps.<cluster\_name>.<base\_domain>** DNS wildcard lookup. All of the application wildcard lookups must resolve to the IP address of the application ingress load balancer:

```
$ dig +noall +answer @<nameserver_ip> random.apps.<cluster_name>.<base_domain>
```

#### Example output

```
random.apps.ocp4.example.com. 0 IN A 192.168.1.5
```



#### NOTE

In the example outputs, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

You can replace **random** with another wildcard value. For example, you can query the route to the OpenShift Container Platform console:

```
$ dig +noall +answer @<nameserver_ip> console-openshift-console.apps.<cluster_name>.<base_domain>
```

#### Example output

```
console-openshift-console.apps.ocp4.example.com. 0 IN A 192.168.1.5
```

- d. Run a lookup against the bootstrap DNS record name. Check that the result points to the IP address of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> bootstrap.<cluster_name>.<base_domain>
```

#### Example output

```
bootstrap.ocp4.example.com. 0 IN A 192.168.1.96
```

- e. Use this method to perform lookups against the DNS record names for the control plane and compute nodes. Check that the results correspond to the IP addresses of each node.
2. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names contained in the responses correspond to the correct components.

- a. Perform a reverse lookup against the IP address of the API load balancer. Check that the response includes the record names for the Kubernetes API and the Kubernetes internal API:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.5
```

### Example output

```
5.1.168.192.in-addr.arpa. 0 IN PTR api-int.ocp4.example.com. 1  
5.1.168.192.in-addr.arpa. 0 IN PTR api.ocp4.example.com. 2
```

- 1 Provides the record name for the Kubernetes internal API.
- 2 Provides the record name for the Kubernetes API.



### NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard. No validation step is needed for reverse DNS resolution against the IP address of the application ingress load balancer.

- b. Perform a reverse lookup against the IP address of the bootstrap node. Check that the result points to the DNS record name of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.96
```

### Example output

```
96.1.168.192.in-addr.arpa. 0 IN PTR bootstrap.ocp4.example.com.
```

- c. Use this method to perform reverse lookups against the IP addresses for the control plane and compute nodes. Check that the results correspond to the DNS record names of each node.

## 19.1.6. Generating a key pair for cluster node SSH access

During an OpenShift Container Platform installation, you can provide an SSH public key to the installation program. The key is passed to the Red Hat Enterprise Linux CoreOS (RHCOS) nodes through their Ignition config files and is used to authenticate SSH access to the nodes. The key is added to the `~/.ssh/authorized_keys` list for the **core** user on each node, which enables password-less authentication.

After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user **core**. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

If you want to SSH in to your cluster nodes to perform installation debugging or disaster recovery, you must provide the SSH public key during the installation process. The `./openshift-install gather` command also requires the SSH public key to be in place on the cluster nodes.



**IMPORTANT**

Do not skip this procedure in production environments, where disaster recovery and debugging is required.

**NOTE**

You must use a local key, not one that you configured with platform-specific approaches such as [AWS key pairs](#).

**Procedure**

1. If you do not have an existing SSH key pair on your local machine to use for authentication onto your cluster nodes, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t ed25519 -N "" -f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_ed25519`, of the new SSH key. If you have an existing key pair, ensure your public key is in the your `~/.ssh` directory.

**NOTE**

If you plan to install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

```
$ cat <path>/<file_name>.pub
```

For example, run the following to view the `~/.ssh/id_ed25519.pub` public key:

```
$ cat ~/.ssh/id_ed25519.pub
```

3. Add the SSH private key identity to the SSH agent for your local user, if it has not already been added. SSH agent management of the key is required for password-less SSH authentication onto your cluster nodes, or if you want to use the `./openshift-install gather` command.

**NOTE**

On some distributions, default SSH private key identities such as `~/.ssh/id_rsa` and `~/.ssh/id_dsa` are managed automatically.

- a. If the **ssh-agent** process is not already running for your local user, start it as a background task:

```
$ eval "$(ssh-agent -s)"
```

**Example output**

Agent pid 31874



#### NOTE

If your cluster is in FIPS mode, only use FIPS-compliant algorithms to generate the SSH key. The key must be either RSA or ECDSA.

4. Add your SSH private key to the **ssh-agent**:

```
$ ssh-add <path>/<file_name> 1
```

- 1** Specify the path and file name for your SSH private key, such as `~/.ssh/id_ed25519`

#### Example output

```
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

#### Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program. If you install a cluster on infrastructure that you provision, you must provide the key to the installation program.

### 19.1.7. Obtaining the installation program

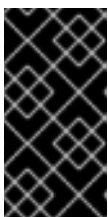
Before you install OpenShift Container Platform, download the installation file on a local computer.

#### Prerequisites

- You have a computer that runs Linux or macOS, with 500 MB of local disk space

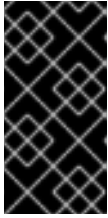
#### Procedure

1. Access the [Infrastructure Provider](#) page on the OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. Select your infrastructure provider.
3. Navigate to the page for your installation type, download the installation program for your operating system, and place the file in the directory where you will store the installation configuration files.



#### IMPORTANT

The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both files are required to delete the cluster.

**IMPORTANT**

Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

4. Extract the installation program. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar -xvf openshift-install-linux.tar.gz
```

5. Download your installation [pull secret from the Red Hat OpenShift Cluster Manager](#) . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

**19.1.8. Installing the OpenShift CLI by downloading the binary**

You can install the OpenShift CLI (**oc**) to interact with OpenShift Container Platform from a command-line interface. You can install **oc** on Linux, Windows, or macOS.

**IMPORTANT**

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.9. Download and install the new version of **oc**.

**Installing the OpenShift CLI on Linux**

You can install the OpenShift CLI (**oc**) binary on Linux by using the following procedure.

**Procedure**

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Linux Client** entry and save the file.
4. Unpack the archive:

```
$ tar xvf <file>
```

5. Place the **oc** binary in a directory that is on your **PATH**. To check your **PATH**, execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

**Installing the OpenShift CLI on Windows**

You can install the OpenShift CLI (**oc**) binary on Windows by using the following procedure.

### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:\> path
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
C:\> oc <command>
```

### Installing the OpenShift CLI on macOS

You can install the OpenShift CLI (**oc**) binary on macOS by using the following procedure.

### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version in the **Version** drop-down menu.
3. Click **Download Now** next to the **OpenShift v4.9 MacOSX Client** entry and save the file.
4. Unpack and unzip the archive.
5. Move the **oc** binary to a directory on your **PATH**.  
To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

After you install the OpenShift CLI, it is available using the **oc** command:

```
$ oc <command>
```

## 19.1.9. Manually creating the installation configuration file

For user-provisioned installations of OpenShift Container Platform, you manually generate your installation configuration file.

### Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

## Procedure

1. Create an installation directory to store your required installation assets in:

```
$ mkdir <installation_directory>
```



### IMPORTANT

You must create a directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual files from another cluster installation, you can copy them into your directory. However, the file names for the installation assets might change between releases. Use caution when copying installation files from an earlier OpenShift Container Platform version.

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation\_directory>**.



### NOTE

You must name this configuration file **install-config.yaml**.



### NOTE

For some platform types, you can alternatively run **./openshift-install create install-config --dir <installation\_directory>** to generate an **install-config.yaml** file. You can provide details about your cluster configuration at the prompts.

3. Back up the **install-config.yaml** file so that you can use it to install multiple clusters.



### IMPORTANT

The **install-config.yaml** file is consumed during the next step of the installation process. You must back it up now.

### 19.1.9.1. Sample install-config.yaml file for other platforms

You can customize the **install-config.yaml** file to specify more details about your OpenShift Container Platform cluster's platform or modify the values of the required parameters.

```
apiVersion: v1
baseDomain: example.com 1
compute: 2
- hyperthreading: Enabled 3
  name: worker
```

```

replicas: 0 4
controlPlane: 5
  hyperthreading: Enabled 6
  name: master
  replicas: 3 7
metadata:
  name: test 8
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14 9
    hostPrefix: 23 10
  networkType: OpenShiftSDN
  serviceNetwork: 11
  - 172.30.0.0/16
platform:
  none: {} 12
fips: false 13
pullSecret: '{"auths": ...}' 14
sshKey: 'ssh-ed25519 AAAA...' 15

```

- 1** The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.
- 2** **5** The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. Only one control plane pool is used.
- 3** **6** Specifies whether to enable or disable simultaneous multithreading (SMT), or hyperthreading. By default, SMT is enabled to increase the performance of the cores in your machines. You can disable it by setting the parameter value to **Disabled**. If you disable SMT, you must disable it in all cluster machines; this includes both control plane and compute machines.



#### NOTE

Simultaneous multithreading (SMT) is enabled by default. If SMT is not enabled in your BIOS settings, the **hyperthreading** parameter has no effect.



#### IMPORTANT

If you disable **hyperthreading**, whether in the BIOS or in the **install-config.yaml** file, ensure that your capacity planning accounts for the dramatically decreased machine performance.

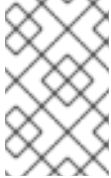
- 4** You must set this value to **0** when you install OpenShift Container Platform on user-provisioned infrastructure. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. In user-provisioned installations, you must manually deploy the compute machines before you finish installing the cluster.



#### NOTE

If you are installing a three-node cluster, do not deploy any compute machines when you install the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

- 7 The number of control plane machines that you add to the cluster. Because the cluster uses these values as the number of etcd endpoints in the cluster, the value must match the number of control
- 8 The cluster name that you specified in your DNS records.
- 9 A block of IP addresses from which pod IP addresses are allocated. This block must not overlap with existing physical networks. These IP addresses are used for the pod network. If you need to access the pods from an external network, you must configure load balancers and routers to manage the traffic.



#### NOTE

Class E CIDR range is reserved for a future use. To use the Class E CIDR range, you must ensure your networking environment accepts the IP addresses within the Class E CIDR range.

- 10 The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23**, then each node is assigned a **/23** subnet out of the given **cidr**, which allows for 510 ( $2^{(32 - 23)} - 2$ ) pod IP addresses. If you are required to provide access to nodes from an external network, configure load balancers and routers to manage the traffic.
- 11 The IP address pool to use for service IP addresses. You can enter only one IP address pool. This block must not overlap with existing physical networks. If you need to access the services from an external network, configure load balancers and routers to manage the traffic.
- 12 You must set the platform to **none**. You cannot provide additional platform configuration variables for your platform.



#### IMPORTANT

Clusters that are installed with the platform type **none** are unable to use some features, such as managing compute machines with the Machine API. This limitation applies even if the compute machines that are attached to the cluster are installed on a platform that would normally support the feature. This parameter cannot be changed after installation.

- 13 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.



#### IMPORTANT

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86\_64** architecture.

- 14 The [pull secret from the Red Hat OpenShift Cluster Manager](#) . This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.
- 15 The SSH public key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).

**NOTE**

For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your **ssh-agent** process uses.

**19.1.9.2. Configuring the cluster-wide proxy during installation**

Production environments can deny direct access to the internet and instead have an HTTP or HTTPS proxy available. You can configure a new OpenShift Container Platform cluster to use a proxy by configuring the proxy settings in the **install-config.yaml** file.

**Prerequisites**

- You have an existing **install-config.yaml** file.
- You reviewed the sites that your cluster requires access to and determined whether any of them need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. You added sites to the **Proxy** object's **spec.noProxy** field to bypass the proxy if necessary.

**NOTE**

The **Proxy** object **status.noProxy** field is populated with the values of the **networking.machineNetwork[].cidr**, **networking.clusterNetwork[].cidr**, and **networking.serviceNetwork[]** fields from your installation configuration.

For installations on Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and Red Hat OpenStack Platform (RHOSP), the **Proxy** object **status.noProxy** field is also populated with the instance metadata endpoint (**169.254.169.254**).

**Procedure**

1. Edit your **install-config.yaml** file and add the proxy settings. For example:

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> 1
  httpsProxy: https://<username>:<pswd>@<ip>:<port> 2
  noProxy: example.com 3
additionalTrustBundle: | 4
  -----BEGIN CERTIFICATE-----
  <MY_TRUSTED_CA_CERT>
  -----END CERTIFICATE-----
...
```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.



- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with `.` to match subdomains only. For
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace to hold the additional CA certificates. If you provide **additionalTrustBundle** and at least one proxy setting, the **Proxy** object is configured to reference the **user-ca-bundle** config map in the **trustedCA** field. The Cluster Network Operator then creates a **trusted-ca-bundle** config map that merges the contents specified for the **trustedCA** parameter with the RHCOS trust bundle. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.

**NOTE**

The installation program does not support the proxy **readinessEndpoints** field.

2. Save the file and reference it when installing OpenShift Container Platform.

The installation program creates a cluster-wide proxy that is named **cluster** that uses the proxy settings in the provided **install-config.yaml** file. If no proxy settings are provided, a **cluster Proxy** object is still created, but it will have a nil **spec**.

**NOTE**

Only the **Proxy** object named **cluster** is supported, and no additional proxies can be created.

### 19.1.9.3. Configuring a three-node cluster

You can optionally deploy zero compute machines in a bare metal cluster that consists of three control plane machines only. This provides smaller, more resource efficient clusters for cluster administrators and developers to use for testing, development, and production.

In three-node OpenShift Container Platform environments, the three control plane machines are schedulable, which means that your application workloads are scheduled to run on them.

#### Prerequisites

- You have an existing **install-config.yaml** file.

#### Procedure

- Ensure that the number of compute replicas is set to **0** in your **install-config.yaml** file, as shown in the following **compute** stanza:

```
compute:
- name: worker
  platform: {}
  replicas: 0
```



## NOTE

You must set the value of the **replicas** parameter for the compute machines to **0** when you install OpenShift Container Platform on user-provisioned infrastructure, regardless of the number of compute machines you are deploying. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. This does not apply to user-provisioned installations, where the compute machines are deployed manually.

For three-node cluster installations, follow these next steps:

- If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes. See the *Load balancing requirements for user-provisioned infrastructure* section for more information.
- When you create the Kubernetes manifest files in the following procedure, ensure that the **mastersSchedulable** parameter in the `<installation_directory>/manifests/cluster-scheduler-02-config.yml` file is set to **true**. This enables your application workloads to run on the control plane nodes.
- Do not deploy any compute nodes when you create the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

### 19.1.10. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.



## IMPORTANT

- The Ignition config files that the OpenShift Container Platform installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

### Prerequisites

- You obtained the OpenShift Container Platform installation program.

- You created the **install-config.yaml** installation configuration file.

## Procedure

- Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

- For **<installation\_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.



### WARNING

If you are installing a three-node cluster, skip the following step to allow the control plane nodes to be schedulable.



### IMPORTANT

When you configure control plane nodes from the default unschedulable to schedulable, additional subscriptions are required. This is because control plane nodes then become worker nodes.

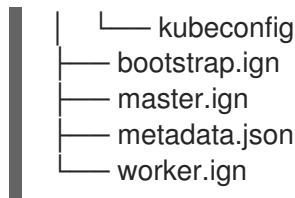
- Check that the **mastersSchedulable** parameter in the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:
  - Open the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** file.
  - Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.
  - Save and exit the file.
- To create the Ignition configuration files, run the following command from the directory that contains the installation program:

```
$ ./openshift-install create ignition-configs --dir <installation_directory> 1
```

- For **<installation\_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation\_directory>/auth** directory:

```
.
├── auth
│   ├── kubeadmin-password
```



### 19.1.11. Installing RHCOS and starting the OpenShift Container Platform bootstrap process

To install OpenShift Container Platform on bare metal infrastructure that you provision, you must install Red Hat Enterprise Linux CoreOS (RHCOS) on the machines. When you install RHCOS, you must provide the Ignition config file that was generated by the OpenShift Container Platform installation program for the type of machine you are installing. If you have configured suitable networking, DNS, and load balancing infrastructure, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS machines have rebooted.

To install RHCOS on the machines, follow either the steps to use an ISO image or network PXE booting.



#### NOTE

The compute node deployment steps included in this installation document are RHCOS-specific. If you choose instead to deploy RHEL-based compute nodes, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and planned for removal in a future release of OpenShift Container Platform 4.

You can configure RHCOS during ISO and PXE installations by using the following methods:

- **Kernel arguments:** You can use kernel arguments to provide installation-specific information. For example, you can specify the locations of the RHCOS installation files that you uploaded to your HTTP server and the location of the Ignition config file for the type of node you are installing. For a PXE installation, you can use the **APPEND** parameter to pass the arguments to the kernel of the live installer. For an ISO installation, you can interrupt the live installation boot process to add the kernel arguments. In both installation cases, you can use special **coreos.inst.\*** arguments to direct the live installer, as well as standard installation boot arguments for turning standard kernel services on or off.
- **Ignition configs:** OpenShift Container Platform Ignition config files (**\*.ign**) are specific to the type of node you are installing. You pass the location of a bootstrap, control plane, or compute node Ignition config file during the RHCOS installation so that it takes effect on first boot. In special cases, you can create a separate, limited Ignition config to pass to the live system. That Ignition config could do a certain set of tasks, such as reporting success to a provisioning system after completing installation. This special Ignition config is consumed by the **coreos-installer** to be applied on first boot of the installed system. Do not provide the standard control plane and compute node Ignition configs to the live ISO directly.
- **coreos-installer:** You can boot the live ISO installer to a shell prompt, which allows you to prepare the permanent system in a variety of ways before first boot. In particular, you can run the **coreos-installer** command to identify various artifacts to include, work with disk partitions, and set up networking. In some cases, you can configure features on the live system and copy them to the installed system.

Whether to use an ISO or PXE install depends on your situation. A PXE install requires an available DHCP service and more preparation, but can make the installation process more automated. An ISO install is a more manual process and can be inconvenient if you are setting up more than a few machines.



## NOTE

As of OpenShift Container Platform 4.6, the RHCOS ISO and other installation artifacts provide support for installation on disks with 4K sectors.

### 19.1.11.1. Installing RHCOS by using an ISO image

You can use an ISO image to install RHCOS on the machines.

#### Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have an HTTP server that can be accessed from your computer, and from the machines that you create.
- You have reviewed the *Advanced RHCOS installation configuration* section for different ways to configure features, such as networking and disk partitioning.

#### Procedure

1. Obtain the SHA512 digest for each of your Ignition config files. For example, you can use the following on a system running Linux to get the SHA512 digest for your **bootstrap.ign** Ignition config file:

```
$ sha512sum <installation_directory>/bootstrap.ign
```

The digests are provided to the **coreos-installer** in a later step to validate the authenticity of the Ignition config files on the cluster nodes.

2. Upload the bootstrap, control plane, and compute node Ignition config files that the installation program created to your HTTP server. Note the URLs of these files.



## IMPORTANT

You can add or change configuration settings in your Ignition configs before saving them to your HTTP server. If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

3. From the installation host, validate that the Ignition config files are available on the URLs. The following example gets the Ignition config file for the bootstrap node:

```
$ curl -k http://<HTTP_server>/bootstrap.ign 1
```

#### Example output

```
% Total    % Received % Xferd Average Speed   Time    Time     Time  Current
           Dload  Upload  Total   Spent    Left    Speed
```

```
0 0 0 0 0 0 0 0 0 --:--:-- --:--:-- --:--:-- 0{"ignition":
{"version":"3.2.0"},"passwd":{"users":[{"name":"core","sshAuthorizedKeys":["ssh-rsa...
```

Replace **bootstrap.ign** with **master.ign** or **worker.ign** in the command to validate that the Ignition config files for the control plane and compute nodes are also available.

- Although it is possible to obtain the RHCOS images that are required for your preferred method of installing operating system instances from the [RHCOS image mirror](#) page, the recommended way to obtain the correct version of your RHCOS images are from the output of **openshift-install** command:

```
$ openshift-install coreos print-stream-json | grep '\.iso[^\.]'
```

### Example output

```
"location": "<url>/art/storage/releases/rhcos-4.9-aarch64/<release>/aarch64/rhcos-
<release>-live.aarch64.iso",
"location": "<url>/art/storage/releases/rhcos-4.9-ppc64le/<release>/ppc64le/rhcos-<release>-
live.ppc64le.iso",
"location": "<url>/art/storage/releases/rhcos-4.9-s390x/<release>/s390x/rhcos-<release>-
live.s390x.iso",
"location": "<url>/art/storage/releases/rhcos-4.9/<release>/x86_64/rhcos-<release>-
live.x86_64.iso",
```



### IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image versions that match your OpenShift Container Platform version if they are available. Use only ISO images for this procedure. RHCOS qcow2 images are not supported for this installation type.

ISO file names resemble the following example:

**rhcos-<version>-live.<architecture>.iso**

- Use the ISO to start the RHCOS installation. Use one of the following installation options:
  - Burn the ISO image to a disk and boot it directly.
  - Use ISO redirection by using a lights-out management (LOM) interface.
- Boot the RHCOS ISO image without specifying any options or interrupting the live boot sequence. Wait for the installer to boot into a shell prompt in the RHCOS live environment.



### NOTE

It is possible to interrupt the RHCOS installation boot process to add kernel arguments. However, for this ISO procedure you should use the **coreos-installer** command as outlined in the following steps, instead of adding kernel arguments.

- Run the **coreos-installer** command and specify the options that meet your installation requirements. At a minimum, you must specify the URL that points to the Ignition config file for the node type, and the device that you are installing to:

```
$ sudo coreos-installer install --ignition-url=http://<HTTP_server>/<node_type>.ign <device>
--ignition-hash=sha512-<digest> 1 2
```

- You must run the **coreos-installer** command by using **sudo**, because the **core** user does not have the required root privileges to perform the installation.
- The **--ignition-hash** option is required when the Ignition config file is obtained through an HTTP URL to validate the authenticity of the Ignition config file on the cluster node. **<digest>** is the Ignition config file SHA512 digest obtained in a preceding step.



#### NOTE

If you want to provide your Ignition config files through an HTTPS server that uses TLS, you can add the internal certificate authority (CA) to the system trust store before running **coreos-installer**.

The following example initializes a bootstrap node installation to the **/dev/sda** device. The Ignition config file for the bootstrap node is obtained from an HTTP web server with the IP address 192.168.1.2:

```
$ sudo coreos-installer install --ignition-
url=http://192.168.1.2:80/installation_directory/bootstrap.ign /dev/sda --ignition-hash=sha512-
a5a2d43879223273c9b60af66b44202a1d1248fc01cf156c46d4a79f552b6bad47bc8cc78ddf011
6e80c59d2ea9e32ba53bc807afbca581aa059311def2c3e3b
```

- Monitor the progress of the RHCOS installation on the console of the machine.



#### IMPORTANT

Be sure that the installation is successful on each node before commencing with the OpenShift Container Platform installation. Observing the installation process can also help to determine the cause of RHCOS installation issues that might arise.

- After RHCOS installs, you must reboot the system. During the system reboot, it applies the Ignition config file that you specified.
- Continue to create the other machines for your cluster.



#### IMPORTANT

You must create the bootstrap and control plane machines at this time. If the control plane machines are not made schedulable, also create at least two compute machines before you install OpenShift Container Platform.

If the required network, DNS, and load balancer infrastructure are in place, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS nodes have rebooted.





Replace **bootstrap.ign** with **master.ign** or **worker.ign** in the command to validate that the Ignition config files for the control plane and compute nodes are also available.

- Although it is possible to obtain the RHCOS **kernel**, **initramfs** and **rootfs** files that are required for your preferred method of installing operating system instances from the [RHCOS image mirror](#) page, the recommended way to obtain the correct version of your RHCOS files are from the output of **openshift-install** command:

```
$ openshift-install coreos print-stream-json | grep -Eo "https.*(kernel|initramfs|rootfs.)w+(\.img)?"
```

### Example output

```
"<url>/art/storage/releases/rhcos-4.9-aarch64/<release>/aarch64/rhcos-<release>-live-
kernel-aarch64"
"<url>/art/storage/releases/rhcos-4.9-aarch64/<release>/aarch64/rhcos-<release>-live-
initramfs.aarch64.img"
"<url>/art/storage/releases/rhcos-4.9-aarch64/<release>/aarch64/rhcos-<release>-live-
rootfs.aarch64.img"
"<url>/art/storage/releases/rhcos-4.9-ppc64le/49.84.202110081256-0/ppc64le/rhcos-
<release>-live-kernel-ppc64le"
"<url>/art/storage/releases/rhcos-4.9-ppc64le/<release>/ppc64le/rhcos-<release>-live-
initramfs.ppc64le.img"
"<url>/art/storage/releases/rhcos-4.9-ppc64le/<release>/ppc64le/rhcos-<release>-live-
rootfs.ppc64le.img"
"<url>/art/storage/releases/rhcos-4.9-s390x/<release>/s390x/rhcos-<release>-live-kernel-
s390x"
"<url>/art/storage/releases/rhcos-4.9-s390x/<release>/s390x/rhcos-<release>-live-
initramfs.s390x.img"
"<url>/art/storage/releases/rhcos-4.9-s390x/<release>/s390x/rhcos-<release>-live-
rootfs.s390x.img"
"<url>/art/storage/releases/rhcos-4.9/<release>/x86_64/rhcos-<release>-live-kernel-x86_64"
"<url>/art/storage/releases/rhcos-4.9/<release>/x86_64/rhcos-<release>-live-
initramfs.x86_64.img"
"<url>/art/storage/releases/rhcos-4.9/<release>/x86_64/rhcos-<release>-live-
rootfs.x86_64.img"
```



### IMPORTANT

The RHCOS artifacts might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Only use the appropriate **kernel**, **initramfs**, and **rootfs** artifacts described below for this procedure. RHCOS QCOW2 images are not supported for this installation type.

The file names contain the OpenShift Container Platform version number. They resemble the following examples:

- **kernel:** rhcos-<version>-live-kernel-<architecture>
- **initramfs:** rhcos-<version>-live-initramfs.<architecture>.img
- **rootfs:** rhcos-<version>-live-rootfs.<architecture>.img

4. Upload the **rootfs**, **kernel**, and **initramfs** files to your HTTP server.



### IMPORTANT

If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

5. Configure the network boot infrastructure so that the machines boot from their local disks after RHCOS is installed on them.
6. Configure PXE or iPXE installation for the RHCOS images and begin the installation. Modify one of the following example menu entries for your environment and verify that the image and Ignition files are properly accessible:

- For PXE:

```

DEFAULT pxeboot
TIMEOUT 20
PROMPT 0
LABEL pxeboot
  KERNEL http://<HTTP_server>/rhcos-<version>-live-kernel-<architecture> 1
  APPEND initrd=http://<HTTP_server>/rhcos-<version>-live-initramfs.
<architecture>.img coreos.live.rootfs_url=http://<HTTP_server>/rhcos-<version>-live-
rootfs.<architecture>.img coreos.inst.install_dev=/dev/sda
coreos.inst.ignition_url=http://<HTTP_server>/bootstrap.ign 2 3

```

- 1** Specify the location of the live **kernel** file that you uploaded to your HTTP server. The URL must be HTTP, TFTP, or FTP; HTTPS and NFS are not supported.
- 2** If you use multiple NICs, specify a single interface in the **ip** option. For example, to use DHCP on a NIC that is named **eno1**, set **ip=eno1:dhcp**.
- 3** Specify the locations of the RHCOS files that you uploaded to your HTTP server. The **initrd** parameter value is the location of the **initramfs** file, the **coreos.live.rootfs\_url** parameter value is the location of the **rootfs** file, and the **coreos.inst.ignition\_url** parameter value is the location of the bootstrap Ignition config file. You can also add more kernel arguments to the **APPEND** line to configure networking or other boot options.



### NOTE

This configuration does not enable serial console access on machines with a graphical console. To configure a different console, add one or more **console=** arguments to the **APPEND** line. For example, add **console=tty0 console=ttyS0** to set the first PC serial port as the primary console and the graphical console as a secondary console. For more information, see [How does one set up a serial terminal and/or console in Red Hat Enterprise Linux?](#)

- For iPXE:

```

kernel http://<HTTP_server>/rhcos-<version>-live-kernel-<architecture> initrd=main
coreos.live.rootfs_url=http://<HTTP_server>/rhcos-<version>-live-rootfs.

```

```
<architecture>.img coreos.inst.install_dev=/dev/sda
coreos.inst.ignition_url=http://<HTTP_server>/bootstrap.ign 1 2
initrd --name main http://<HTTP_server>/rhcos-<version>-live-initramfs.
<architecture>.img 3
boot
```

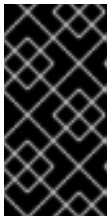
- 1 Specify the locations of the RHCOS files that you uploaded to your HTTP server. The **kernel** parameter value is the location of the **kernel** file, the **initrd=main** argument is needed for booting on UEFI systems, the **coreos.live.rootfs\_url** parameter value is the location of the **rootfs** file, and the **coreos.inst.ignition\_url** parameter value is the location of the bootstrap Ignition config file.
- 2 If you use multiple NICs, specify a single interface in the **ip** option. For example, to use DHCP on a NIC that is named **eno1**, set **ip=eno1:dhcp**.
- 3 Specify the location of the **initramfs** file that you uploaded to your HTTP server.



### NOTE

This configuration does not enable serial console access on machines with a graphical console. To configure a different console, add one or more **console=** arguments to the **kernel** line. For example, add **console=tty0** **console=ttyS0** to set the first PC serial port as the primary console and the graphical console as a secondary console. For more information, see [How does one set up a serial terminal and/or console in Red Hat Enterprise Linux?](#)

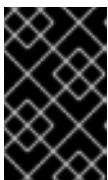
7. Monitor the progress of the RHCOS installation on the console of the machine.



### IMPORTANT

Be sure that the installation is successful on each node before commencing with the OpenShift Container Platform installation. Observing the installation process can also help to determine the cause of RHCOS installation issues that might arise.

8. After RHCOS installs, the system reboots. During reboot, the system applies the Ignition config file that you specified.
9. Continue to create the machines for your cluster.



### IMPORTANT

You must create the bootstrap and control plane machines at this time. If the control plane machines are not made schedulable, also create at least two compute machines before you install the cluster.

If the required network, DNS, and load balancer infrastructure are in place, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS nodes have rebooted.



## NOTE

RHCOS nodes do not include a default password for the **core** user. You can access the nodes by running **ssh core@<node>.<cluster\_name>.<base\_domain>** as a user with access to the SSH private key that is paired to the public key that you specified in your **install\_config.yaml** file. OpenShift Container Platform 4 cluster nodes running RHCOS are immutable and rely on Operators to apply cluster changes. Accessing cluster nodes by using SSH is not recommended. However, when investigating installation issues, if the OpenShift Container Platform API is not available, or the kubelet is not properly functioning on a target node, SSH access might be required for debugging or disaster recovery.

### 19.1.11.3. Advanced RHCOS installation configuration

A key benefit for manually provisioning the Red Hat Enterprise Linux CoreOS (RHCOS) nodes for OpenShift Container Platform is to be able to do configuration that is not available through default OpenShift Container Platform installation methods. This section describes some of the configurations that you can do using techniques that include:

- Passing kernel arguments to the live installer
- Running **coreos-installer** manually from the live system
- Embedding Ignition configs in an ISO

The advanced configuration topics for manual Red Hat Enterprise Linux CoreOS (RHCOS) installations detailed in this section relate to disk partitioning, networking, and using Ignition configs in different ways.

#### 19.1.11.3.1. Using advanced networking options for PXE and ISO installations

Networking for OpenShift Container Platform nodes uses DHCP by default to gather all necessary configuration settings. To set up static IP addresses or configure special settings, such as bonding, you can do one of the following:

- Pass special kernel parameters when you boot the live installer.
- Use a machine config to copy networking files to the installed system.
- Configure networking from a live installer shell prompt, then copy those settings to the installed system so that they take effect when the installed system first boots.

To configure a PXE or iPXE installation, use one of the following options:

- See the "Advanced RHCOS installation reference" tables.
- Use a machine config to copy networking files to the installed system.

To configure an ISO installation, use the following procedure.

#### Procedure

1. Boot the ISO installer.
2. From the live system shell prompt, configure networking for the live system using available RHEL tools, such as **nmcli** or **nmtui**.

- Run the **coreos-installer** command to install the system, adding the **--copy-network** option to copy networking configuration. For example:

```
$ sudo coreos-installer install --copy-network \
  --ignition-url=http://host/worker.ign /dev/sda
```



### IMPORTANT

The **--copy-network** option only copies networking configuration found under **/etc/NetworkManager/system-connections**. In particular, it does not copy the system hostname.

- Reboot into the installed system.

### Additional resources

- See [Getting started with nmcli](#) and [Getting started with nmtui](#) in the RHEL 8 documentation for more information about the **nmcli** and **nmtui** tools.

#### 19.1.11.3.2. Disk partitioning

The disk partitions are created on OpenShift Container Platform cluster nodes during the Red Hat Enterprise Linux CoreOS (RHCOS) installation. Each RHCOS node of a particular architecture uses the same partition layout, unless the default partitioning configuration is overridden. During the RHCOS installation, the size of the root file system is increased to use the remaining available space on the target device.

There are two cases where you might want to override the default partitioning when installing RHCOS on an OpenShift Container Platform cluster node:

- Creating separate partitions: For greenfield installations on an empty disk, you might want to add separate storage to a partition. This is officially supported for mounting **/var** or a subdirectory of **/var**, such as **/var/lib/etcd**, on a separate partition, but not both.



### IMPORTANT

For disk sizes larger than 100GB, and especially disk sizes larger than 1TB, create a separate **/var** partition. See "Creating a separate **/var** partition" and this [Red Hat Knowledgebase article](#) for more information.



### IMPORTANT

Kubernetes supports only two file system partitions. If you add more than one partition to the original configuration, Kubernetes cannot monitor all of them.

- Retaining existing partitions: For a brownfield installation where you are reinstalling OpenShift Container Platform on an existing node and want to retain data partitions installed from your previous operating system, there are both boot arguments and options to **coreos-installer** that allow you to retain existing data partitions.

**WARNING**

The use of custom partitions could result in those partitions not being monitored by OpenShift Container Platform or alerted on. If you are overriding the default partitioning, see [Understanding OpenShift File System Monitoring \(eviction conditions\)](#) for more information about how OpenShift Container Platform monitors your host file systems.

**19.1.11.3.2.1. Creating a separate `/var` partition**

In general, you should use the default disk partitioning that is created during the RHCOS installation. However, there are cases where you might want to create a separate partition for a directory that you expect to grow.

OpenShift Container Platform supports the addition of a single partition to attach storage to either the `/var` directory or a subdirectory of `/var`. For example:

- **`/var/lib/containers`**: Holds container-related content that can grow as more images and containers are added to a system.
- **`/var/lib/etcd`**: Holds data that you might want to keep separate for purposes such as performance optimization of etcd storage.
- **`/var`**: Holds data that you might want to keep separate for purposes such as auditing.

**IMPORTANT**

For disk sizes larger than 100GB, and especially larger than 1TB, create a separate `/var` partition.

Storing the contents of a `/var` directory separately makes it easier to grow storage for those areas as needed and reinstall OpenShift Container Platform at a later date and keep that data intact. With this method, you will not have to pull all your containers again, nor will you have to copy massive log files when you update systems.

The use of a separate partition for the `/var` directory or a subdirectory of `/var` also prevents data growth in the partitioned directory from filling up the root file system.

The following procedure sets up a separate `/var` partition by adding a machine config manifest that is wrapped into the Ignition config file for a node type during the preparation phase of an installation.

**Procedure**

1. On your installation host, change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

```
$ openshift-install create manifests --dir <installation_directory>
```

2. Create a Butane config that configures the additional partition. For example, name the file **`$HOME/clusterconfig/98-var-partition.bu`**, change the disk device name to the name of the storage device on the **worker** systems, and set the storage size as appropriate. This example

places the **/var** directory on a separate partition:

```
variant: openshift
version: 4.9.0
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 98-var-partition
storage:
  disks:
    - device: /dev/<device_name> ❶
    partitions:
      - label: var
        start_mib: <partition_start_offset> ❷
        size_mib: <partition_size> ❸
    filesystems:
      - device: /dev/disk/by-partlabel/var
        path: /var
        format: xfs
        mount_options: [defaults, prjquota] ❹
        with_mount_unit: true
```

- ❶ The storage device name of the disk that you want to partition.
- ❷ When adding a data partition to the boot disk, a minimum offset value of 25000 mebibytes is recommended. The root file system is automatically resized to fill all available space up to the specified offset. If no offset value is specified, or if the specified value is smaller than the recommended minimum, the resulting root file system will be too small, and future reinstalls of RHCOS might overwrite the beginning of the data partition.
- ❸ The size of the data partition in mebibytes.
- ❹ The **prjquota** mount option must be enabled for filesystems used for container storage.



## NOTE

When creating a separate **/var** partition, you cannot use different instance types for compute nodes, if the different instance types do not have the same device name.

3. Create a manifest from the Butane config and save it to the **clusterconfig/openshift** directory. For example, run the following command:

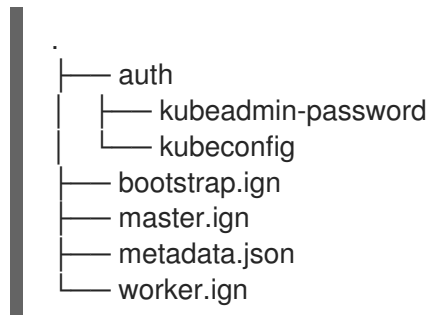
```
$ butane $HOME/clusterconfig/98-var-partition.bu -o $HOME/clusterconfig/openshift/98-var-partition.yaml
```

4. Create the Ignition config files:

```
$ openshift-install create ignition-configs --dir <installation_directory> ❶
```

- ❶ For **<installation\_directory>**, specify the same installation directory.

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory:



The files in the `<installation_directory>/manifest` and `<installation_directory>/openshift` directories are wrapped into the Ignition config files, including the file that contains the **98-var-partition** custom **MachineConfig** object.

### Next steps

- You can apply the custom disk partitioning by referencing the Ignition config files during the RHCOS installations.

#### 19.11.3.2.2. Retaining existing partitions

For an ISO installation, you can add options to the **coreos-installer** command that cause the installer to maintain one or more existing partitions. For a PXE installation, you can add **coreos.inst.\*** options to the **APPEND** parameter to preserve partitions.

Saved partitions might be data partitions from an existing OpenShift Container Platform system. You can identify the disk partitions you want to keep either by partition label or by number.



#### NOTE

If you save existing partitions, and those partitions do not leave enough space for RHCOS, the installation will fail without damaging the saved partitions.

### Retaining existing partitions during an ISO installation

This example preserves any partition in which the partition label begins with **data** (**data\***):

```
# coreos-installer install --ignition-url http://10.0.2.2:8080/user.ign \
  --save-partlabel 'data*' /dev/sda
```

The following example illustrates running the **coreos-installer** in a way that preserves the sixth (6) partition on the disk:

```
# coreos-installer install --ignition-url http://10.0.2.2:8080/user.ign \
  --save-partindex 6 /dev/sda
```

This example preserves partitions 5 and higher:

```
# coreos-installer install --ignition-url http://10.0.2.2:8080/user.ign \
  --save-partindex 5- /dev/sda
```



In the previous examples where partition saving is used, **coreos-installer** recreates the partition immediately.

### Retaining existing partitions during a PXE installation

This **APPEND** option preserves any partition in which the partition label begins with 'data' ('data\*'):

```
coreos.inst.save_partlabel=data*
```

This **APPEND** option preserves partitions 5 and higher:

```
coreos.inst.save_partindex=5-
```

This **APPEND** option preserves partition 6:

```
coreos.inst.save_partindex=6
```

#### 19.1.11.3.3. Identifying Ignition configs

When doing an RHCOS manual installation, there are two types of Ignition configs that you can provide, with different reasons for providing each one:

- **Permanent install Ignition config:** Every manual RHCOS installation needs to pass one of the Ignition config files generated by **openshift-installer**, such as **bootstrap.ign**, **master.ign** and **worker.ign**, to carry out the installation.



#### IMPORTANT

It is not recommended to modify these Ignition config files directly. You can update the manifest files that are wrapped into the Ignition config files, as outlined in examples in the preceding sections.

For PXE installations, you pass the Ignition configs on the **APPEND** line using the **coreos.inst.ignition\_url=** option. For ISO installations, after the ISO boots to the shell prompt, you identify the Ignition config on the **coreos-installer** command line with the **--ignition-url=** option. In both cases, only HTTP and HTTPS protocols are supported.

- **Live install Ignition config:** This type must be created manually and should be avoided if possible, as it is not supported by Red Hat. With this method, the Ignition config passes to the live install medium, runs immediately upon booting, and performs setup tasks before and/or after the RHCOS system installs to disk. This method should only be used for performing tasks that must be done once and not applied again later, such as with advanced partitioning that cannot be done using a machine config.

For PXE or ISO boots, you can create the Ignition config and **APPEND** the **ignition.config.url=** option to identify the location of the Ignition config. You also need to append **ignition.firstboot** **ignition.platform.id=metal** or the **ignition.config.url** option will be ignored.

##### 19.1.11.3.3.1. Embedding a live install Ignition config in the RHCOS ISO

You can embed a live install Ignition config directly in an RHCOS ISO image. When the ISO image is booted, the embedded config will be applied automatically.

#### Procedure

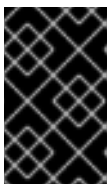
1. Download the **coreos-installer** binary from the following image mirror page:  
<https://mirror.openshift.com/pub/openshift-v4/clients/coreos-installer/latest/>.
2. Retrieve the RHCOS ISO image and the Ignition config file, and copy them into an accessible directory, such as **/mnt**:

```
# cp rhcos-<version>-live.x86_64.iso bootstrap.ign /mnt/
# chmod 644 /mnt/rhcos-<version>-live.x86_64.iso
```

3. Run the following command to embed the Ignition config into the ISO:

```
# ./coreos-installer iso ignition embed -i /mnt/bootstrap.ign \
  /mnt/rhcos-<version>-live.x86_64.iso
```

You can now use that ISO to install RHCOS using the specified live install Ignition config.



### IMPORTANT

Using **coreos-installer iso ignition embed** to embed a file generated by **openshift-installer**, such as **bootstrap.ign**, **master.ign** and **worker.ign**, is unsupported and not recommended.

4. To show the contents of the embedded Ignition config and direct it into a file, run:

```
# ./coreos-installer iso ignition show /mnt/rhcos-<version>-live.x86_64.iso > mybootstrap.ign
# diff -s bootstrap.ign mybootstrap.ign
```

### Example output

```
Files bootstrap.ign and mybootstrap.ign are identical
```

5. To remove the Ignition config and return the ISO to its pristine state so you can reuse it, run:

```
# ./coreos-installer iso ignition remove /mnt/rhcos-<version>-live.x86_64.iso
```

You can now embed another Ignition config into the ISO or use the ISO in its pristine state.

#### 19.1.11.3.4. Advanced RHCOS installation reference

This section illustrates the networking configuration and other advanced options that allow you to modify the Red Hat Enterprise Linux CoreOS (RHCOS) manual installation process. The following tables describe the kernel arguments and command-line options you can use with the RHCOS live installer and the **coreos-installer** command.

##### 19.1.11.3.4.1. Networking and bonding options for ISO installations

If you install RHCOS from an ISO image, you can add kernel arguments manually when you boot the image to configure networking for a node. If no networking arguments are specified, DHCP is activated in the initramfs when RHCOS detects that networking is required to fetch the Ignition config file.

**IMPORTANT**

When adding networking arguments manually, you must also add the **rd.neednet=1** kernel argument to bring the network up in the initramfs.

The following table provides examples for configuring networking and bonding on your RHCOS nodes for ISO installations. The examples describe how to use the **ip=**, **nameserver=**, and **bond=** kernel arguments.

**NOTE**

Ordering is important when adding the kernel arguments: **ip=**, **nameserver=**, and then **bond=**.

The networking options are passed to the **dracut** tool during system boot. For more information about the networking options supported by **dracut**, see the **dracut.cmdline** manual page.

The following information provides examples for configuring networking on your RHCOS nodes for ISO installations. The examples describe how to use the **ip=** and **nameserver=** kernel arguments.

**NOTE**

Ordering is important when adding the kernel arguments: **ip=** and **nameserver=**.

The networking options are passed to the **dracut** tool during system boot. For more information about the networking options supported by **dracut**, see the **dracut.cmdline** manual page.

The following examples are the networking options for ISO installation.

Configuring DHCP or static IP addresses

To configure an IP address, either use DHCP (**ip=dhcp**) or set an individual static IP address (**ip=<host\_ip>**). If setting a static IP, you must then identify the DNS server IP address (**nameserver=<dns\_ip>**) on each node. The following example sets:

- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The hostname to **core0.example.com**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
nameserver=4.4.4.41
```

**NOTE**

When you use DHCP to configure IP addressing for the RHCOS machines, the machines also obtain the DNS server information through DHCP. For DHCP-based deployments, you can define the DNS server address that is used by the RHCOS nodes through your DHCP server configuration.

## Configuring an IP address without a static hostname

You can configure an IP address without assigning a static hostname. If a static hostname is not set by the user, it will be picked up and automatically set by a reverse DNS lookup. To configure an IP address without a static hostname refer to the following example:

- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0::enp1s0:none
nameserver=4.4.4.41
```

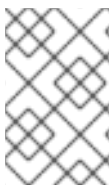
## Specifying multiple network interfaces

You can specify multiple network interfaces by setting multiple **ip=** entries.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=10.10.10.3::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

## Configuring default gateway and route

Optional: You can configure routes to additional networks by setting an **rd.route=** value.

**NOTE**

When you configure one or multiple networks, one default gateway is required. If the additional network gateway is different from the primary network gateway, the default gateway must be the primary network gateway.

- Run the following command to configure the default gateway:

```
ip=::10.10.10.254:::
```

- Enter the following command to configure the route for the additional network:

```
rd.route=20.20.20.0/24:20.20.20.254:enp2s0
```

## Disabling DHCP on a single interface

You can disable DHCP on a single interface, such as when there are two or more network interfaces and only one interface is being used. In the example, the **enp1s0** interface has a static networking configuration and DHCP is disabled for **enp2s0**, which is not used:

■

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=:::core0.example.com:enp2s0:none
```

#### Combining DHCP and static IP configurations

You can combine DHCP and static IP configurations on systems with multiple network interfaces, for example:

```
ip=enp1s0:dhcp
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

#### Configuring VLANs on individual interfaces

Optional: You can configure VLANs on individual interfaces by using the **vlan=** parameter.

- To configure a VLAN on a network interface and use a static IP address, run the following command:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0.100:none
vlan=enp2s0.100:enp2s0
```

- To configure a VLAN on a network interface and to use DHCP, run the following command:

```
ip=enp2s0.100:dhcp
vlan=enp2s0.100:enp2s0
```

#### Providing multiple DNS servers

You can provide multiple DNS servers by adding a **nameserver=** entry for each server, for example:

```
nameserver=1.1.1.1
nameserver=8.8.8.8
```

#### Bonding multiple network interfaces to a single interface

Optional: You can bond multiple network interfaces to a single interface by using the **bond=** option.

Refer to the following examples:

- The syntax for configuring a bonded interface is: **bond=name[:network\_interfaces][:options]** *name* is the bonding device name (**bond0**), *network\_interfaces* represents a comma-separated list of physical (ethernet) interfaces (**em1,em2**), and *options* is a comma-separated list of bonding options. Enter **modinfo bonding** to see available options.
- When you create a bonded interface using **bond=**, you must specify how the IP address is assigned and other information for the bonded interface.
- To configure the bonded interface to use DHCP, set the bond's IP address to **dhcp**. For example:

```
bond=bond0:em1,em2:mode=active-backup
ip=bond0:dhcp
```

- To configure the bonded interface to use a static IP address, enter the specific IP address you want and related information. For example:

```
bond=bond0:em1,em2:mode=active-backup
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0:none
```

Bonding multiple network interfaces to a single interface

Optional: You can configure VLANs on bonded interfaces by using the **vlan=** parameter and to use DHCP, for example:

```
ip=bond0.100:dhcp
bond=bond0:em1,em2:mode=active-backup
vlan=bond0.100:bond0
```

Use the following example to configure the bonded interface with a VLAN and to use a static IP address:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0.100:none
bond=bond0:em1,em2:mode=active-backup
vlan=bond0.100:bond0
```

Using network teaming

Optional: You can use a network teaming as an alternative to bonding by using the **team=** parameter:

- The syntax for configuring a team interface is: **team=name[:network\_interfaces]**  
*name* is the team device name (**team0**) and *network\_interfaces* represents a comma-separated list of physical (ethernet) interfaces (**em1, em2**).

Teaming is planned to be deprecated when RHCOS switches to an upcoming version of RHEL. For more information, see this [Red Hat Knowledgebase Article](#).

Use the following example to configure a network team:

```
team=team0:em1,em2
ip=team0:dhcp
```


#### 19.1.11.3.4.2. coreos-installer options for ISO installations

You can install RHCOS by running **coreos-installer install <options> <device>** at the command prompt, after booting into the RHCOS live environment from an ISO image.

The following table shows the subcommands, options, and arguments you can pass to the **coreos-installer** command.

**Table 19.9. coreos-installer subcommands, command-line options, and arguments**

coreos-installer install subcommand	
<i>Subcommand</i>	<i>Description</i>
<b>\$ coreos-installer install &lt;options&gt; &lt;device&gt;</b>	Embed an Ignition config in an ISO image.
coreos-installer install subcommand options	
<i>Option</i>	<i>Description</i>
<b>-u, --image-url &lt;url&gt;</b>	Specify the image URL manually.

<b>-f, --image-file &lt;path&gt;</b>	Specify a local image file manually. Used for debugging.
<b>-i, --ignition-file &lt;path&gt;</b>	Embed an Ignition config from a file.
<b>-l, --ignition-url &lt;URL&gt;</b>	Embed an Ignition config from a URL.
<b>--ignition-hash &lt;digest&gt;</b>	Digest <b>type-value</b> of the Ignition config.
<b>-p, --platform &lt;name&gt;</b>	Override the Ignition platform ID for the installed system.
<b>--append-karg &lt;arg&gt;...</b>	Append a default kernel argument to the installed system.
<b>--delete-karg &lt;arg&gt;...</b>	Delete a default kernel argument from the installed system.
<b>-n, --copy-network</b>	Copy the network configuration from the install environment.   <b>IMPORTANT</b> The <b>--copy-network</b> option only copies networking configuration found under <b>/etc/NetworkManager/system-connections</b> . In particular, it does not copy the system hostname.
<b>--network-dir &lt;path&gt;</b>	For use with <b>-n</b> . Default is <b>/etc/NetworkManager/system-connections/</b> .
<b>--save-partlabel &lt;lx&gt;..</b>	Save partitions with this label glob.
<b>--save-partindex &lt;id&gt;...</b>	Save partitions with this number or range.
<b>--insecure</b>	Skip signature verification.
<b>--insecure-ignition</b>	Allow Ignition URL without HTTPS or hash.
<b>--architecture &lt;name&gt;</b>	Target CPU architecture. Default is <b>x86_64</b> .
<b>--preserve-on-error</b>	Do not clear partition table on error.
<b>-h, --help</b>	Print help information.
<b>coreos-install install subcommand argument</b>	

<i>Argument</i>	<i>Description</i>
<b>&lt;device&gt;</b>	The destination device.
coreos-installer ISO Ignition subcommands	
<i>Subcommand</i>	<i>Description</i>
<b>\$ coreos-installer iso ignition embed &lt;options&gt; --ignition-file &lt;file_path&gt; &lt;ISO_image&gt;</b>	Embed an Ignition config in an ISO image.
<b>coreos-installer iso ignition show &lt;options&gt; &lt;ISO_image&gt;</b>	Show the embedded Ignition config from an ISO image.
<b>coreos-installer iso ignition remove &lt;options&gt; &lt;ISO_image&gt;</b>	Remove the embedded Ignition config from an ISO image.
coreos-installer ISO Ignition subcommand options	
<i>Option</i>	<i>Description</i>
<b>-f, --force</b>	Overwrite an existing Ignition config.
<b>-i, --ignition-file &lt;path&gt;</b>	The Ignition config to be used. Default is <b>stdin</b> .
<b>-o, --output &lt;path&gt;</b>	Write the ISO to a new output file.
<b>-h, --help</b>	Print help information.
coreos-installer PXE Ignition subcommands	
<i>Subcommand</i>	<i>Description</i>
Note that not all of these options are accepted by all subcommands.	
<b>coreos-installer pxe ignition wrap &lt;options&gt;</b>	Wrap an Ignition config in an image.
<b>coreos-installer pxe ignition unwrap &lt;options&gt; &lt;image_name&gt;</b>	Show the wrapped Ignition config in an image.
coreos-installer PXE Ignition subcommand options	
<i>Option</i>	<i>Description</i>
Note that not all of these options are accepted by all subcommands.	



<b>-i, --ignition-file &lt;path&gt;</b>	The Ignition config to be used. Default is <b>stdin</b> .
<b>-o, --output &lt;path&gt;</b>	Write the ISO to a new output file.
<b>-h, --help</b>	Print help information.

#### 19.1.11.3.4.3. **coreos.inst** boot options for ISO or PXE installations

You can automatically invoke **coreos-installer** options at boot time by passing **coreos.inst** boot arguments to the RHCOS live installer. These are provided in addition to the standard boot arguments.

- For ISO installations, the **coreos.inst** options can be added by interrupting the automatic boot at the bootloader menu. You can interrupt the automatic boot by pressing **TAB** while the **RHEL CoreOS (Live)** menu option is highlighted.
- For PXE or iPXE installations, the **coreos.inst** options must be added to the **APPEND** line before the RHCOS live installer is booted.

The following table shows the RHCOS live installer **coreos.inst** boot options for ISO and PXE installations.

**Table 19.10. coreos.inst boot options**

Argument	Description
<b>coreos.inst.install_dev</b>	Required. The block device on the system to install to. It is recommended to use the full path, such as <b>/dev/sda</b> , although <b>sda</b> is allowed.
<b>coreos.inst.ignition_url</b>	Optional: The URL of the Ignition config to embed into the installed system. If no URL is specified, no Ignition config is embedded. Only HTTP and HTTPS protocols are supported.
<b>coreos.inst.save_partlabel</b>	Optional: Comma-separated labels of partitions to preserve during the install. Glob-style wildcards are permitted. The specified partitions do not need to exist.
<b>coreos.inst.save_partindex</b>	Optional: Comma-separated indexes of partitions to preserve during the install. Ranges <b>m-n</b> are permitted, and either <b>m</b> or <b>n</b> can be omitted. The specified partitions do not need to exist.
<b>coreos.inst.insecure</b>	Optional: Permits the OS image that is specified by <b>coreos.inst.image_url</b> to be unsigned.

Argument	Description
<b>coreos.inst.image_url</b>	<p>Optional: Download and install the specified RHCOS image.</p> <ul style="list-style-type: none"> <li>• This argument should not be used in production environments and is intended for debugging purposes only.</li> <li>• While this argument can be used to install a version of RHCOS that does not match the live media, it is recommended that you instead use the media that matches the version you want to install.</li> <li>• If you are using <b>coreos.inst.image_url</b>, you must also use <b>coreos.inst.insecure</b>. This is because the bare-metal media are not GPG-signed for OpenShift Container Platform.</li> <li>• Only HTTP and HTTPS protocols are supported.</li> </ul>
<b>coreos.inst.skip_reboot</b>	<p>Optional: The system will not reboot after installing. After the install finishes, you will receive a prompt that allows you to inspect what is happening during installation. This argument should not be used in production environments and is intended for debugging purposes only.</p>
<b>coreos.inst.platform_id</b>	<p>Optional: The Ignition platform ID of the platform the RHCOS image is being installed on. Default is <b>metal</b>. This option determines whether or not to request an Ignition config from the cloud provider, such as VMware. For example: <b>coreos.inst.platform_id=vmware</b>.</p>
<b>ignition.config.url</b>	<p>Optional: The URL of the Ignition config for the live boot. For example, this can be used to customize how <b>coreos-installer</b> is invoked, or to run code before or after the installation. This is different from <b>coreos.inst.ignition_url</b>, which is the Ignition config for the installed system.</p>

#### 19.1.11.4. Updating the bootloader using bootupd

To update the bootloader by using **bootupd**, you must either install **bootupd** on RHCOS machines manually or provide a machine config with the enabled **systemd** unit. Unlike **grubby** or other bootloader tools, **bootupd** does not manage kernel space configuration such as passing kernel arguments.

After you have installed **bootupd**, you can manage it remotely from the OpenShift Container Platform cluster.



## NOTE

It is recommended that you use **bootupd** only on bare metal or virtualized hypervisor installations, such as for protection against the BootHole vulnerability.

## Manual install method

You can manually install **bootupd** by using the **bootctl** command-line tool.

1. Inspect the system status:

```
# bootupctl status
```

### Example output

```
Component EFI
Installed: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
Update: At latest version
```

2. RHCOS images created without **bootupd** installed on them require an explicit adoption phase. If the system status is **Adoptable**, perform the adoption:

```
# bootupctl adopt-and-update
```

### Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

3. If an update is available, apply the update so that the changes take effect on the next reboot:

```
# bootupctl update
```

### Example output

```
Updated: grub2-efi-x64-1:2.04-31.fc33.x86_64,shim-x64-15-8.x86_64
```

## Machine config method

Another way to enable **bootupd** is by providing a machine config.

- Provide a machine config file with the enabled **systemd** unit, as shown in the following example:

### Example output

```
variant: rhcos
version: 1.1.0
systemd:
units:
- name: custom-bootupd-auto.service
  enabled: true
  contents: |
    [Unit]
    Description=Bootupd automatic update
```

```
[Service]
ExecStart=/usr/bin/bootupctl update
RemainAfterExit=yes

[Install]
WantedBy=multi-user.target
```

### 19.1.12. Waiting for the bootstrap process to complete

The OpenShift Container Platform bootstrap process begins after the cluster nodes first boot into the persistent RHCOS environment that has been installed to disk. The configuration information provided through the Ignition config files is used to initialize the bootstrap process and install OpenShift Container Platform on the machines. You must wait for the bootstrap process to complete.

#### Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have obtained the installation program and generated the Ignition config files for your cluster.
- You installed RHCOS on your cluster machines and provided the Ignition config files that the OpenShift Container Platform installation program generated.
- Your machines have direct internet access or have an HTTP or HTTPS proxy available.

#### Procedure

1. Monitor the bootstrap process:

```
$ ./openshift-install --dir <installation_directory> wait-for bootstrap-complete \ 1
--log-level=info 2
```

- 1 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

- 2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

#### Example output

```
INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...
INFO API v1.22.1 up
INFO Waiting up to 30m0s for bootstrapping to complete...
INFO It is now safe to remove the bootstrap resources
```

The command succeeds when the Kubernetes API server signals that it has been bootstrapped on the control plane machines.

2. After bootstrap process is complete, remove the bootstrap machine from the load balancer.



## IMPORTANT

You must remove the bootstrap machine from the load balancer at this point. You can also remove or reformat the bootstrap machine itself.

### 19.1.13. Logging in to the cluster by using the CLI

You can log in to your cluster as a default system user by exporting the cluster **kubeconfig** file. The **kubeconfig** file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during OpenShift Container Platform installation.

#### Prerequisites

- You deployed an OpenShift Container Platform cluster.
- You installed the **oc** CLI.

#### Procedure

1. Export the **kubeadmin** credentials:

```
$ export KUBECONFIG=<installation_directory>/auth/kubeconfig 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

2. Verify you can run **oc** commands successfully using the exported configuration:

```
$ oc whoami
```

#### Example output

```
system:admin
```

### 19.1.14. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

#### Prerequisites

- You added machines to your cluster.

#### Procedure

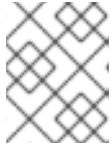
1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

#### Example output

NAME	STATUS	ROLES	AGE	VERSION
master-0	Ready	master	63m	v1.22.1
master-1	Ready	master	63m	v1.22.1
master-2	Ready	master	64m	v1.22.1

The output lists all of the machines that you created.



#### NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

- Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

#### Example output

NAME	AGE	REQUESTOR	CONDITION
csr-8b2br	15m	system:serviceaccount:openshift-machine-config-operator:node-bootstrapper	Pending
csr-8vnps	15m	system:serviceaccount:openshift-machine-config-operator:node-bootstrapper	Pending
...			

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

- If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:



#### NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.

**NOTE**

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrap** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

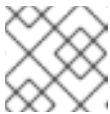
- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{"\n"}\n{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```

**NOTE**

Some Operators might not become available until some CSRs are approved.

4. Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

**Example output**

```
NAME      AGE   REQUESTOR                                     CONDITION
csr-bfd72 5m26s system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending
csr-c57lv 5m26s system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

5. If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 1
```

- 1** **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}{\n"}\n{{end}}' | xargs oc adm certificate approve
```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

### Example output

```
NAME      STATUS  ROLES  AGE  VERSION
master-0  Ready   master 73m  v1.22.1
master-1  Ready   master 73m  v1.22.1
master-2  Ready   master 74m  v1.22.1
worker-0  Ready   worker 11m  v1.22.1
worker-1  Ready   worker 11m  v1.22.1
```



### NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

### Additional information

- For more information on CSRs, see [Certificate Signing Requests](#).

## 19.1.15. Initial Operator configuration

After the control plane initializes, you must immediately configure some Operators so that they all become available.

### Prerequisites

- Your control plane has initialized.

### Procedure

1. Watch the cluster components come online:

```
$ watch -n5 oc get clusteroperators
```

### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
authentication	4.9.0	True	False	False	19m
baremetal	4.9.0	True	False	False	37m
cloud-credential	4.9.0	True	False	False	40m
cluster-autoscaler	4.9.0	True	False	False	37m
config-operator	4.9.0	True	False	False	38m



console	4.9.0	True	False	False	26m
csi-snapshot-controller	4.9.0	True	False	False	37m
dns	4.9.0	True	False	False	37m
etcd	4.9.0	True	False	False	36m
image-registry	4.9.0	True	False	False	31m
ingress	4.9.0	True	False	False	30m
insights	4.9.0	True	False	False	31m
kube-apiserver	4.9.0	True	False	False	26m
kube-controller-manager	4.9.0	True	False	False	36m
kube-scheduler	4.9.0	True	False	False	36m
kube-storage-version-migrator	4.9.0	True	False	False	37m
machine-api	4.9.0	True	False	False	29m
machine-approver	4.9.0	True	False	False	37m
machine-config	4.9.0	True	False	False	36m
marketplace	4.9.0	True	False	False	37m
monitoring	4.9.0	True	False	False	29m
network	4.9.0	True	False	False	38m
node-tuning	4.9.0	True	False	False	37m
openshift-apiserver	4.9.0	True	False	False	32m
openshift-controller-manager	4.9.0	True	False	False	30m
openshift-samples	4.9.0	True	False	False	32m
operator-lifecycle-manager	4.9.0	True	False	False	37m
operator-lifecycle-manager-catalog	4.9.0	True	False	False	37m
operator-lifecycle-manager-packageserver	4.9.0	True	False	False	32m
service-ca	4.9.0	True	False	False	38m
storage	4.9.0	True	False	False	37m

2. Configure the Operators that are not available.

### 19.1.15.1. Disabling the default OperatorHub sources

Operator catalogs that source content provided by Red Hat and community projects are configured for OperatorHub by default during an OpenShift Container Platform installation. In a restricted network environment, you must disable the default catalogs as a cluster administrator.

#### Procedure

- Disable the sources for the default catalogs by adding **disableAllDefaultSources: true** to the **OperatorHub** object:

```
$ oc patch OperatorHub cluster --type json \
  -p [{"op": "add", "path": "/spec/disableAllDefaultSources", "value": true}]
```

#### TIP

Alternatively, you can use the web console to manage catalog sources. From the **Administration** → **Cluster Settings** → **Configuration** → **OperatorHub** page, click the **Sources** tab, where you can create, delete, disable, and enable individual sources.

### 19.1.15.2. Image registry removed during installation

On platforms that do not provide shareable object storage, the OpenShift Image Registry Operator bootstraps itself as **Removed**. This allows **openshift-installer** to complete installations on these platform types.

After installation, you must edit the Image Registry Operator configuration to switch the **managementState** from **Removed** to **Managed**.



#### NOTE

The Prometheus console provides an **ImageRegistryRemoved** alert, for example:

"Image Registry has been removed. **ImageStreamTags**, **BuildConfigs** and **DeploymentConfigs** which reference **ImageStreamTags** may not work as expected. Please configure storage and update the config to **Managed** state by editing `configs.imageregistry.operator.openshift.io`."

### 19.1.15.3. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

#### 19.1.15.3.1. Configuring registry storage for bare metal and other manual installations

As a cluster administrator, following installation you must configure your registry to use storage.

#### Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.
- You have a cluster that uses manually-provisioned Red Hat Enterprise Linux CoreOS (RHCOS) nodes, such as bare metal.
- You have provisioned persistent storage for your cluster, such as Red Hat OpenShift Container Storage.



#### IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have 100Gi capacity.

#### Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.

**NOTE**

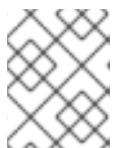
When using shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

**Example output**

```
No resources found in openshift-image-registry namespace
```

**NOTE**

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io
```

**Example output**

```
storage:
  pvc:
    claim:
```

Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** PVC.

4. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

**Example output**

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
image-registry	4.9	True	False	False	6h50m

5. Ensure that your registry is set to managed to enable building and pushing of images.

- Run:

```
$ oc edit configs.imageregistry/cluster
```

Then, change the line

```
managementState: Removed
```

to

managementState: Managed

### 19.15.3.2. Configuring storage for the image registry in non-production clusters

You must configure storage for the Image Registry Operator. For non-production clusters, you can set the image registry to an empty directory. If you do so, all images are lost if you restart the registry.

#### Procedure

- To set the image registry storage to an empty directory:

```
$ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec": {"storage":{"emptyDir":{}}}'
```



#### WARNING

Configure this option for only non-production clusters.

If you run this command before the Image Registry Operator initializes its components, the **oc patch** command fails with the following error:

```
Error from server (NotFound): configs.imageregistry.operator.openshift.io "cluster" not found
```

Wait a few minutes and run the command again.

### 19.15.3.3. Configuring block registry storage

To allow the image registry to use block storage types during upgrades as a cluster administrator, you can use the **Recreate** rollout strategy.



#### IMPORTANT

Block storage volumes are supported but not recommended for use with the image registry on production clusters. An installation where the registry is configured on block storage is not highly available because the registry cannot have more than one replica.

#### Procedure

- To set the image registry storage as a block storage type, patch the registry so that it uses the **Recreate** rollout strategy and runs with only one ( **1** ) replica:

```
$ oc patch config.imageregistry.operator.openshift.io/cluster --type=merge -p '{"spec": {"rolloutStrategy":"Recreate","replicas":1}}'
```

- Provision the PV for the block storage device, and create a PVC for that volume. The requested block volume uses the ReadWriteOnce (RWO) access mode.
- Edit the registry configuration so that it references the correct PVC.

## 19.1.16. Completing installation on user-provisioned infrastructure

After you complete the Operator configuration, you can finish installing the cluster on infrastructure that you provide.

### Prerequisites

- Your control plane has initialized.
- You have completed the initial Operator configuration.

### Procedure

1. Confirm that all the cluster components are online with the following command:

```
$ watch -n5 oc get clusteroperators
```

### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
authentication	4.9.0	True	False	False	19m
baremetal	4.9.0	True	False	False	37m
cloud-credential	4.9.0	True	False	False	40m
cluster-autoscaler	4.9.0	True	False	False	37m
config-operator	4.9.0	True	False	False	38m
console	4.9.0	True	False	False	26m
csi-snapshot-controller	4.9.0	True	False	False	37m
dns	4.9.0	True	False	False	37m
etcd	4.9.0	True	False	False	36m
image-registry	4.9.0	True	False	False	31m
ingress	4.9.0	True	False	False	30m
insights	4.9.0	True	False	False	31m
kube-apiserver	4.9.0	True	False	False	26m
kube-controller-manager	4.9.0	True	False	False	36m
kube-scheduler	4.9.0	True	False	False	36m
kube-storage-version-migrator	4.9.0	True	False	False	37m
machine-api	4.9.0	True	False	False	29m
machine-approver	4.9.0	True	False	False	37m
machine-config	4.9.0	True	False	False	36m
marketplace	4.9.0	True	False	False	37m
monitoring	4.9.0	True	False	False	29m
network	4.9.0	True	False	False	38m
node-tuning	4.9.0	True	False	False	37m
openshift-apiserver	4.9.0	True	False	False	32m
openshift-controller-manager	4.9.0	True	False	False	30m
openshift-samples	4.9.0	True	False	False	32m
operator-lifecycle-manager	4.9.0	True	False	False	37m
operator-lifecycle-manager-catalog	4.9.0	True	False	False	37m
operator-lifecycle-manager-packageserver	4.9.0	True	False	False	32m
service-ca	4.9.0	True	False	False	38m
storage	4.9.0	True	False	False	37m

Alternatively, the following command notifies you when all of the clusters are available. It also retrieves and displays credentials:

```
$ ./openshift-install --dir <installation_directory> wait-for install-complete 1
```

- 1** For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.

### Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

The command succeeds when the Cluster Version Operator finishes deploying the OpenShift Container Platform cluster from Kubernetes API server.



### IMPORTANT

- The Ignition config files that the installation program generates contain certificates that expire after 24 hours, which are then renewed at that time. If the cluster is shut down before renewing the certificates and the cluster is later restarted after the 24 hours have elapsed, the cluster automatically recovers the expired certificates. The exception is that you must manually approve the pending **node-bootstrapper** certificate signing requests (CSRs) to recover kubelet certificates. See the documentation for *Recovering from expired control plane certificates* for more information.
- It is recommended that you use Ignition config files within 12 hours after they are generated because the 24-hour certificate rotates from 16 to 22 hours after the cluster is installed. By using the Ignition config files within 12 hours, you can avoid installation failure if the certificate update runs during installation.

2. Confirm that the Kubernetes API server is communicating with the pods.
  - a. To view a list of all pods, use the following command:

```
$ oc get pods --all-namespaces
```

### Example output

```

NAMESPACE           NAME                                     READY  STATUS
RESTARTS  AGE
openshift-apiserver-operator  openshift-apiserver-operator-85cb746d55-zqhs8  1/1
Running   1    9m
openshift-apiserver          apiserver-67b9g                                1/1  Running  0
3m
openshift-apiserver          apiserver-ljcmx                                1/1  Running  0
1m
openshift-apiserver          apiserver-z25h4                                1/1  Running  0
2m
openshift-authentication-operator  authentication-operator-69d5d8bf84-vh2n8      1/1
Running   0    5m
...

```

- b. View the logs for a pod that is listed in the output of the previous command by using the following command:

```
$ oc logs <pod_name> -n <namespace> 1
```

- 1 Specify the pod name and namespace, as shown in the output of the previous command.

If the pod logs display, the Kubernetes API server can communicate with the cluster machines.

3. For an installation with Fibre Channel Protocol (FCP), additional steps are required to enable multipathing. Do not enable multipathing during installation. See "Enabling multipathing with kernel arguments on RHCOS" in the *Post-installation machine configuration tasks* documentation for more information.

### 19.1.17. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.9, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

After you confirm that your [OpenShift Cluster Manager](#) inventory is correct, either maintained automatically by Telemetry or manually by using OpenShift Cluster Manager, [use subscription watch](#) to track your OpenShift Container Platform subscriptions at the account or multi-cluster level.

#### Additional resources

- See [About remote health monitoring](#) for more information about the Telemetry service

### 19.1.18. Next steps

- [Customize your cluster](#).
- If necessary, you can [opt out of remote health reporting](#) .
- [Set up your registry and configure registry storage](#) .

## CHAPTER 20. INSTALLATION CONFIGURATION

### 20.1. CUSTOMIZING NODES

Although directly making changes to OpenShift Container Platform nodes is discouraged, there are times when it is necessary to implement a required low-level security, redundancy, networking, or performance feature. Direct changes to OpenShift Container Platform nodes can be done by:

- Creating machine configs that are included in manifest files to start up a cluster during **openshift-install**.
- Creating machine configs that are passed to running OpenShift Container Platform nodes via the Machine Config Operator.
- Creating an Ignition config that is passed to **coreos-installer** when installing bare-metal nodes.

The following sections describe features that you might want to configure on your nodes in this way.

#### 20.1.1. Creating machine configs with Butane

Machine configs are used to configure control plane and worker machines by instructing machines how to create users and file systems, set up the network, install systemd units, and more.

Because modifying machine configs can be difficult, you can use Butane configs to create machine configs for you, thereby making node configuration much easier.

##### 20.1.1.1. About Butane

Butane is a command-line utility that OpenShift Container Platform uses to provide convenient, short-hand syntax for writing machine configs, as well as for performing additional validation of machine configs. The format of the Butane config file that Butane accepts is defined in the [OpenShift Butane config spec](#).

##### 20.1.1.2. Installing Butane

You can install the Butane tool (**butane**) to create OpenShift Container Platform machine configs from a command-line interface. You can install **butane** on Linux, Windows, or macOS by downloading the corresponding binary file.

#### TIP

Butane releases are backwards-compatible with older releases and with the Fedora CoreOS Config Transpiler (FCCT).

#### Procedure

1. Navigate to the Butane image download page at <https://mirror.openshift.com/pub/openshift-v4/clients/butane/>.
2. Get the **butane** binary:
  - a. For the newest version of Butane, save the latest **butane** image to your current directory:



```
$ curl https://mirror.openshift.com/pub/openshift-v4/clients/butane/latest/butane --output butane
```

- b. Optional: For a specific type of architecture you are installing Butane on, such as aarch64 or ppc64le, indicate the appropriate URL. For example:

```
$ curl https://mirror.openshift.com/pub/openshift-v4/clients/butane/latest/butane-aarch64 --output butane
```

3. Make the downloaded binary file executable:

```
$ chmod +x butane
```

4. Move the **butane** binary file to a directory on your **PATH**. To check your **PATH**, open a terminal and execute the following command:

```
$ echo $PATH
```

### Verification steps

- You can now use the Butane tool by running the **butane** command:

```
$ butane <butane_file>
```

### 20.1.1.3. Creating a MachineConfig object by using Butane

You can use Butane to produce a **MachineConfig** object so that you can configure worker or control plane nodes at installation time or via the Machine Config Operator.

#### Prerequisites

- You have installed the **butane** utility.

#### Procedure

1. Create a Butane config file. The following example creates a file named **99-worker-custom.bu** that configures the system console to show kernel debug messages and specifies custom settings for the chrony time service:

```
variant: openshift
version: 4.9.0
metadata:
  name: 99-worker-custom
  labels:
    machineconfiguration.openshift.io/role: worker
openshift:
  kernel_arguments:
    - loglevel=7
storage:
  files:
    - path: /etc/chrony.conf
      mode: 0644
```

```

overwrite: true
contents:
  inline: |
    pool 0.rhel.pool.ntp.org iburst
    driftfile /var/lib/chrony/drift
    makestep 1.0 3
    rtsync
    logdir /var/log/chrony

```



## NOTE

The **99-worker-custom.bu** file is set to create a machine config for worker nodes. To deploy on control plane nodes, change the role from **worker** to **master**. To do both, you could repeat the whole procedure using different file names for the two types of deployments.

2. Create a **MachineConfig** object by giving Butane the file that you created in the previous step:

```
$ butane 99-worker-custom.bu -o ./99-worker-custom.yaml
```

A **MachineConfig** object YAML file is created for you to finish configuring your machines.

3. Save the Butane config in case you need to update the **MachineConfig** object in the future.
4. If the cluster is not running yet, generate manifest files and add the **MachineConfig** object YAML file to the **openshift** directory. If the cluster is already running, apply the file as follows:

```
$ oc create -f 99-worker-custom.yaml
```

## Additional resources

- [Adding kernel modules to nodes](#)
- [Encrypting and mirroring disks during installation](#)

## 20.1.2. Adding day-1 kernel arguments

Although it is often preferable to modify kernel arguments as a day-2 activity, you might want to add kernel arguments to all master or worker nodes during initial cluster installation. Here are some reasons you might want to add kernel arguments during cluster installation so they take effect before the systems first boot up:

- You want to disable a feature, such as SELinux, so it has no impact on the systems when they first come up.



## WARNING

Disabling SELinux on RHCOS is not supported.

- You need to do some low-level network configuration before the systems start.

To add kernel arguments to master or worker nodes, you can create a **MachineConfig** object and inject that object into the set of manifest files used by Ignition during cluster setup.

For a listing of arguments you can pass to a RHEL 8 kernel at boot time, see [Kernel.org kernel parameters](#). It is best to only add kernel arguments with this procedure if they are needed to complete the initial OpenShift Container Platform installation.

## Procedure

1. Change to the directory that contains the installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory>
```

2. Decide if you want to add kernel arguments to worker or control plane nodes.
3. In the **openshift** directory, create a file (for example, **99-openshift-machineconfig-master-kargs.yaml**) to define a **MachineConfig** object to add the kernel settings. This example adds a **loglevel=7** kernel argument to control plane nodes:

```
$ cat << EOF > 99-openshift-machineconfig-master-kargs.yaml
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: master
  name: 99-openshift-machineconfig-master-kargs
spec:
  kernelArguments:
    - loglevel=7
EOF
```

You can change **master** to **worker** to add kernel arguments to worker nodes instead. Create a separate YAML file to add to both master and worker nodes.

You can now continue on to create the cluster.

### 20.1.3. Adding kernel modules to nodes

For most common hardware, the Linux kernel includes the device driver modules needed to use that hardware when the computer starts up. For some hardware, however, modules are not available in Linux. Therefore, you must find a way to provide those modules to each host computer. This procedure describes how to do that for nodes in an OpenShift Container Platform cluster.

When a kernel module is first deployed by following these instructions, the module is made available for the current kernel. If a new kernel is installed, the `kmods-via-containers` software will rebuild and deploy the module so a compatible version of that module is available with the new kernel.

The way that this feature is able to keep the module up to date on each node is by:

- Adding a systemd service to each node that starts at boot time to detect if a new kernel has been installed and

- If a new kernel is detected, the service rebuilds the module and installs it to the kernel

For information on the software needed for this procedure, see the [kmods-via-containers](#) github site.

A few important issues to keep in mind:

- This procedure is Technology Preview.
- Software tools and examples are not yet available in official RPM form and can only be obtained for now from unofficial **github.com** sites noted in the procedure.
- Third-party kernel modules you might add through these procedures are not supported by Red Hat.
- In this procedure, the software needed to build your kernel modules is deployed in a RHEL 8 container. Keep in mind that modules are rebuilt automatically on each node when that node gets a new kernel. For that reason, each node needs access to a **yum** repository that contains the kernel and related packages needed to rebuild the module. That content is best provided with a valid RHEL subscription.

### 20.1.3.1. Building and testing the kernel module container

Before deploying kernel modules to your OpenShift Container Platform cluster, you can test the process on a separate RHEL system. Gather the kernel module's source code, the KVC framework, and the `kmod-via-containers` software. Then build and test the module. To do that on a RHEL 8 system, do the following:

#### Procedure

1. Register a RHEL 8 system:

```
# subscription-manager register
```

2. Attach a subscription to the RHEL 8 system:

```
# subscription-manager attach --auto
```

3. Install software that is required to build the software and container:

```
# yum install podman make git -y
```

4. Clone the **kmod-via-containers** repository:

- a. Create a folder for the repository:

```
$ mkdir kmods; cd kmods
```

- b. Clone the repository:

```
$ git clone https://github.com/kmods-via-containers/kmods-via-containers
```

5. Install a KVC framework instance on your RHEL 8 build host to test the module. This adds a **kmods-via-container** systemd service and loads it:

- a. Change to the **kmod-via-containers** directory:

```
$ cd kmods-via-containers/
```

- b. Install the KVC framework instance:

```
$ sudo make install
```

- c. Reload the systemd manager configuration:

```
$ sudo systemctl daemon-reload
```

6. Get the kernel module source code. The source code might be used to build a third-party module that you do not have control over, but is supplied by others. You will need content similar to the content shown in the **kvc-simple-kmod** example that can be cloned to your system as follows:

```
$ cd .. ; git clone https://github.com/kmods-via-containers/kvc-simple-kmod
```

7. Edit the configuration file, **simple-kmod.conf** file, in this example, and change the name of the Dockerfile to **Dockerfile.rhel**:

- a. Change to the **kvc-simple-kmod** directory:

```
$ cd kvc-simple-kmod
```

- b. Rename the Dockerfile:

```
$ cat simple-kmod.conf
```

### Example Dockerfile

```
KMOD_CONTAINER_BUILD_CONTEXT="https://github.com/kmods-via-containers/kvc-
simple-kmod.git"
KMOD_CONTAINER_BUILD_FILE=Dockerfile.rhel
KMOD_SOFTWARE_VERSION=dd1a7d4
KMOD_NAMES="simple-kmod simple-procfs-kmod"
```

8. Create an instance of **kmods-via-containers@.service** for your kernel module, **simple-kmod** in this example:

```
$ sudo make install
```

9. Enable the **kmods-via-containers@.service** instance:

```
$ sudo kmods-via-containers build simple-kmod $(uname -r)
```

10. Enable and start the systemd service:

```
$ sudo systemctl enable kmods-via-containers@simple-kmod.service --now
```

- a. Review the service status:

```
$ sudo systemctl status kmods-via-containers@simple-kmod.service
```

### Example output

- `kmods-via-containers@simple-kmod.service` - Kmods Via Containers - simple-kmod  
Loaded: loaded (/etc/systemd/system/kmods-via-containers@.service;  
enabled; vendor preset: disabled)  
Active: active (exited) since Sun 2020-01-12 23:49:49 EST; 5s ago...

11. To confirm that the kernel modules are loaded, use the **lsmod** command to list the modules:

```
$ lsmod | grep simple_
```

### Example output

```
simple_procfs_kmod 16384 0
simple_kmod 16384 0
```

12. Optional. Use other methods to check that the **simple-kmod** example is working:

- Look for a "Hello world" message in the kernel ring buffer with **dmesg**:

```
$ dmesg | grep 'Hello world'
```

### Example output

```
[ 6420.761332] Hello world from simple_kmod.
```

- Check the value of **simple-procfs-kmod** in **/proc**:

```
$ sudo cat /proc/simple-procfs-kmod
```

### Example output

```
simple-procfs-kmod number = 0
```

- Run the **spkut** command to get more information from the module:

```
$ sudo spkut 44
```

### Example output

```
KVC: wrapper simple-kmod for 4.18.0-147.3.1.el8_1.x86_64
Running userspace wrapper using the kernel module container...
+ podman run -i --rm --privileged
  simple-kmod-dd1a7d4:4.18.0-147.3.1.el8_1.x86_64 spkut 44
simple-procfs-kmod number = 0
simple-procfs-kmod number = 44
```

Going forward, when the system boots this service will check if a new kernel is running. If there is a new kernel, the service builds a new version of the kernel module and then loads it. If the module is already built, it will just load it.

### 20.1.3.2. Provisioning a kernel module to OpenShift Container Platform

Depending on whether or not you must have the kernel module in place when OpenShift Container Platform cluster first boots, you can set up the kernel modules to be deployed in one of two ways:

- **Provision kernel modules at cluster install time (day-1)** You can create the content as a **MachineConfig** object and provide it to **openshift-install** by including it with a set of manifest files.
- **Provision kernel modules via Machine Config Operator (day-2)** If you can wait until the cluster is up and running to add your kernel module, you can deploy the kernel module software via the Machine Config Operator (MCO).

In either case, each node needs to be able to get the kernel packages and related software packages at the time that a new kernel is detected. There are a few ways you can set up each node to be able to obtain that content.

- Provide RHEL entitlements to each node.
- Get RHEL entitlements from an existing RHEL host, from the **/etc/pki/entitlement** directory and copy them to the same location as the other files you provide when you build your Ignition config.
- Inside the Dockerfile, add pointers to a **yum** repository containing the kernel and other packages. This must include new kernel packages as they are needed to match newly installed kernels.

#### 20.1.3.2.1. Provision kernel modules via a MachineConfig object

By packaging kernel module software with a **MachineConfig** object, you can deliver that software to worker or control plane nodes at installation time or via the Machine Config Operator.

#### Procedure

1. Register a RHEL 8 system:

```
# subscription-manager register
```

2. Attach a subscription to the RHEL 8 system:

```
# subscription-manager attach --auto
```

3. Install software needed to build the software:

```
# yum install podman make git -y
```

4. Create a directory to host the kernel module and tooling:

```
$ mkdir kmods; cd kmods
```

5. Get the **kmods-via-containers** software:

a. Clone the **kmods-via-containers** repository:

```
$ git clone https://github.com/kmods-via-containers/kmods-via-containers
```

b. Clone the **kvc-simple-kmod** repository:

```
$ git clone https://github.com/kmods-via-containers/kvc-simple-kmod
```

6. Get your module software. In this example, **kvc-simple-kmod** is used.

7. Create a fakeroot directory and populate it with files that you want to deliver via Ignition, using the repositories cloned earlier:

a. Create the directory:

```
$ FAKEROOT=$(mktemp -d)
```

b. Change to the **kmod-via-containers** directory:

```
$ cd kmods-via-containers
```

c. Install the KVC framework instance:

```
$ make install DESTDIR=${FAKEROOT}/usr/local CONFDIR=${FAKEROOT}/etc/
```

d. Change to the **kvc-simple-kmod** directory:

```
$ cd ../kvc-simple-kmod
```

e. Create the instance:

```
$ make install DESTDIR=${FAKEROOT}/usr/local CONFDIR=${FAKEROOT}/etc/
```

8. Clone the fakeroot directory, replacing any symbolic links with copies of their targets, by running the following command:

```
$ cd .. && rm -rf kmod-tree && cp -Lpr ${FAKEROOT} kmod-tree
```

9. Create a Butane config file, **99-simple-kmod.bu**, that embeds the kernel module tree and enables the systemd service.



#### NOTE

See "Creating machine configs with Butane" for information about Butane.

```
variant: openshift
version: 4.9.0
metadata:
  name: 99-simple-kmod
  labels:
```



```

machineconfiguration.openshift.io/role: worker 1
storage:
  trees:
    - local: kmod-tree
systemd:
  units:
    - name: kmods-via-containers@simple-kmod.service
      enabled: true

```

- 1** To deploy on control plane nodes, change **worker** to **master**. To deploy on both control plane and worker nodes, perform the remainder of these instructions once for each node type.

10. Use Butane to generate a machine config YAML file, **99-simple-kmod.yaml**, containing the files and configuration to be delivered:

```
$ butane 99-simple-kmod.bu --files-dir . -o 99-simple-kmod.yaml
```

11. If the cluster is not up yet, generate manifest files and add this file to the **openshift** directory. If the cluster is already running, apply the file as follows:

```
$ oc create -f 99-simple-kmod.yaml
```

Your nodes will start the **kmods-via-containers@simple-kmod.service** service and the kernel modules will be loaded.

12. To confirm that the kernel modules are loaded, you can log in to a node (using **oc debug node/<openshift-node>**, then **chroot /host**). To list the modules, use the **lsmod** command:

```
$ lsmod | grep simple_
```

### Example output

```

simple_procfs_kmod 16384 0
simple_kmod        16384 0

```

## 20.1.4. Encrypting and mirroring disks during installation

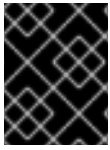
During an OpenShift Container Platform installation, you can enable boot disk encryption and mirroring on the cluster nodes.

### 20.1.4.1. About disk encryption

You can enable encryption for the boot disks on the control plane and compute nodes at installation time. OpenShift Container Platform supports the Trusted Platform Module (TPM) v2 and Tang encryption modes.

- **TPM v2:** This is the preferred mode. TPM v2 stores passphrases in a secure cryptoprocessor contained within a server. You can use this mode to prevent the boot disk data on a cluster node from being decrypted if the disk is removed from the server.
- **Tang:** Tang and Clevis are server and client components that enable network-bound disk encryption (NBDE). You can bind the boot disk data on your cluster nodes to one or more Tang

servers. This prevents the data from being decrypted unless the nodes are on a secure network where the Tang servers can be accessed. Clevis is an automated decryption framework that is used to implement the decryption on the client side.



### IMPORTANT

The use of the Tang encryption mode to encrypt your disks is only supported for bare metal and vSphere installations on user-provisioned infrastructure.



### NOTE

On previous versions of Red Hat Enterprise Linux CoreOS (RHCOS), disk encryption was configured by specifying `/etc/clevis.json` in the Ignition config. That file is not supported in clusters created with OpenShift Container Platform 4.7 or above, and disk encryption should be configured by using the following procedure.

When the TPM v2 or Tang encryption modes are enabled, the RHCOS boot disks are encrypted using the LUKS2 format.

This feature:

- Is available for installer-provisioned infrastructure and user-provisioned infrastructure deployments
- Is supported on Red Hat Enterprise Linux CoreOS (RHCOS) systems only
- Sets up disk encryption during the manifest installation phase so all data written to disk, from first boot forward, is encrypted
- Requires no user intervention for providing passphrases
- Uses AES-256-XTS encryption, or AES-256-CBC if FIPS mode is enabled

#### 20.1.4.1.1. Configuring an encryption threshold

In OpenShift Container Platform, you can specify a requirement for more than one Tang server. You can also configure the TPM v2 and Tang encryption modes simultaneously, so that the boot disk data can be decrypted only if the TPM secure cryptoprocessor is present and the Tang servers can be accessed over a secure network.

You can use the **threshold** attribute in your Butane configuration to define the minimum number of TPM v2 and Tang encryption conditions that must be met for decryption to occur. The threshold is met when the stated value is reached through any combination of the declared conditions. For example, the **threshold** value of **2** in the following configuration can be reached by accessing the two Tang servers, or by accessing the TPM secure cryptoprocessor and one of the Tang servers:

#### Example Butane configuration for disk encryption

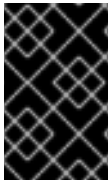
```
variant: openshift
version: 4.9.0
metadata:
  name: worker-storage
  labels:
    machineconfiguration.openshift.io/role: worker
boot_device:
```

```

layout: x86_64
luks:
  tpm2: true 1
  tang: 2
    - url: http://tang1.example.com:7500
      thumbprint: jwGN5tRFK-kF6pIX89ssF3khxxX
    - url: http://tang2.example.com:7500
      thumbprint: VCJsvZFjBSIHSlw78rOrq7h2ZF
  threshold: 2 3
openshift:
  fips: true

```

- 1 Include this field if you want to use a Trusted Platform Module (TPM) to encrypt the root file system.
- 2 Include this section if you want to use one or more Tang servers.
- 3 Specify the minimum number of TPM v2 and Tang encryption conditions that must be met for decryption to occur.



### IMPORTANT

The default **threshold** value is **1**. If you include multiple encryption conditions in your configuration but do not specify a threshold, decryption can occur if any of the conditions are met.



### NOTE

If you require both TPM v2 and Tang for decryption, the value of the **threshold** attribute must equal the total number of stated Tang servers plus one. If the **threshold** value is lower, it is possible for the threshold to be reached by using one of the encryption modes only. For example, if **tpm2** is set to **true** and you specify two Tang servers, a threshold of **2** can be met by accessing the two Tang servers even if the TPM secure cryptoprocessor is not available.

#### 20.1.4.2. About disk mirroring

During OpenShift Container Platform installation on control plane and worker nodes, you can enable mirroring of the boot and other disks to two or more redundant storage devices. A node continues to function after storage device failure as long as one device remains available.

Mirroring does not support replacement of a failed disk. To restore the mirror to a pristine, non-degraded state, reprovision the node.



### NOTE

For user-provisioned infrastructure deployments, mirroring is available only on RHCOS systems. Support for mirroring is available on **x86\_64** nodes booted with BIOS or UEFI and on **ppc64le** nodes.

#### 20.1.4.3. Configuring disk encryption and mirroring

You can enable and configure encryption and mirroring during an OpenShift Container Platform installation.

### Prerequisites

- You have downloaded the OpenShift Container Platform installation program on your installation node.
- You installed Butane on your installation node.



#### NOTE

Butane is a command-line utility that OpenShift Container Platform uses to provide convenient, short-hand syntax for writing machine configs, as well as for performing additional validation of machine configs. For more information, see the *Creating machine configs with Butane* section.

- You have access to a Red Hat Enterprise Linux (RHEL) 8 machine that can be used to generate a thumbprint of the Tang exchange key.

### Procedure

1. If you want to use TPM v2 to encrypt your cluster, check to see if TPM v2 encryption needs to be enabled in the BIOS on each node. This is required on most Dell systems. Check the manual for your computer.
2. If you want to use Tang to encrypt your cluster, follow these preparatory steps:
  - a. Set up a Tang server or access an existing one. See [Network-bound disk encryption](#) for instructions.
  - b. Install the **clevis** package on a RHEL 8 machine, if it is not already installed:

```
$ sudo yum install clevis
```

- c. On the RHEL 8 machine, run the following command to generate a thumbprint of the exchange key. Replace **http://tang.example.com:7500** with the URL of your Tang server:

```
$ clevis-encrypt-tang '{"url":"http://tang.example.com:7500"}' < /dev/null > /dev/null 1
```

- 1** In this example, **tangd.socket** is listening on port **7500** on the Tang server.



#### NOTE

The **clevis-encrypt-tang** command is used in this step only to generate a thumbprint of the exchange key. No data is being passed to the command for encryption at this point, so **/dev/null** is provided as an input instead of plain text. The encrypted output is also sent to **/dev/null**, because it is not required for this procedure.

### Example output

The advertisement contains the following signing keys:

```
PLjNyRdGw03zlRoGjQYMahSZGu9 1
```

- 1** The thumbprint of the exchange key.

When the **Do you wish to trust these keys? [ynYN]** prompt displays, type **Y**.



#### NOTE

RHEL 8 provides Clevis version 15, which uses the SHA-1 hash algorithm to generate thumbprints. Some other distributions provide Clevis version 17 or later, which use the SHA-256 hash algorithm for thumbprints. You must use a Clevis version that uses SHA-1 to create the thumbprint, to prevent Clevis binding issues when you install Red Hat Enterprise Linux CoreOS (RHCOS) on your OpenShift Container Platform cluster nodes.

- d. If the nodes are configured with static IP addressing, use the **coreos-installer --append-karg** option when installing RHCOS nodes to set the IP address of the installed system. Append the **ip=** and other arguments needed for your network.



#### IMPORTANT

Some methods for configuring static IPs do not affect the initramfs after the first boot and will not work with Tang encryption. These include the **coreos-installer --copy-network** option, as well as adding **ip=** arguments to the kernel command line of the live ISO or PXE image during installation. Incorrect static IP configuration causes the second boot of the node to fail.

3. On your installation node, change to the directory that contains the installation program and generate the Kubernetes manifests for the cluster:

```
$ ./openshift-install create manifests --dir <installation_directory> 1
```

- 1** Replace **<installation\_directory>** with the path to the directory that you want to store the installation files in.

4. Create a Butane config that configures disk encryption, mirroring, or both. For example, to configure storage for compute nodes, create a **\$HOME/clusterconfig/worker-storage.bu** file.

#### Butane config example for a boot device

```
variant: openshift
version: 4.9.0
metadata:
  name: worker-storage 1
  labels:
    machineconfiguration.openshift.io/role: worker 2
boot_device:
  layout: x86_64 3
  luks: 4
```

```

tpm2: true 5
tang: 6
  - url: http://tang.example.com:7500 7
    thumbprint: PLjNyRdGw03zIRoGjQYMahSZGu9 8
threshold: 1 9
mirror: 10
  devices: 11
    - /dev/sda
    - /dev/sdb
openshift:
  fips: true 12

```

- 1 2 For control plane configurations, replace **worker** with **master** in both of these locations.
- 3 On ppc64le nodes, set this field to **ppc64le**. On all other nodes, this field can be omitted.
- 4 Include this section if you want to encrypt the root file system. For more details, see the *About disk encryption* section.
- 5 Include this field if you want to use a Trusted Platform Module (TPM) to encrypt the root file system.
- 6 Include this section if you want to use one or more Tang servers.
- 7 Specify the URL of a Tang server. In this example, **tangd.socket** is listening on port **7500** on the Tang server.
- 8 Specify the exchange key thumbprint, which was generated in a preceding step.
- 9 Specify the minimum number of TPM v2 and Tang encryption conditions that must be met for decryption to occur. The default value is **1**. For more information on this topic, see the *Configuring an encryption threshold* section.
- 10 Include this section if you want to mirror the boot disk. For more details, see *About disk mirroring*.
- 11 List all disk devices that should be included in the boot disk mirror, including the disk that RHCOS will be installed onto.
- 12 Include this directive to enable FIPS mode on your cluster.



### IMPORTANT

If you are configuring nodes to use both disk encryption and mirroring, both features must be configured in the same Butane config. In addition, if you are configuring disk encryption on a node with FIPS mode enabled, you must include the **fips** directive in the same Butane config, even if FIPS mode is also enabled in a separate manifest.

5. Create a control plane or compute node manifest from the corresponding Butane config and save it to the **<installation\_directory>/openshift** directory. For example, to create a manifest for the compute nodes, run the following command:

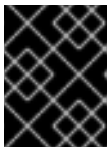
```
$ butane $HOME/clusterconfig/worker-storage.bu -o <installation_directory>/openshift/99-
worker-storage.yaml
```

Repeat this step for each node type that requires disk encryption or mirroring.

6. Save the Butane configs in case you need to update the manifests in the future.
7. Continue with the remainder of the OpenShift Container Platform installation.

## TIP

You can monitor the console log on the RHCOS nodes during installation for error messages relating to disk encryption or mirroring.



## IMPORTANT

If you configure additional data partitions, they will not be encrypted unless encryption is explicitly requested.

## Verification

After installing OpenShift Container Platform, you can verify if boot disk encryption or mirroring is enabled on the cluster nodes.

1. From the installation host, access a cluster node by using a debug pod:
  - a. Start a debug pod for the node. The following example starts a debug pod for the **compute-1** node:
- b. Set **/host** as the root directory within the debug shell. The debug pod mounts the root file system of the node in **/host** within the pod. By changing the root directory to **/host**, you can run binaries contained in the executable paths on the node:

```
$ oc debug node/compute-1
```

```
# chroot /host
```



## NOTE

OpenShift Container Platform cluster nodes running Red Hat Enterprise Linux CoreOS (RHCOS) are immutable and rely on Operators to apply cluster changes. Accessing cluster nodes using SSH is not recommended. However, if the OpenShift Container Platform API is not available, or **kubelet** is not properly functioning on the target node, **oc** operations will be impacted. In such situations, it is possible to access nodes using **ssh core@<node>.<cluster\_name>.<base\_domain>** instead.

2. If you configured boot disk encryption, verify if it is enabled:
  - a. From the debug shell, review the status of the root mapping on the node:

```
# cryptsetup status root
```

## Example output

```

/dev/mapper/root is active and is in use.
type: LUKS2 1
cipher: aes-xts-plain64 2
keysize: 512 bits
key location: keyring
device: /dev/sda4 3
sector size: 512
offset: 32768 sectors
size: 15683456 sectors
mode: read/write

```

- 1** The encryption format. When the TPM v2 or Tang encryption modes are enabled, the RHCOS boot disks are encrypted using the LUKS2 format.
- 2** The encryption algorithm used to encrypt the LUKS2 volume. The **aes-cbc-essiv:sha256** cipher is used if FIPS mode is enabled.
- 3** The device that contains the encrypted LUKS2 volume. If mirroring is enabled, the value will represent a software mirror device, for example **/dev/md126**.

- b. List the Clevis plugins that are bound to the encrypted device:

```
# clevis luks list -d /dev/sda4 1
```

- 1** Specify the device that is listed in the **device** field in the output of the preceding step.

## Example output

```
1: sss '{"t":1,"pins":{"tang":{"url":"http://tang.example.com:7500"}}}' 1
```

- 1** In the example output, the Tang plugin is used by the Shamir's Secret Sharing (SSS) Clevis plugin for the **/dev/sda4** device.

3. If you configured mirroring, verify if it is enabled:

- a. From the debug shell, list the software RAID devices on the node:

```
# cat /proc/mdstat
```

## Example output

```

Personalities : [raid1]
md126 : active raid1 sdb3[1] sda3[0] 1
        393152 blocks super 1.0 [2/2] [UU]

md127 : active raid1 sda4[0] sdb4[1] 2
        51869632 blocks super 1.2 [2/2] [UU]

unused devices: <none>

```



- 
- 1 In the example, the **/dev/md126** software RAID mirror device uses the **/dev/sda3** and **/dev/sdb3** disk devices on the cluster node.
- 2 In the example, the **/dev/md127** software RAID mirror device uses the **/dev/sda4** and **/dev/sdb4** disk devices on the cluster node.

b. Review the details of each of the software RAID devices listed in the output of the preceding command. The following example lists the details of the **/dev/md126** device:

```
# mdadm --detail /dev/md126
```

### Example output

```
/dev/md126:
  Version : 1.0
  Creation Time : Wed Jul 7 11:07:36 2021
  Raid Level : raid1 1
  Array Size : 393152 (383.94 MiB 402.59 MB)
  Used Dev Size : 393152 (383.94 MiB 402.59 MB)
  Raid Devices : 2
  Total Devices : 2
  Persistence : Superblock is persistent

  Update Time : Wed Jul 7 11:18:24 2021
  State : clean 2
  Active Devices : 2 3
  Working Devices : 2 4
  Failed Devices : 0 5
  Spare Devices : 0

Consistency Policy : resync

  Name : any:md-boot 6
  UUID : ccfa3801:c520e0b5:2bee2755:69043055
  Events : 19

Number Major Minor RaidDevice State
 0   252    3    0   active sync  /dev/sda3 7
 1   252   19    1   active sync  /dev/sdb3 8
```

- 1 Specifies the RAID level of the device. **raid1** indicates RAID 1 disk mirroring.
- 2 Specifies the state of the RAID device.
- 3 4 States the number of underlying disk devices that are active and working.
- 5 States the number of underlying disk devices that are in a failed state.
- 6 The name of the software RAID device.
- 7 8 Provides information about the underlying disk devices that are used by the software RAID device.

- c. List the file systems that are mounted on the software RAID devices:

```
# mount | grep /dev/md
```

### Example output

```
/dev/md127 on / type xfs
(rw,relatime,seclabel,attr2,inode64,logbufs=8,logbsize=32k,prjquota)
/dev/md127 on /etc type xfs
(rw,relatime,seclabel,attr2,inode64,logbufs=8,logbsize=32k,prjquota)
/dev/md127 on /usr type xfs
(ro,relatime,seclabel,attr2,inode64,logbufs=8,logbsize=32k,prjquota)
/dev/md127 on /sysroot type xfs
(ro,relatime,seclabel,attr2,inode64,logbufs=8,logbsize=32k,prjquota)
/dev/md127 on /var type xfs
(rw,relatime,seclabel,attr2,inode64,logbufs=8,logbsize=32k,prjquota)
/dev/md127 on /var/lib/containers/storage/overlay type xfs
(rw,relatime,seclabel,attr2,inode64,logbufs=8,logbsize=32k,prjquota)
/dev/md127 on /var/lib/kubelet/pods/e5054ed5-f882-4d14-b599-99c050d4e0c0/volume-
subpaths/etc/tuned/1 type xfs
(rw,relatime,seclabel,attr2,inode64,logbufs=8,logbsize=32k,prjquota)
/dev/md127 on /var/lib/kubelet/pods/e5054ed5-f882-4d14-b599-99c050d4e0c0/volume-
subpaths/etc/tuned/2 type xfs
(rw,relatime,seclabel,attr2,inode64,logbufs=8,logbsize=32k,prjquota)
/dev/md127 on /var/lib/kubelet/pods/e5054ed5-f882-4d14-b599-99c050d4e0c0/volume-
subpaths/etc/tuned/3 type xfs
(rw,relatime,seclabel,attr2,inode64,logbufs=8,logbsize=32k,prjquota)
/dev/md127 on /var/lib/kubelet/pods/e5054ed5-f882-4d14-b599-99c050d4e0c0/volume-
subpaths/etc/tuned/4 type xfs
(rw,relatime,seclabel,attr2,inode64,logbufs=8,logbsize=32k,prjquota)
/dev/md127 on /var/lib/kubelet/pods/e5054ed5-f882-4d14-b599-99c050d4e0c0/volume-
subpaths/etc/tuned/5 type xfs
(rw,relatime,seclabel,attr2,inode64,logbufs=8,logbsize=32k,prjquota)
/dev/md126 on /boot type ext4 (rw,relatime,seclabel)
```

In the example output, the **/boot** file system is mounted on the **/dev/md126** software RAID device and the root file system is mounted on **/dev/md127**.

4. Repeat the verification steps for each OpenShift Container Platform node type.

### Additional resources

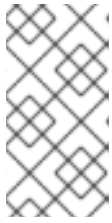
- For more information about the TPM v2 and Tang encryption modes, see [Configuring automated unlocking of encrypted volumes using policy-based decryption](#).

#### 20.1.4.4. Configuring a RAID-enabled data volume

You can enable software RAID partitioning to provide an external data volume. OpenShift Container Platform supports RAID 0, RAID 1, RAID 4, RAID 5, RAID 6, and RAID 10 for data protection and fault tolerance. See "About disk mirroring" for more details.

### Prerequisites

- You have downloaded the OpenShift Container Platform installation program on your installation node.
- You have installed Butane on your installation node.



## NOTE

Butane is a command-line utility that OpenShift Container Platform uses to provide convenient, short-hand syntax for writing machine configs, as well as for performing additional validation of machine configs. For more information, see the *Creating machine configs with Butane* section.

## Procedure

1. Create a Butane config that configures a data volume by using software RAID.
  - To configure a data volume with RAID 1 on the same disks that are used for a mirrored boot disk, create a **\$HOME/clusterconfig/raid1-storage.bu** file, for example:

### RAID 1 on mirrored boot disk

```
variant: openshift
version: 4.9.0
metadata:
  name: raid1-storage
  labels:
    machineconfiguration.openshift.io/role: worker
boot_device:
  mirror:
    devices:
      - /dev/sda
      - /dev/sdb
storage:
  disks:
    - device: /dev/sda
      partitions:
        - label: root-1
          size_mib: 25000 1
        - label: var-1
    - device: /dev/sdb
      partitions:
        - label: root-2
          size_mib: 25000 2
        - label: var-2
  raid:
    - name: md-var
      level: raid1
      devices:
        - /dev/disk/by-partlabel/var-1
        - /dev/disk/by-partlabel/var-2
filesystems:
  - device: /dev/md/md-var
    path: /var
```

```
format: xfs
wipe_filesystem: true
with_mount_unit: true
```

- 1** **2** When adding a data partition to the boot disk, a minimum value of 25000 mebibytes is recommended. If no value is specified, or if the specified value is smaller than the recommended minimum, the resulting root file system will be too small, and future reinstalls of RHCOS might overwrite the beginning of the data partition.

- To configure a data volume with RAID 1 on secondary disks, create a **\$HOME/clusterconfig/raid1-alt-storage.bu** file, for example:

### RAID 1 on secondary disks

```
variant: openshift
version: 4.9.0
metadata:
  name: raid1-alt-storage
  labels:
    machineconfiguration.openshift.io/role: worker
storage:
  disks:
    - device: /dev/sdc
      wipe_table: true
      partitions:
        - label: data-1
    - device: /dev/sdd
      wipe_table: true
      partitions:
        - label: data-2
  raid:
    - name: md-var-lib-containers
      level: raid1
      devices:
        - /dev/disk/by-partlabel/data-1
        - /dev/disk/by-partlabel/data-2
  filesystems:
    - device: /dev/md/md-var-lib-containers
      path: /var/lib/containers
      format: xfs
      wipe_filesystem: true
      with_mount_unit: true
```

2. Create a RAID manifest from the Butane config you created in the previous step and save it to the **<installation\_directory>/openshift** directory. For example, to create a manifest for the compute nodes, run the following command:

```
$ butane $HOME/clusterconfig/<butane_config>.bu -o
<installation_directory>/openshift/<manifest_name>.yaml 1
```

- 1** Replace **<butane\_config>** and **<manifest\_name>** with the file names from the previous step. For example, **raid1-alt-storage.bu** and **raid1-alt-storage.yaml** for secondary disks.

3. Save the Butane config in case you need to update the manifest in the future.
4. Continue with the remainder of the OpenShift Container Platform installation.

## 20.1.5. Configuring chrony time service

You can set the time server and related settings used by the chrony time service (**chronyd**) by modifying the contents of the **chrony.conf** file and passing those contents to your nodes as a machine config.

### Procedure

1. Create a Butane config including the contents of the **chrony.conf** file. For example, to configure chrony on worker nodes, create a **99-worker-chrony.bu** file.



### NOTE

See "Creating machine configs with Butane" for information about Butane.

```
variant: openshift
version: 4.9.0
metadata:
  name: 99-worker-chrony 1
  labels:
    machineconfiguration.openshift.io/role: worker 2
storage:
  files:
  - path: /etc/chrony.conf
    mode: 0644 3
    overwrite: true
    contents:
      inline: |
        pool 0.rhel.pool.ntp.org iburst 4
        driftfile /var/lib/chrony/drift
        makestep 1.0 3
        rtsync
        logdir /var/log/chrony
```

- 1 2 On control plane nodes, substitute **master** for **worker** in both of these locations.
- 3 Specify an octal value mode for the **mode** field in the machine config file. After creating the file and applying the changes, the **mode** is converted to a decimal value. You can check the YAML file with the command **oc get mc <mc-name> -o yaml**.
- 4 Specify any valid, reachable time source, such as the one provided by your DHCP server. Alternately, you can specify any of the following NTP servers: **1.rhel.pool.ntp.org**, **2.rhel.pool.ntp.org**, or **3.rhel.pool.ntp.org**.

2. Use Butane to generate a **MachineConfig** object file, **99-worker-chrony.yaml**, containing the configuration to be delivered to the nodes:

```
$ butane 99-worker-chrony.bu -o 99-worker-chrony.yaml
```

3. Apply the configurations in one of two ways:

- If the cluster is not running yet, after you generate manifest files, add the **MachineConfig** object file to the **<installation\_directory>/openshift** directory, and then continue to create the cluster.
- If the cluster is already running, apply the file:

```
$ oc apply -f ./99-worker-chrony.yaml
```

### 20.1.6. Additional resources

- For information on Butane, see [Creating machine configs with Butane](#).
- For information on FIPS support, see [Support for FIPS cryptography](#).

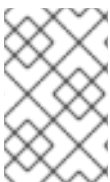
## 20.2. CONFIGURING YOUR FIREWALL

If you use a firewall, you must configure it so that OpenShift Container Platform can access the sites that it requires to function. You must always grant access to some sites, and you grant access to more if you use Red Hat Insights, the Telemetry service, a cloud to host your cluster, and certain build strategies.

### 20.2.1. Configuring your firewall for OpenShift Container Platform

Before you install OpenShift Container Platform, you must configure your firewall to grant access to the sites that OpenShift Container Platform requires.

There are no special configuration considerations for services running on only controller nodes compared to worker nodes.



#### NOTE

If your environment has a dedicated load balancer in front of your OpenShift Container Platform cluster, review the allowlists between your firewall and load balancer to prevent unwanted network restrictions to your cluster.

#### Procedure

1. Allowlist the following registry URLs:

URL	Port	Function
<b>registry.redhat.io</b>	443, 80	Provides core container images
<b>access.redhat.com</b>	443, 80	Provides core container images
<b>quay.io</b>	443, 80	Provides core container images
<b>cdn.quay.io</b>	443, 80	Provides core container images
<b>cdn01.quay.io</b>	443, 80	Provides core container images

URL	Port	Function
<b>cdn02.quay.io</b>	443, 80	Provides core container images
<b>cdn03.quay.io</b>	443, 80	Provides core container images
<b>sso.redhat.com</b>	443, 80	The <a href="https://console.redhat.com/openshift">https://console.redhat.com/openshift</a> site uses authentication from <b>sso.redhat.com</b>

You can use the wildcard **\*.quay.io** instead of **cdn0[1-3].quay.io** in your allowlist. When you add a site, such as **quay.io**, to your allowlist, do not add a wildcard entry, such as **\*.quay.io**, to your denylist. In most cases, image registries use a content delivery network (CDN) to serve images. If a firewall blocks access, image downloads are denied when the initial download request redirects to a hostname such as **cdn01.quay.io**.

2. Allowlist any site that provides resources for a language or framework that your builds require.
3. If you do not disable Telemetry, you must grant access to the following URLs to access Red Hat Insights:

URL	Port	Function
<b>cert-api.access.redhat.com</b>	443, 80	Required for Telemetry
<b>api.access.redhat.com</b>	443, 80	Required for Telemetry
<b>infogw.api.openshift.com</b>	443, 80	Required for Telemetry
<b>console.redhat.com/api/ingress,</b> <b>cloud.redhat.com/api/ingress</b>	443, 80	Required for Telemetry and for <b>insights-operator</b>

4. If you use Amazon Web Services (AWS), Microsoft Azure, or Google Cloud Platform (GCP) to host your cluster, you must grant access to the URLs that provide the cloud provider API and DNS for that cloud:

Cloud	URL	Port	Function
AWS	<b>*.amazonaws.com</b>  Alternatively, if you choose to not use a wildcard for AWS APIs, you must allowlist the following URLs:	443, 80	Required to access AWS services and resources. Review the <a href="#">AWS Service Endpoints</a> in the AWS documentation to determine the exact endpoints to allow for the regions that you use.
	<b>ec2.amazonaws.com</b>	443	Used to install and manage clusters in an AWS environment.

Cloud	URL	Port	Function
	<b>events.amazonaws.com</b>	443	Used to install and manage clusters in an AWS environment.
	<b>iam.amazonaws.com</b>	443	Used to install and manage clusters in an AWS environment.
	<b>route53.amazonaws.com</b>	443	Used to install and manage clusters in an AWS environment.
	<b>s3.amazonaws.com</b>	443	Used to install and manage clusters in an AWS environment.
	<b>s3.&lt;aws_region&gt;.amazonaws.com</b>	443	Used to install and manage clusters in an AWS environment.
	<b>s3.dualstack.&lt;aws_region&gt;.amazonaws.com</b>	443	Used to install and manage clusters in an AWS environment.
	<b>sts.amazonaws.com</b>	443	Used to install and manage clusters in an AWS environment.
	<b>sts.&lt;aws_region&gt;.amazonaws.com</b>	443	Used to install and manage clusters in an AWS environment.
	<b>tagging.us-east-1.amazonaws.com</b>	443	Used to install and manage clusters in an AWS environment. This endpoint is always <b>us-east-1</b> , regardless of the region the cluster is deployed in.
	<b>ec2.&lt;aws_region&gt;.amazonaws.com</b>	443	Used to install and manage clusters in an AWS environment.
	<b>elasticloadbalancing.&lt;aws_region&gt;.amazonaws.com</b>	443	Used to install and manage clusters in an AWS environment.
	<b>servicequotas.&lt;aws_region&gt;.amazonaws.com</b>	443, 80	Required. Used to confirm quotas for deploying the service.
	<b>tagging.&lt;aws_region&gt;.amazonaws.com</b>	443, 80	Allows the assignment of metadata about AWS resources in the form of tags.
GCP	<b>*.googleapis.com</b>	443, 80	Required to access GCP services and resources. Review <a href="#">Cloud Endpoints</a> in the GCP documentation to determine the endpoints to allow for your APIs.



Cloud	URL	Port	Function
	<b>accounts.google.com</b>	443, 80	Required to access your GCP account.
Azure	<b>management.azure.com</b>	443, 80	Required to access Azure services and resources. Review the <a href="#">Azure REST API reference</a> in the Azure documentation to determine the endpoints to allow for your APIs.
	<b>*.blob.core.windows.net</b>	443, 80	Required to download Ignition files.
	<b>login.microsoftonline.com</b>	443, 80	Required to access Azure services and resources. Review the <a href="#">Azure REST API reference</a> in the Azure documentation to determine the endpoints to allow for your APIs.

5. Allowlist the following URLs:

URL	Port	Function
<b>mirror.openshift.com</b>	443, 80	Required to access mirrored installation content and images. This site is also a source of release image signatures, although the Cluster Version Operator needs only a single functioning source.
<b>storage.googleapis.com/openshift-release</b>	443, 80	A source of release image signatures, although the Cluster Version Operator needs only a single functioning source.
<b>*.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;</b>	443, 80	Required to access the default cluster routes unless you set an ingress wildcard during installation.
<b>quayio-production-s3.s3.amazonaws.com</b>	443, 80	Required to access Quay image content in AWS.

URL	Port	Function
<b>api.openshift.com</b>	443, 80	Required both for your cluster token and to check if updates are available for the cluster.
<b>rhcos-redirector.apps.art.xq1c.p1.openshiftapps.com, rhcos.mirror.openshift.com</b>	443, 80	Required to download Red Hat Enterprise Linux CoreOS (RHCOS) images.
<b>console.redhat.com/openshift</b>	443, 80	Required for your cluster token.
<b>registry.access.redhat.com</b>	443, 80	Required for <b>odo</b> CLI.
<b>sso.redhat.com</b>	443, 80	The <a href="https://console.redhat.com/openshift">https://console.redhat.com/openshift</a> site uses authentication from <b>sso.redhat.com</b>

Operators require route access to perform health checks. Specifically, the authentication and web console Operators connect to two routes to verify that the routes work. If you are the cluster administrator and do not want to allow **\*.apps.<cluster\_name>.<base\_domain>**, then allow these routes:

- **oauth-openshift.apps.<cluster\_name>.<base\_domain>**
- **console-openshift-console.apps.<cluster\_name>.<base\_domain>**, or the hostname that is specified in the **spec.route.hostname** field of the **consoles.operator/cluster** object if the field is not empty.

6. Allowlist the following URLs for optional third-party content:

URL	Port	Function
<b>registry.connect.redhat.com</b>	443, 80	Required for all third-party images and certified operators.
<b>rhc4tp-prod-z8cxf-image-registry-us-east-1-evenkyleffocxqvofrk.s3.dualstack.us-east-1.amazonaws.com</b>	443, 80	Provides access to container images hosted on <b>registry.connect.redhat.com</b>
<b>oso-rhc4tp-docker-registry.s3-us-west-2.amazonaws.com</b>	443, 80	Required for Sonatype Nexus, F5 Big IP operators.

7. If you use a default Red Hat Network Time Protocol (NTP) server allow the following URLs:

- **1.rhel.pool.ntp.org**
- **2.rhel.pool.ntp.org**
- **3.rhel.pool.ntp.org**



#### **NOTE**

If you do not use a default Red Hat NTP server, verify the NTP server for your platform and allow it in your firewall.

## CHAPTER 21. VALIDATING AN INSTALLATION

You can check the status of an OpenShift Container Platform cluster after an installation by following the procedures in this document.

### 21.1. REVIEWING THE INSTALLATION LOG

You can review a summary of an installation in the OpenShift Container Platform installation log. If an installation succeeds, the information required to access the cluster is included in the log.

#### Prerequisites

- You have access to the installation host.

#### Procedure

- Review the `.openshift_install.log` log file in the installation directory on your installation host:

```
$ cat <install_dir>/openshift_install.log
```

#### Example output

Cluster credentials are included at the end of the log if the installation is successful, as outlined in the following example:

```
...
time="2020-12-03T09:50:47Z" level=info msg="Install complete!"
time="2020-12-03T09:50:47Z" level=info msg="To access the cluster as the system:admin
user when using 'oc', run 'export KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'"
time="2020-12-03T09:50:47Z" level=info msg="Access the OpenShift web-console here:
https://console-openshift-console.apps.mycluster.example.com"
time="2020-12-03T09:50:47Z" level=info msg="Login to the console with user: \"kubeadmin\",
and password: \"6zYIx-ckbW3-4d2Ne-IWvDF\""
time="2020-12-03T09:50:47Z" level=debug msg="Time elapsed per stage:"
time="2020-12-03T09:50:47Z" level=debug msg=" Infrastructure: 6m45s"
time="2020-12-03T09:50:47Z" level=debug msg="Bootstrap Complete: 11m30s"
time="2020-12-03T09:50:47Z" level=debug msg=" Bootstrap Destroy: 1m5s"
time="2020-12-03T09:50:47Z" level=debug msg=" Cluster Operators: 17m31s"
time="2020-12-03T09:50:47Z" level=info msg="Time elapsed: 37m26s"
```

### 21.2. VIEWING THE IMAGE PULL SOURCE

For clusters with unrestricted network connectivity, you can view the source of your pulled images by using a command on a node, such as `crictl images`.

However, for disconnected installations, to view the source of pulled images, you must review the CRI-O logs to locate the **Trying to access** log entry, as shown in the following procedure. Other methods to view the image pull source, such as the `crictl images` command, show the non-mirrored image name, even though the image is pulled from the mirrored location.

#### Prerequisites

- You have access to the cluster as a user with the `cluster-admin` role.

## Procedure

- Review the CRI-O logs for a master or worker node:

```
$ oc adm node-logs <node_name> -u crio
```

## Example output

The **Trying to access** log entry indicates where the image is being pulled from.

```
...
Mar 17 02:52:50 ip-10-0-138-140.ec2.internal crio[1366]: time="2021-08-05
10:33:21.594930907Z" level=info msg="Pulling image: quay.io/openshift-release-dev/ocp-
release:4.9.0-ppc64le" id=abcd713b-d0e1-4844-ac1c-474c5b60c07c
name=/runtime.v1alpha2.ImageService/PullImage
Mar 17 02:52:50 ip-10-0-138-140.ec2.internal crio[1484]: time="2021-03-17
02:52:50.194341109Z" level=info msg="Trying to access \"li0317gcp1.mirror-
registry.qe.gcp.devcluster.openshift.com:5000/ocp/release@sha256:1926eae7cacb9c00f142ec
98b00628970e974284b6ddaf9a6a086cb9af7a6c31\""
Mar 17 02:52:50 ip-10-0-138-140.ec2.internal crio[1484]: time="2021-03-17
02:52:50.226788351Z" level=info msg="Trying to access \"li0317gcp1.mirror-
registry.qe.gcp.devcluster.openshift.com:5000/ocp/release@sha256:1926eae7cacb9c00f142ec
98b00628970e974284b6ddaf9a6a086cb9af7a6c31\""
...
```

The log might show the image pull source twice, as shown in the preceding example.

If your **ImageContentSourcePolicy** object lists multiple mirrors, OpenShift Container Platform attempts to pull the images in the order listed in the configuration, for example:

```
Trying to access \"li0317gcp1.mirror-
registry.qe.gcp.devcluster.openshift.com:5000/ocp/release@sha256:1926eae7cacb9c00f142ec
98b00628970e974284b6ddaf9a6a086cb9af7a6c31\""
Trying to access \"li0317gcp2.mirror-
registry.qe.gcp.devcluster.openshift.com:5000/ocp/release@sha256:1926eae7cacb9c00f142ec
98b00628970e974284b6ddaf9a6a086cb9af7a6c31\""
```

## 21.3. GETTING CLUSTER VERSION, STATUS, AND UPDATE DETAILS

You can view the cluster version and status by running the **oc get clusterversion** command. If the status shows that the installation is still progressing, you can review the status of the Operators for more information.

You can also list the current update channel and review the available cluster updates.

### Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.
- You have installed the OpenShift CLI (**oc**).

### Procedure

1. Obtain the cluster version and overall status:

-

```
$ oc get clusterversion
```

### Example output

```
NAME     VERSION  AVAILABLE  PROGRESSING  SINCE  STATUS
version  4.6.4    True       False        6m25s  Cluster version is 4.6.4
```

The example output indicates that the cluster has been installed successfully.

2. If the cluster status indicates that the installation is still progressing, you can obtain more detailed progress information by checking the status of the Operators:

```
$ oc get clusteroperators.config.openshift.io
```

3. View a detailed summary of cluster specifications, update availability, and update history:

```
$ oc describe clusterversion
```

4. List the current update channel:

```
$ oc get clusterversion -o jsonpath='{.items[0].spec}{"\n"}'
```

### Example output

```
{"channel":"stable-4.6","clusterID":"245539c1-72a3-41aa-9cec-72ed8cf25c5c"}
```

5. Review the available cluster updates:

```
$ oc adm upgrade
```

### Example output

```
Cluster version is 4.6.4
```

```
Updates:
```

```
VERSION IMAGE
```

```
4.6.6 quay.io/openshift-release-dev/ocp-
release@sha256:c7e8f18e8116356701bd23ae3a23fb9892dd5ea66c8300662ef30563d7104f3
9
```

### Additional resources

- See [Querying Operator status after installation](#) for more information about querying Operator status if your installation is still progressing.
- See [Troubleshooting Operator issues](#) for information about investigating issues with Operators.
- See [Updating a cluster](#) for more information on updating your cluster.
- See [OpenShift Container Platform upgrade channels and releases](#) for an overview about upgrade release channels.

## 21.4. QUERYING THE STATUS OF THE CLUSTER NODES BY USING THE CLI

You can verify the status of the cluster nodes after an installation.

### Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.
- You have installed the OpenShift CLI (**oc**).

### Procedure

1. List the status of the cluster nodes. Verify that the output lists all of the expected control plane and compute nodes and that each node has a **Ready** status:

```
$ oc get nodes
```

### Example output

```
NAME                                STATUS  ROLES  AGE  VERSION
compute-1.example.com              Ready  worker  33m  v1.22.1
control-plane-1.example.com        Ready  master  41m  v1.22.1
control-plane-2.example.com        Ready  master  45m  v1.22.1
compute-2.example.com              Ready  worker  38m  v1.22.1
compute-3.example.com              Ready  worker  33m  v1.22.1
control-plane-3.example.com        Ready  master  41m  v1.22.1
```

2. Review CPU and memory resource availability for each cluster node:

```
$ oc adm top nodes
```

### Example output

```
NAME                                CPU(cores)  CPU%  MEMORY(bytes)  MEMORY%
compute-1.example.com              128m        8%    1132Mi         16%
control-plane-1.example.com        801m        22%    3471Mi         23%
control-plane-2.example.com        1718m       49%    6085Mi         40%
compute-2.example.com              935m        62%    5178Mi         75%
compute-3.example.com              111m        7%    1131Mi         16%
control-plane-3.example.com        942m        26%    4100Mi         27%
```

### Additional resources

- See [Verifying node health](#) for more details about reviewing node health and investigating node issues.

## 21.5. REVIEWING THE CLUSTER STATUS FROM THE OPENSIFT CONTAINER PLATFORM WEB CONSOLE

You can review the following information in the **Overview** page in the OpenShift Container Platform web console:

- The general status of your cluster
- The status of the control plane, cluster Operators, and storage
- CPU, memory, file system, network transfer, and pod availability
- The API address of the cluster, the cluster ID, and the name of the provider
- Cluster version information
- Cluster update status, including details of the current update channel and available updates
- A cluster inventory detailing node, pod, storage class, and persistent volume claim (PVC) information
- A list of ongoing cluster activities and recent events

### Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.

### Procedure

- In the **Administrator** perspective, navigate to **Home** → **Overview**.

## 21.6. REVIEWING THE CLUSTER STATUS FROM RED HAT OPENSIFT CLUSTER MANAGER

From the OpenShift Container Platform web console, you can review detailed information about the status of your cluster on OpenShift Cluster Manager.

### Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.

### Procedure

1. In the **Administrator** perspective, navigate to **Home** → **Overview** → **Details** → **Cluster ID** → **OpenShift Cluster Manager** to open your cluster's **Overview** tab in the OpenShift Cluster Manager web console.
2. From the **Overview** tab on [OpenShift Cluster Manager](#), review the following information about your cluster:
  - vCPU and memory availability and resource usage
  - The cluster ID, status, type, region, and the provider name
  - Node counts by node type
  - Cluster version details, the creation date of the cluster, and the name of the cluster owner
  - The life cycle support status of the cluster



- Subscription information, including the service level agreement (SLA) status, the subscription unit type, the production status of the cluster, the subscription obligation, and the service level

### TIP

To view the history for your cluster, click the **Cluster history** tab.

3. Navigate to the **Monitoring** page to review the following information:
  - A list of any issues that have been detected
  - A list of alerts that are firing
  - The cluster Operator status and version
  - The cluster's resource usage
4. Optional: You can view information about your cluster that Red Hat Insights collects by navigating to the **Overview** menu. From this menu you can view the following information:
  - Potential issues that your cluster might be exposed to, categorized by risk level
  - Health-check status by category

### Additional resources

- See [Using Insights to identify issues with your cluster](#) for more information about reviewing potential issues with your cluster.

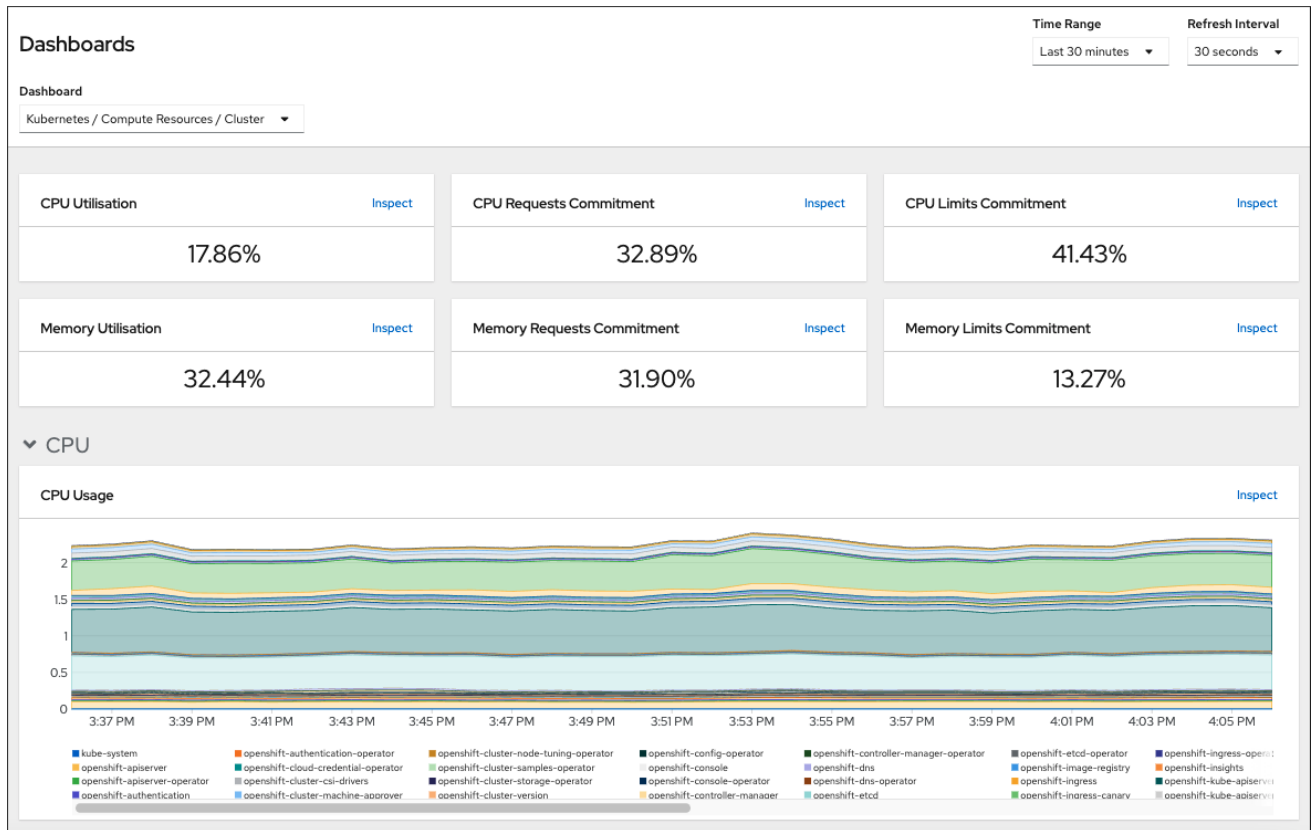
## 21.7. CHECKING CLUSTER RESOURCE AVAILABILITY AND UTILIZATION

OpenShift Container Platform provides a comprehensive set of monitoring dashboards that help you understand the state of cluster components.

In the **Administrator** perspective, you can access dashboards for core OpenShift Container Platform components, including:

- etcd
- Kubernetes compute resources
- Kubernetes network resources
- Prometheus
- Dashboards relating to cluster and node performance

Figure 21.1. Example compute resources dashboard



## Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.

## Procedure

- In the **Administrator** perspective in the OpenShift Container Platform web console, navigate to **Observe → Dashboards**.
- Choose a dashboard in the **Dashboard** list. Some dashboards, such as the **etcd** dashboard, produce additional sub-menus when selected.
- Optional: Select a time range for the graphs in the **Time Range** list.
  - Select a pre-defined time period.
  - Set a custom time range by selecting **Custom time range** in the **Time Range** list.
    - Input or select the **From** and **To** dates and times.
    - Click **Save** to save the custom time range.
- Optional: Select a **Refresh Interval**
- Hover over each of the graphs within a dashboard to display detailed information about specific items.

## Additional resources

- See [Monitoring overview](#) for more information about the OpenShift Container Platform monitoring stack.

## 21.8. LISTING ALERTS THAT ARE FIRING

Alerts provide notifications when a set of defined conditions are true in an OpenShift Container Platform cluster. You can review the alerts that are firing in your cluster by using the Alerting UI in the OpenShift Container Platform web console.

### Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.

### Procedure

1. In the **Administrator** perspective, navigate to the **Observe → Alerting → Alerts** page.
2. Review the alerts that are firing, including their **Severity**, **State**, and **Source**.
3. Select an alert to view more detailed information in the **Alert Details** page.

### Additional resources

- See [Managing alerts](#) for further details about alerting in OpenShift Container Platform.

## 21.9. NEXT STEPS

- See [Troubleshooting installations](#) if you experience issues when installing your cluster.
- After installing OpenShift Container Platform, you can [further expand and customize your cluster](#).

## CHAPTER 22. TROUBLESHOOTING INSTALLATION ISSUES

To assist in troubleshooting a failed OpenShift Container Platform installation, you can gather logs from the bootstrap and control plane machines. You can also get debug information from the installation program. If you are unable to resolve the issue using the logs and debug information, see [Determining where installation issues occur](#) for component-specific troubleshooting.



### NOTE

If your OpenShift Container Platform installation fails and the debug output or logs contain network timeouts or other connectivity errors, review the guidelines for [configuring your firewall](#). Gathering logs from your firewall and load balancer can help you diagnose network-related errors.

### 22.1. PREREQUISITES

- You attempted to install an OpenShift Container Platform cluster and the installation failed.

### 22.2. GATHERING LOGS FROM A FAILED INSTALLATION

If you gave an SSH key to your installation program, you can gather data about your failed installation.



### NOTE

You use a different command to gather logs about an unsuccessful installation than to gather logs from a running cluster. If you must gather logs from a running cluster, use the **oc adm must-gather** command.

#### Prerequisites

- Your OpenShift Container Platform installation failed before the bootstrap process finished. The bootstrap node is running and accessible through SSH.
- The **ssh-agent** process is active on your computer, and you provided the same SSH key to both the **ssh-agent** process and the installation program.
- If you tried to install a cluster on infrastructure that you provisioned, you must have the fully qualified domain names of the bootstrap and control plane nodes.

#### Procedure

1. Generate the commands that are required to obtain the installation logs from the bootstrap and control plane machines:
  - If you used installer-provisioned infrastructure, change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install gather bootstrap --dir <installation_directory> 1
```

- 1** **installation\_directory** is the directory you specified when you ran **./openshift-install create cluster**. This directory contains the OpenShift Container Platform definition files that the installation program creates.

For installer-provisioned infrastructure, the installation program stores information about the cluster, so you do not specify the hostnames or IP addresses.

- If you used infrastructure that you provisioned yourself, change to the directory that contains the installation program and run the following command:

```
$ ./openshift-install gather bootstrap --dir <installation_directory> \ 1
--bootstrap <bootstrap_address> \ 2
--master <master_1_address> \ 3
--master <master_2_address> \ 4
--master <master_3_address>" 5
```

- 1** For **installation\_directory**, specify the same directory you specified when you ran **./openshift-install create cluster**. This directory contains the OpenShift Container Platform definition files that the installation program creates.
- 2** **<bootstrap\_address>** is the fully qualified domain name or IP address of the cluster's bootstrap machine.
- 3** **4** **5** For each control plane, or master, machine in your cluster, replace **<master\_\*\_address>** with its fully qualified domain name or IP address.



#### NOTE

A default cluster contains three control plane machines. List all of your control plane machines as shown, no matter how many your cluster uses.

#### Example output

```
INFO Pulling debug logs from the bootstrap machine
INFO Bootstrap gather logs captured here "<installation_directory>/log-bundle-
<timestamp>.tar.gz"
```

If you open a Red Hat support case about your installation failure, include the compressed logs in the case.

## 22.3. MANUALLY GATHERING LOGS WITH SSH ACCESS TO YOUR HOST(S)

Manually gather logs in situations where **must-gather** or automated collection methods do not work.



#### IMPORTANT

By default, SSH access to the OpenShift Container Platform nodes is disabled on the Red Hat OpenStack Platform (RHOSP) based installations.

#### Prerequisites

- You must have SSH access to your host(s).

#### Procedure

1. Collect the **bootkube.service** service logs from the bootstrap host using the **journalctl** command by running:

```
$ journalctl -b -f -u bootkube.service
```

2. Collect the bootstrap host's container logs using the podman logs. This is shown as a loop to get all of the container logs from the host:

```
$ for pod in $(sudo podman ps -a -q); do sudo podman logs $pod; done
```

3. Alternatively, collect the host's container logs using the **tail** command by running:

```
# tail -f /var/lib/containers/storage/overlay-containers/*/userdata/ctr.log
```

4. Collect the **kubelet.service** and **crio.service** service logs from the master and worker hosts using the **journalctl** command by running:

```
$ journalctl -b -f -u kubelet.service -u crio.service
```

5. Collect the master and worker host container logs using the **tail** command by running:

```
$ sudo tail -f /var/log/containers/*
```

## 22.4. MANUALLY GATHERING LOGS WITHOUT SSH ACCESS TO YOUR HOST(S)

Manually gather logs in situations where **must-gather** or automated collection methods do not work.

If you do not have SSH access to your node, you can access the systems journal to investigate what is happening on your host.

### Prerequisites

- Your OpenShift Container Platform installation must be complete.
- Your API service is still functional.
- You have system administrator privileges.

### Procedure

1. Access **journald** unit logs under **/var/log** by running:

```
$ oc adm node-logs --role=master -u kubelet
```

2. Access host file paths under **/var/log** by running:

```
$ oc adm node-logs --role=master --path=openshift-apiserver
```

## 22.5. GETTING DEBUG INFORMATION FROM THE INSTALLATION PROGRAM

You can use any of the following actions to get debug information from the installation program.

- Look at debug messages from a past installation in the hidden **.openshift\_install.log** file. For example, enter:

```
$ cat ~/<installation_directory>/.openshift_install.log 1
```

- 1 For **installation\_directory**, specify the same directory you specified when you ran **./openshift-install create cluster**.

- Change to the directory that contains the installation program and re-run it with **--log-level=debug**:

```
$ ./openshift-install create cluster --dir <installation_directory> --log-level debug 1
```

- 1 For **installation\_directory**, specify the same directory you specified when you ran **./openshift-install create cluster**.

## 22.6. REINSTALLING THE OPENSIFT CONTAINER PLATFORM CLUSTER

If you are unable to debug and resolve issues in the failed OpenShift Container Platform installation, consider installing a new OpenShift Container Platform cluster. Before starting the installation process again, you must complete thorough cleanup. For a user-provisioned infrastructure (UPI) installation, you must manually destroy the cluster and delete all associated resources. The following procedure is for an installer-provisioned infrastructure (IPI) installation.

### Procedure

1. Destroy the cluster and remove all the resources associated with the cluster, including the hidden installer state files in the installation directory:

```
$ ./openshift-install destroy cluster --dir <installation_directory> 1
```

- 1 **installation\_directory** is the directory you specified when you ran **./openshift-install create cluster**. This directory contains the OpenShift Container Platform definition files that the installation program creates.

2. Before reinstalling the cluster, delete the installation directory:

```
$ rm -rf <installation_directory>
```

3. Follow the procedure for installing a new OpenShift Container Platform cluster.

### Additional resources

- [Installing an OpenShift Container Platform cluster](#)

## CHAPTER 23. SUPPORT FOR FIPS CRYPTOGRAPHY

You can install an OpenShift Container Platform cluster that uses FIPS Validated / Modules in Process cryptographic libraries on the **x86\_64** architecture.

For the Red Hat Enterprise Linux CoreOS (RHCOS) machines in your cluster, this change is applied when the machines are deployed based on the status of an option in the **install-config.yaml** file, which governs the cluster options that a user can change during cluster deployment. With Red Hat Enterprise Linux (RHEL) machines, you must enable FIPS mode when you install the operating system on the machines that you plan to use as worker machines. These configuration methods ensure that your cluster meet the requirements of a FIPS compliance audit: only FIPS Validated / Modules in Process cryptography packages are enabled before the initial system boot.

Because FIPS must be enabled before the operating system that your cluster uses boots for the first time, you cannot enable FIPS after you deploy a cluster.

### 23.1. FIPS VALIDATION IN OPENSIFT CONTAINER PLATFORM

OpenShift Container Platform uses certain FIPS Validated / Modules in Process modules within RHEL and RHCOS for the operating system components that it uses. See [RHEL8 core crypto components](#). For example, when users SSH into OpenShift Container Platform clusters and containers, those connections are properly encrypted.

OpenShift Container Platform components are written in Go and built with Red Hat's go lang compiler. When you enable FIPS mode for your cluster, all OpenShift Container Platform components that require cryptographic signing call RHEL and RHCOS cryptographic libraries.

**Table 23.1. FIPS mode attributes and limitations in OpenShift Container Platform 4.9**

Attributes	Limitations
FIPS support in RHEL 7, RHEL 8, and RHCOS operating systems.	The FIPS implementation does not offer a single function that both computes hash functions and validates the keys that are based on that hash. This limitation will continue to be evaluated and improved in future OpenShift Container Platform releases.
FIPS support in CRI-O runtimes.	
FIPS support in OpenShift Container Platform services.	
FIPS Validated / Modules in Process cryptographic module and algorithms that are obtained from RHEL 7, RHEL 8, and RHCOS binaries and images.	
Use of FIPS compatible go lang compiler.	TLS FIPS support is not complete but is planned for future OpenShift Container Platform releases.
FIPS support across multiple architectures.	FIPS is currently only supported on OpenShift Container Platform deployments using the <b>x86_64</b> architecture.

### 23.2. FIPS SUPPORT IN COMPONENTS THAT THE CLUSTER USES



Although the OpenShift Container Platform cluster itself uses FIPS Validated / Modules in Process modules, ensure that the systems that support your OpenShift Container Platform cluster use FIPS Validated / Modules in Process modules for cryptography.

### 23.2.1. etcd

To ensure that the secrets that are stored in etcd use FIPS Validated / Modules in Process encryption, boot the node in FIPS mode. After you install the cluster in FIPS mode, you can [encrypt the etcd data](#) by using the FIPS-approved **aes cbc** cryptographic algorithm.

### 23.2.2. Storage

For local storage, use RHEL-provided disk encryption or Container Native Storage that uses RHEL-provided disk encryption. By storing all data in volumes that use RHEL-provided disk encryption and enabling FIPS mode for your cluster, both data at rest and data in motion, or network data, are protected by FIPS Validated / Modules in Process encryption. You can configure your cluster to encrypt the root filesystem of each node, as described in [Customizing nodes](#).

### 23.2.3. Runtimes

To ensure that containers know that they are running on a host that is using FIPS Validated / Modules in Process cryptography modules, use CRI-O to manage your runtimes. CRI-O supports FIPS mode, in that it configures the containers to know that they are running in FIPS mode.

## 23.3. INSTALLING A CLUSTER IN FIPS MODE

To install a cluster in FIPS mode, follow the instructions to install a customized cluster on your preferred infrastructure. Ensure that you set **fips: true** in the **install-config.yaml** file before you deploy your cluster.

- [Amazon Web Services](#)
- [Microsoft Azure](#)
- [Bare metal](#)
- [Google Cloud Platform](#)
- [Red Hat OpenStack Platform \(RHOSP\)](#)
- [VMware vSphere](#)



#### NOTE

If you are using Azure File storage, you cannot enable FIPS mode.

To apply **AES CBC** encryption to your etcd data store, follow the [Encrypting etcd data](#) process after you install your cluster.

If you add RHEL nodes to your cluster, ensure that you enable FIPS mode on the machines before their initial boot. See [Adding RHEL compute machines to an OpenShift Container Platform cluster](#) and [Enabling FIPS Mode](#) in the RHEL 7 documentation or [Enabling FIPS Mode](#) in the RHEL 8 documentation

