



OpenShift Container Platform 4.2

Installing on vSphere

Installing OpenShift Container Platform 4.2 vSphere clusters

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Abstract

This document provides instructions for installing OpenShift Container Platform 4.2 clusters on VMware vSphere.

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CHAPTER 1. INSTALLING ON VSPHERE

1.1. INSTALLING A CLUSTER ON VSPHERE

In OpenShift Container Platform version 4.2, you can install a cluster on VMware vSphere infrastructure that you provision.

Prerequisites

- Provision [persistent storage](#) for your cluster. To deploy a private image registry, your storage must provide ReadWriteMany access modes.
- Review details about the [OpenShift Container Platform installation and update](#) processes.
- If you use a firewall, you must [configure 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.

1.1.1. Internet and Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.2, you require access to the internet to install your cluster. The Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, also requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to the [Red Hat OpenShift Cluster Manager \(OCM\)](#).

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

You must have internet access to:

- Access the [Red Hat OpenShift Cluster Manager](#) page 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 content that is required and use it to populate a mirror registry with the packages that you need to install a cluster and generate the installation program. 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.

1.1.2. VMware vSphere infrastructure requirements

You must install the OpenShift Container Platform cluster on a VMware vSphere version that meets the requirements for the components that you use.

If you use a vSphere version 6.5 instance, consider upgrading to 6.7 before you install OpenShift Container Platform.

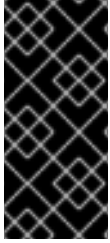
Table 1.1. Minimum supported vSphere version for VMware components

Component	Minimum supported versions	Description
Hypervisor	vSphere 6.5 with HW version 13	This version is the minimum version that Red Hat Enterprise Linux CoreOS (RHCOS) supports. See the Red Hat Enterprise Linux 8 supported hypervisors list .
Networking (NSX-T)	n/a	vSphere 6.5 or vSphere 6.7U2+ are required for OpenShift Container Platform. Because previous versions of vSphere with NSX-T are not currently compatible with OpenShift Container Platform, NSX-T is not supported. NSX-T certification is in process and will be supported in a future release.
Storage with in-tree drivers	vSphere 6.5 or vSphere 6.7	This plug-in creates vSphere storage by using the in-tree storage drivers for vSphere included in OpenShift Container Platform and can be used when vSphere CSI drivers are not available.
Storage with vSphere CSI driver	vSphere 6.7U3 and later	This plug-in creates vSphere storage by using the standard Container Storage Interface. The vSphere CSI driver is provided and supported by VMware.



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.

**IMPORTANT**

A limitation of using VPC is that the Storage Distributed Resource Scheduler (SDRS) is not supported. See [link:https://vmware.github.io/vsphere-storage-for-kubernetes/documentation/faqs.html](https://vmware.github.io/vsphere-storage-for-kubernetes/documentation/faqs.html)[vSphere Storage for Kubernetes FAQs] in the VMware documentation.

1.1.3. 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.

1.1.3.1. Required machines

The smallest OpenShift Container Platform clusters require the following hosts:

- One temporary bootstrap machine
- Three control plane, or master, machines
- At least two compute machines, which are also known as worker machines

**NOTE**

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.

**IMPORTANT**

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap, control plane, and compute machines must use the Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system.

Note that RHCOS is based on Red Hat Enterprise Linux 8 and inherits all of its hardware certifications and requirements. See [Red Hat Enterprise Linux technology capabilities and limits](#) .

1.1.3.2. Network connectivity requirements

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require network in **inittamfs** during boot to fetch Ignition config files from the Machine Config Server. During the initial boot, the machines require a DHCP server in order to establish a network connection to download their Ignition config files.

1.1.3.3. Minimum resource requirements

Each cluster machine must meet the following minimum requirements:

Machine	Operating System	vCPU	Virtual RAM	Storage
Bootstrap	RHCOS	4	16 GB	120 GB

Machine	Operating System	vCPU	Virtual RAM	Storage
Control plane	RHCOS	4	16 GB	120 GB
Compute	RHCOS or RHEL 7.6	2	8 GB	120 GB

1.1.3.4. 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.

1.1.4. Creating the user-provisioned infrastructure

Before you deploy an OpenShift Container Platform cluster that uses user-provisioned infrastructure, you must create the underlying infrastructure.

Prerequisites

- Review the [OpenShift Container Platform 4.x Tested Integrations](#) page before you create the supporting infrastructure for your cluster.

Procedure

1. Configure DHCP.
2. Provision the required load balancers.
3. Configure the ports for your machines.
4. Configure DNS.
5. Ensure network connectivity.

1.1.4.1. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require network in **initramfs** during boot to fetch Ignition config from the Machine Config Server.

During the initial boot, the machines require a DHCP server in order to establish a network connection, which allows them to download their Ignition config files.

It is recommended to use the DHCP server to manage the machines for the cluster long-term. Ensure that the DHCP server is configured to provide persistent IP addresses and host names to the cluster machines.

The Kubernetes API server, which runs on each master node after a successful cluster installation, 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.

You must configure the network connectivity between machines to allow cluster components to communicate. Each machine must be able to resolve the host names of all other machines in the cluster.

Table 1.2. All machines to all machines

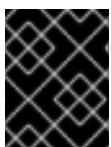
Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	9000-9999	Host level services, including the node exporter on ports 9100-9101 and the Cluster Version Operator on port 9099 .
	10250-10259	The default ports that Kubernetes reserves
	10256	openshift-sdn
UDP	4789	VXLAN and GENEVE
	6081	VXLAN and GENEVE
	9000-9999	Host level services, including the node exporter on ports 9100-9101 .
TCP/UDP	30000-32767	Kubernetes NodePort

Table 1.3. All machines to control plane

Protocol	Port	Description
TCP	2379-2380	etcd server, peer, and metrics ports
	6443	Kubernetes API

Network topology requirements

The infrastructure that you provision for your cluster must meet the following network topology requirements.



IMPORTANT

OpenShift Container Platform requires all nodes to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

Load balancers

Before you install OpenShift Container Platform, you must provision two layer-4 load balancers. The API requires one load balancer and the default Ingress Controller needs the second load balancer to provide ingress to applications.

Port	Machines	Internal	External	Description
6443	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	x	x	Kubernetes API server
22623	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
443	The machines that run the Ingress router pods, compute, or worker, by default.	x	x	HTTPS traffic
80	The machines that run the Ingress router pods, compute, or worker by default.	x	x	HTTP traffic



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.

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.

1.1.4.2. User-provisioned DNS requirements

The following DNS records are required for an OpenShift Container Platform cluster that uses user-provisioned infrastructure. In each record, **<cluster_name>** is the cluster name and **<base_domain>** is the cluster base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster_name>.<base_domain>.**

Table 1.4. Required DNS records

Component	Record	Description
Kubernetes API	api.<cluster_name>.<base_domain>.	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.
	api-int.<cluster_name>.<base_domain>.	<p>This DNS A/AAAA or CNAME record must point to the load balancer for the control plane machines. This record must be resolvable from all the nodes within the cluster.</p> <div style="display: flex; align-items: flex-start;">  <div style="flex-grow: 1;"> <p>IMPORTANT</p> <p>The API server must be able to resolve the worker nodes by the host names that are recorded in Kubernetes. If it cannot resolve the node names, proxied API calls can fail, and you cannot retrieve logs from Pods.</p> </div> </div>
Routes	*.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.

Component	Record	Description
etcd	etcd-<code><index></code>.<code><cluster_name></code>.<code><base_domain></code>.	OpenShift Container Platform requires DNS A/AAAA records for each etcd instance to point to the control plane machines that host the instances. The etcd instances are differentiated by <code><index></code> values, which start with 0 and end with <code>n-1</code> , where n is the number of control plane machines in the cluster. The DNS record must resolve to an unicast IPv4 address for the control plane machine, and the records must be resolvable from all the nodes in the cluster.
	_etcd-server-ssl._tcp.<code><cluster_name></code>.<code><base_domain></code>.	<p>For each control plane machine, OpenShift Container Platform also requires a SRV DNS record for etcd server on that machine with priority 0, weight 10 and port 2380. A cluster that uses three control plane machines requires the following records:</p> <pre data-bbox="1043 1151 1436 1921"> # _service._proto.name. TTL class SRV priority weight port target. _etcd-server-ssl._tcp. <cluster_name>. <base_domain>. 86400 IN SRV 0 10 2380 etcd- 0.<cluster_name>. <base_domain> _etcd-server-ssl._tcp. <cluster_name>. <base_domain>. 86400 IN SRV 0 10 2380 etcd- 1.<cluster_name>. <base_domain> _etcd-server-ssl._tcp. <cluster_name>. <base_domain>. 86400 IN SRV 0 10 2380 etcd- 2.<cluster_name>. <base_domain> </pre>

1.1.5. Generating an SSH private key and adding it to the agent

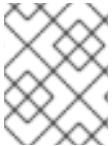
If you want to perform installation debugging or disaster recovery on your cluster, you must provide an SSH key to both your **ssh-agent** and to the installation program.



NOTE

In a production environment, you require disaster recovery and debugging.

You can use this key to SSH into the master nodes as the user **core**. When you deploy the cluster, the key is added to the **core** user's `~/.ssh/authorized_keys` list.



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 SSH key that is configured for password-less authentication on your computer, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t rsa -b 4096 -N "" \
-f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_rsa`, of the SSH key.

Running this command generates an SSH key that does not require a password in the location that you specified.

2. Start the **ssh-agent** process as a background task:

```
$ eval "$(ssh-agent -s)"
Agent pid 31874
```

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

```
$ ssh-add <path>/<file_name> 1
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

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

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 this key to your cluster's machines.

1.1.6. Obtaining the installation program

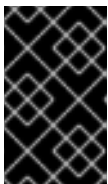
Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

- You must install the cluster from a computer that uses Linux or macOS.
- You need 500 MB of local disk space to download the installation program.

Procedure

1. Access the [Infrastructure Provider](#) page on the Red Hat OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. 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 both the installation program and the files that the installation program creates after you finish installing the cluster.



IMPORTANT

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

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

```
$ tar xvf <installation_program>.tar.gz
```

4. From the [Pull Secret](#) page on the Red Hat OpenShift Cluster Manager site, download your installation pull secret as a **.txt** file. 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.

1.1.7. Manually creating the installation configuration file

For installations of OpenShift Container Platform that use user-provisioned infrastructure, you must manually generate your installation configuration file.

Prerequisites

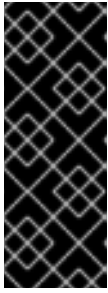
- Obtain the OpenShift Container Platform installation program and the access token for your cluster.

Procedure

1. Create an installation directory to store your required installation assets in:

■

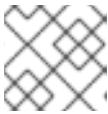
```
$ mkdir <installation_directory>
```



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.

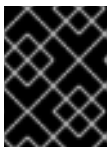
2. Customize the following **install-config.yaml** file template and save it in the **<installation_directory>**.



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.

1.1.7.1. 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
pullSecret: '{"auths": ...}' 14
sshKey: 'ssh-ed25519 AAAA...' 15
```

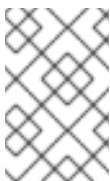
- 1 The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.
- 2 5 The **controlPlane** section is a single mapping, but the compute section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. 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 host name 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 The pull secret that you obtained from the [Pull Secret](#) page on the Red Hat OpenShift Cluster Manager site. 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 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 on, specify an SSH key that your **ssh-agent** process uses.

1.1.7.2. 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

- An existing **install-config.yaml** file.
- Review the sites that your cluster requires access to and determine whether any need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. Add sites to the Proxy object's **spec.noProxy** field to bypass the proxy if necessary.



NOTE

The Proxy object's **status.noProxy** field is populated by default with the instance metadata endpoint (**169.254.169.254**) and with the values of the **networking.machineCIDR**, **networking.clusterNetwork.cidr**, and **networking.serviceNetwork** fields from your installation configuration.

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: http://<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. If this field is not specified, then **httpProxy** is used for both HTTP and HTTPS connections. The URL scheme must be **http**; **https** is currently not supported.
- 3 A comma-separated list of destination domain names, domains, IP addresses, or other network CIDRs to exclude proxying. Preface a domain with **.** to include all subdomains of that domain. Use ***** to bypass 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 ConfigMap that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** ConfigMap that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this ConfigMap is referenced in the Proxy object's **trustedCA** field. 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**.

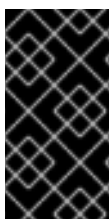


NOTE

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

1.1.8. 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 make its machines.



IMPORTANT

The Ignition config files that the installation program generates contain certificates that expire after 24 hours. You must complete your cluster installation and keep the cluster running for 24 hours in a non-degraded state to ensure that the first certificate rotation has finished.

Prerequisites

- Obtain the OpenShift Container Platform installation program.
- Create the **install-config.yaml** installation configuration file.

Procedure

1. Generate the Kubernetes manifests for the cluster:

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

WARNING There are no compute nodes specified. The cluster will not fully initialize without compute nodes.

INFO Consuming "Install Config" from target directory

- 1** For **<installation_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

Because you create your own compute machines later in the installation process, you can safely ignore this warning.

2. Modify the **manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file to prevent Pods from being scheduled on the control plane machines:
 - a. Open the **manifests/cluster-scheduler-02-config.yml** file.
 - b. Locate the **mastersSchedulable** parameter and set its value to **False**.
 - c. Save and exit the file.



NOTE

Currently, due to a [Kubernetes limitation](#), router Pods running on control plane machines will not be reachable by the ingress load balancer. This step might not be required in a future minor version of OpenShift Container Platform.

3. Obtain the Ignition config files:

```
$ ./openshift-install create ignition-configs --dir=<installation_directory> 1
```

- 1** For **<installation_directory>**, specify the same installation directory.

The following files are generated in the directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

1.1.9. Creating Red Hat Enterprise Linux CoreOS (RHCOS) machines in vSphere

Before you install a cluster that contains user-provisioned infrastructure on VMware vSphere, you must create RHCOS machines on vSphere hosts for it to use.

Prerequisites

- Obtain the Ignition config files for your cluster.
- Have access to an HTTP server that you can access from your computer and that the machines that you create can access.
- Create 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.
You must host the bootstrap Ignition config file because it is too large to fit in a vApp property.

- Save the following secondary Ignition config file for your bootstrap node to your computer as **<installation_directory>/append-bootstrap.ign**.

```
{
  "ignition": {
    "config": {
      "append": [
        {
          "source": "<bootstrap_ignition_config_url>", 1
          "verification": {}
        }
      ]
    },
    "timeouts": {},
    "version": "2.1.0"
  },
  "networkd": {},
  "passwd": {},
  "storage": {},
  "systemd": {}
}
```

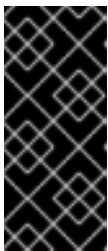
- Specify the URL of the bootstrap Ignition config file that you hosted.

When you create the Virtual Machine (VM) for the bootstrap machine, you use this Ignition config file.

- Convert the master, worker, and secondary bootstrap Ignition config files to Base64 encoding. 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>/append-bootstrap.ign >
<installation_directory>/append-bootstrap.64
```

- Obtain the RHCOS OVA image from the [Product Downloads](#) page on the Red Hat customer portal or 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>-<architecture>-vmware.ova**.

- In the vSphere Client, create a folder in your datacenter to store your VMs.
 - 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. The folder name must match the cluster name that you specified in the **install-config.yaml** file.
6. In the vSphere Client, create a template for the OVA image.

**NOTE**

In the following steps, you use the same template for all of your cluster machines and provide the location for the Ignition config file for that machine type when you provision the VMs.

- a. From the **Hosts and Clusters** tab, right-click your cluster's name and click **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**, such as 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**.
 - 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. If you plan to use the same template for all cluster machine types, do not specify values on the **Customize template** tab.
7. 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 **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: In the event of cluster performance issues, 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 Ignition config file for this machine type.
 - **guestinfo.ignition.config.data.encoding**: Specify **base64**.
 - **disk.EnableUUID**: Specify **TRUE**.
 - Alternatively, prior to powering on the virtual machine add via vApp properties:
 - Navigate to a virtual machine from the vCenter Server inventory.
 - On the **Configure** tab, expand **Settings** and select **vApp options**.
 - Scroll down and under **Properties** apply the configurations from above.
- 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.
8. 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 machine before you install the cluster.

1.1.10. Installing the CLI

You can install the OpenShift CLI (**oc**) in order 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 4.2. Download and install the new version of **oc**.

1.1.10.1. Installing the CLI on Linux

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

Procedure

1. Navigate to the [Infrastructure Provider](#) page on the Red Hat OpenShift Cluster Manager site.
2. Select your infrastructure provider, and, if applicable, your installation type.
3. In the **Command-line interface** section, select **Linux** from the drop-down menu and click **Download command-line tools**.

4. Unpack the archive:

```
$ tar xvzf <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 CLI, it is available using the **oc** command:

```
$ oc <command>
```

1.1.10.2. Installing the CLI on Windows

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

Procedure

1. Navigate to the [Infrastructure Provider](#) page on the Red Hat OpenShift Cluster Manager site.
2. Select your infrastructure provider, and, if applicable, your installation type.
3. In the **Command-line interface** section, select **Windows** from the drop-down menu and click **Download command-line tools**.
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 CLI, it is available using the **oc** command:

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

1.1.10.3. Installing the CLI on macOS

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

Procedure

1. Navigate to the [Infrastructure Provider](#) page on the Red Hat OpenShift Cluster Manager site.
2. Select your infrastructure provider, and, if applicable, your installation type.
3. In the **Command-line interface** section, select **MacOS** from the drop-down menu and click **Download command-line tools**.
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 CLI, it is available using the **oc** command:

```
$ oc <command>
```

1.1.11. Creating the cluster

To create the OpenShift Container Platform cluster, you 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

- Create the required infrastructure for the cluster.
- You obtained the installation program and generated the Ignition config files for your cluster.
- You used the Ignition config files to create RHCOS machines for your cluster.
- Your machines have direct internet access.

Procedure

1. Monitor the bootstrap process:

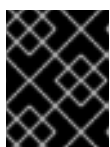
```
$ ./openshift-install --dir=<installation_directory> wait-for bootstrap-complete \ 1
--log-level=info 2
INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...
INFO API v1.14.6+c4799753c up
INFO Waiting up to 30m0s for the bootstrap-complete event...
```

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**.

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 machine itself.

1.1.12. Logging in to the cluster

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

- Deploy an OpenShift Container Platform cluster.
- Install 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  
system:admin
```

1.1.13. Approving the CSRs for your machines

When you add machines to a cluster, two pending certificates signing request (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself.

Prerequisites

- You added machines to your cluster.

Procedure

1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes  
  
NAME      STATUS    ROLES    AGE   VERSION  
master-0  Ready     master   63m   v1.14.6+c4799753c  
master-1  Ready     master   63m   v1.14.6+c4799753c  
master-2  Ready     master   64m   v1.14.6+c4799753c  
worker-0  NotReady  worker   76s   v1.14.6+c4799753c  
worker-1  NotReady  worker   70s   v1.14.6+c4799753c
```

The output lists all of the machines that you created.

2. Review the pending certificate signing requests (CSRs) and ensure that the you see a client and server request with **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

NAME	AGE	REQUESTOR	CONDITION
csr-8b2br	15m	system:serviceaccount:openshift-machine-config-operator:node-bootstrapper	Pending 1
csr-8vnps	15m	system:serviceaccount:openshift-machine-config-operator:node-bootstrapper	Pending
csr-bfd72	5m26s	system:node:ip-10-0-50-126.us-east-2.compute.internal	Pending 2
csr-c57lv	5m26s	system:node:ip-10-0-95-157.us-east-2.compute.internal	Pending
...			

- 1** A client request CSR.
- 2** A server request CSR.

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 you approve the initial CSRs, the subsequent node client CSRs are automatically approved by the cluster **kube-controller-manager**. You must implement a method of automatically approving the kubelet serving certificate requests.

- 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
```

1.1.14. 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
```

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
authentication	4.2.0	True	False	False	69s
cloud-credential	4.2.0	True	False	False	12m
cluster-autoscaler	4.2.0	True	False	False	11m
console	4.2.0	True	False	False	46s
dns	4.2.0	True	False	False	11m
image-registry	4.2.0	False	True	False	5m26s
ingress	4.2.0	True	False	False	5m36s
kube-apiserver	4.2.0	True	False	False	8m53s
kube-controller-manager	4.2.0	True	False	False	7m24s
kube-scheduler	4.2.0	True	False	False	12m
machine-api	4.2.0	True	False	False	12m
machine-config	4.2.0	True	False	False	7m36s
marketplace	4.2.0	True	False	False	7m54m
monitoring	4.2.0	True	False	False	7h54s
network	4.2.0	True	False	False	5m9s
node-tuning	4.2.0	True	False	False	11m
openshift-apiserver	4.2.0	True	False	False	11m
openshift-controller-manager	4.2.0	True	False	False	5m943s
openshift-samples	4.2.0	True	False	False	3m55s
operator-lifecycle-manager	4.2.0	True	False	False	11m
operator-lifecycle-manager-catalog	4.2.0	True	False	False	11m
service-ca	4.2.0	True	False	False	11m
service-catalog-apiserver	4.2.0	True	False	False	5m26s
service-catalog-controller-manager	4.2.0	True	False	False	5m25s
storage	4.2.0	True	False	False	5m30s

2. Configure the Operators that are not available.

1.1.14.1. Image registry storage configuration

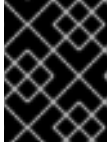
If the **image-registry** Operator is not available, you must configure storage for it. Instructions for both configuring a PersistentVolume, which is required for production clusters, and for configuring an empty directory as the storage location, which is available for only non-production clusters, are shown.

1.1.14.1.1. 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.
- A provisioned persistent volume (PV) with **ReadWriteMany** access mode, such as **NFS**.



IMPORTANT

vSphere volumes do not support the **ReadWriteMany** access mode. You must use a different storage backend, such as **NFS**, to configure the registry storage.

- Must have "100Gi" capacity.

Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.
2. Verify you do not have a registry Pod:

```
$ oc get pod -n openshift-image-registry
```



NOTE

If the storage type is **emptyDIR**, the replica number cannot be greater than **1**. If the storage type is **NFS**, and you want to scale up the registry Pod by setting **replica>1** you must enable the **no_wdelay** mount option. For example:

```
# cat /etc/exports
/mnt/data *(rw,sync,no_wdelay,no_root_squash,insecure,fsid=0)
sh-4.3# exportfs -rv
exporting */mnt/data
```

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io

storage:
  pvc:
    claim:
```

Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** PVC.

4. Optional: Add a new storage class to a PV:
 - a. Create the PV:

```
$ oc create -f -

apiVersion: v1
kind: PersistentVolume
metadata:
  name: image-registry-pv
spec:
  accessModes:
    ReadWriteMany
  capacity:
    storage: 100Gi
  nfs:
```

```

path: /registry
server: 172.16.231.181
persistentVolumeReclaimPolicy: Retain
storageClassName: nfs01

```

```
$ oc get pv
```

b. Create the PVC:

```
$ oc create -n openshift-image-registry -f -
```

```

apiVersion: "v1"
kind: "PersistentVolumeClaim"
metadata:
  name: "image-registry-pvc"
spec:
  accessModes:
    - ReadWriteMany
  resources:
    requests:
      storage: 100Gi
  storageClassName: nfs01
  volumeMode: Filesystem

```

```
$ oc get pvc -n openshift-image-registry
```

Finally, add the name of your PVC:

```
$ oc edit configs.imageregistry.operator.openshift.io -o yaml
```

```

storage:
  pvc:
    claim: image-registry-pvc 1

```

1 Creating a custom PVC allows you to leave the **claim** field blank for default automatic creation of an **image-registry-storage** PVC.

5. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

1.1.14.1.2. 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.

1.1.15. 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:

```
$ watch -n5 oc get clusteroperators
```

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
authentication	4.2.0	True	False	False	10m
cloud-credential	4.2.0	True	False	False	22m
cluster-autoscaler	4.2.0	True	False	False	21m
console	4.2.0	True	False	False	10m
dns	4.2.0	True	False	False	21m
image-registry	4.2.0	True	False	False	16m
ingress	4.2.0	True	False	False	16m
kube-apiserver	4.2.0	True	False	False	19m
kube-controller-manager	4.2.0	True	False	False	18m
kube-scheduler	4.2.0	True	False	False	22m
machine-api	4.2.0	True	False	False	22m
machine-config	4.2.0	True	False	False	18m
marketplace	4.2.0	True	False	False	18m
monitoring	4.2.0	True	False	False	18m
network	4.2.0	True	False	False	16m
node-tuning	4.2.0	True	False	False	21m

openshift-apiserver	4.2.0	True	False	False	21m
openshift-controller-manager	4.2.0	True	False	False	17m
openshift-samples	4.2.0	True	False	False	14m
operator-lifecycle-manager	4.2.0	True	False	False	21m
operator-lifecycle-manager-catalog	4.2.0	True	False	False	21m
service-ca	4.2.0	True	False	False	21m
service-catalog-apiserver	4.2.0	True	False	False	16m
service-catalog-controller-manager	4.2.0	True	False	False	16m
storage	4.2.0	True	False	False	16m

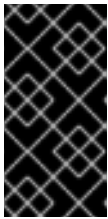
When all of the cluster Operators are **AVAILABLE**, you can complete the installation.

2. Monitor for cluster completion:

```
$ ./openshift-install --dir=<installation_directory> wait-for install-complete 1
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.

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. You must keep the cluster running for 24 hours in a non-degraded state to ensure that the first certificate rotation has finished.

3. 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

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.

Next steps

- [Customize your cluster](#).
- If necessary, you can [opt out of remote health reporting](#) .

1.2. INSTALLING A CLUSTER ON VSPHERE WITH NETWORK CUSTOMIZATIONS

In OpenShift Container Platform version 4.2, 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.

Prerequisites

- Provision [persistent storage](#) for your cluster. To deploy a private image registry, your storage must provide ReadWriteMany access modes.
- Review details about the [OpenShift Container Platform installation and update](#) processes.
- If you use a firewall, you must [configure it to access Red Hat Insights](#) .

1.2.1. Internet and Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.2, you require access to the internet to install your cluster. The Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, also requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to the [Red Hat OpenShift Cluster Manager \(OCM\)](#) .

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

You must have internet access to:

- Access the [Red Hat OpenShift Cluster Manager](#) page 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 content that is required and use it to populate a mirror registry with the packages that you need to install a cluster and generate the installation program. 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.

1.2.2. VMware vSphere infrastructure requirements

You must install the OpenShift Container Platform cluster on a VMware vSphere version that meets the requirements for the components that you use.

If you use a vSphere version 6.5 instance, consider upgrading to 6.7 before you install OpenShift Container Platform.

Table 1.5. Minimum supported vSphere version for VMware components

Component	Minimum supported versions	Description
Hypervisor	vSphere 6.5 with HW version 13	This version is the minimum version that Red Hat Enterprise Linux CoreOS (RHCOS) supports. See the Red Hat Enterprise Linux 8 supported hypervisors list .
Networking (NSX-T)	n/a	vSphere 6.5 or vSphere 6.7U2+ are required for OpenShift Container Platform. Because previous versions of vSphere with NSX-T are not currently compatible with OpenShift Container Platform, NSX-T is not supported. NSX-T certification is in process and will be supported in a future release.
Storage with in-tree drivers	vSphere 6.5 or vSphere 6.7	This plug-in creates vSphere storage by using the in-tree storage drivers for vSphere included in OpenShift Container Platform and can be used when vSphere CSI drivers are not available.
Storage with vSphere CSI driver	vSphere 6.7U3 and later	This plug-in creates vSphere storage by using the standard Container Storage Interface. The vSphere CSI driver is provided and supported by VMware.

**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.

**IMPORTANT**

A limitation of using VPC is that the Storage Distributed Resource Scheduler (SDRS) is not supported. See [link:https://vmware.github.io/vsphere-storage-for-kubernetes/documentation/faqs.html](https://vmware.github.io/vsphere-storage-for-kubernetes/documentation/faqs.html)[vSphere Storage for Kubernetes FAQs] in the VMware documentation.

1.2.3. 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.

1.2.3.1. Required machines

The smallest OpenShift Container Platform clusters require the following hosts:

- One temporary bootstrap machine
- Three control plane, or master, machines
- At least two compute machines, which are also known as worker machines

**NOTE**

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.

**IMPORTANT**

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap, control plane, and compute machines must use the Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system.

Note that RHCOS is based on Red Hat Enterprise Linux 8 and inherits all of its hardware certifications and requirements. See [Red Hat Enterprise Linux technology capabilities and limits](#) .

1.2.3.2. Network connectivity requirements

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require network in **initramfs** during boot to fetch Ignition config files from the Machine Config Server. During the initial boot, the machines require a DHCP server in order to establish a network connection to download their Ignition config files.

1.2.3.3. Minimum resource requirements

Each cluster machine must meet the following minimum requirements:

Machine	Operating System	vCPU	Virtual RAM	Storage
Bootstrap	RHCOS	4	16 GB	120 GB
Control plane	RHCOS	4	16 GB	120 GB
Compute	RHCOS or RHEL 7.6	2	8 GB	120 GB

1.2.3.4. 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.

1.2.4. Creating the user-provisioned infrastructure

Before you deploy an OpenShift Container Platform cluster that uses user-provisioned infrastructure, you must create the underlying infrastructure.

Prerequisites

- Review the [OpenShift Container Platform 4.x Tested Integrations](#) page before you create the supporting infrastructure for your cluster.

Procedure

1. Configure DHCP.
2. Provision the required load balancers.
3. Configure the ports for your machines.
4. Configure DNS.
5. Ensure network connectivity.

1.2.4.1. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require network in **initramfs** during boot to fetch Ignition config from the Machine Config Server.

During the initial boot, the machines require a DHCP server in order to establish a network connection, which allows them to download their Ignition config files.

It is recommended to use the DHCP server to manage the machines for the cluster long-term. Ensure that the DHCP server is configured to provide persistent IP addresses and host names to the cluster machines.

The Kubernetes API server, which runs on each master node after a successful cluster installation, 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.

You must configure the network connectivity between machines to allow cluster components to communicate. Each machine must be able to resolve the host names of all other machines in the cluster.

Table 1.6. All machines to all machines

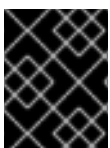
Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	9000-9999	Host level services, including the node exporter on ports 9100-9101 and the Cluster Version Operator on port 9099 .
	10250-10259	The default ports that Kubernetes reserves
	10256	openshift-sdn
UDP	4789	VXLAN and GENEVE
	6081	VXLAN and GENEVE
	9000-9999	Host level services, including the node exporter on ports 9100-9101 .
TCP/UDP	30000-32767	Kubernetes NodePort

Table 1.7. All machines to control plane

Protocol	Port	Description
TCP	2379-2380	etcd server, peer, and metrics ports
	6443	Kubernetes API

Network topology requirements

The infrastructure that you provision for your cluster must meet the following network topology requirements.



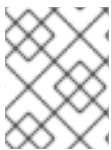
IMPORTANT

OpenShift Container Platform requires all nodes to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

Load balancers

Before you install OpenShift Container Platform, you must provision two layer-4 load balancers. The API requires one load balancer and the default Ingress Controller needs the second load balancer to provide ingress to applications.

Port	Machines	Internal	External	Description
6443	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	x	x	Kubernetes API server
22623	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
443	The machines that run the Ingress router pods, compute, or worker, by default.	x	x	HTTPS traffic
80	The machines that run the Ingress router pods, compute, or worker by default.	x	x	HTTP traffic



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.

1.2.4.2. User-provisioned DNS requirements

The following DNS records are required for an OpenShift Container Platform cluster that uses user-provisioned infrastructure. In each record, **<cluster_name>** is the cluster name and **<base_domain>** is the cluster base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster_name>.<base_domain>.**

Table 1.8. Required DNS records

Component	Record	Description
Kubernetes API	api.<cluster_name>.<base_domain>.	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
	api-int.<cluster_name>.<base_domain>.	<p>This DNS A/AAAA or CNAME record must point to the load balancer for the control plane machines. This record must be resolvable from all the nodes within the cluster.</p> <div data-bbox="1040 517 1147 987" style="background-color: black; width: 67px; height: 210px; margin-bottom: 10px;"></div> <p>IMPORTANT</p> <p>The API server must be able to resolve the worker nodes by the host names that are recorded in Kubernetes. If it cannot resolve the node names, proxied API calls can fail, and you cannot retrieve logs from Pods.</p>
Routes	*.apps.<cluster_name>.<base_domain>.	<p>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.</p>
etcd	etcd-<index>.<cluster_name>.<base_domain>.	<p>OpenShift Container Platform requires DNS A/AAAA records for each etcd instance to point to the control plane machines that host the instances. The etcd instances are differentiated by <index> values, which start with 0 and end with n-1, where n is the number of control plane machines in the cluster. The DNS record must resolve to an unicast IPv4 address for the control plane machine, and the records must be resolvable from all the nodes in the cluster.</p>

Component	Record	Description
	<code>_etcd-server-ssl._tcp.<cluster_name>.<base_domain></code>	<p>For each control plane machine, OpenShift Container Platform also requires a SRV DNS record for etcd server on that machine with priority 0, weight 10 and port 2380. A cluster that uses three control plane machines requires the following records:</p> <pre># _service._proto.name. TTL class SRV priority weight port target. _etcd-server-ssl._tcp. <cluster_name>. <base_domain>. 86400 IN SRV 0 10 2380 etcd- 0.<cluster_name>. <base_domain> _etcd-server-ssl._tcp. <cluster_name>. <base_domain>. 86400 IN SRV 0 10 2380 etcd- 1.<cluster_name>. <base_domain> _etcd-server-ssl._tcp. <cluster_name>. <base_domain>. 86400 IN SRV 0 10 2380 etcd- 2.<cluster_name>. <base_domain></pre>

1.2.5. Generating an SSH private key and adding it to the agent

If you want to perform installation debugging or disaster recovery on your cluster, you must provide an SSH key to both your **ssh-agent** and to the installation program.



NOTE

In a production environment, you require disaster recovery and debugging.

You can use this key to SSH into the master nodes as the user **core**. When you deploy the cluster, the key is added to the **core** user's `~/.ssh/authorized_keys` list.



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 SSH key that is configured for password-less authentication on your computer, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t rsa -b 4096 -N "" \
-f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_rsa`, of the SSH key.

Running this command generates an SSH key that does not require a password in the location that you specified.

2. Start the **ssh-agent** process as a background task:

```
$ eval "$(ssh-agent -s)"
Agent pid 31874
```

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

```
$ ssh-add <path>/<file_name> 1
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

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

Next steps

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

1.2.6. Obtaining the installation program

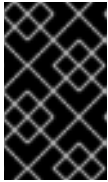
Before you install OpenShift Container Platform, download the installation file on a local computer.

Prerequisites

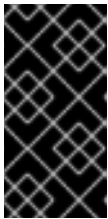
- You must install the cluster from a computer that uses Linux or macOS.
- You need 500 MB of local disk space to download the installation program.

Procedure

1. Access the [Infrastructure Provider](#) page on the Red Hat OpenShift Cluster Manager site. If you have a Red Hat account, log in with your credentials. If you do not, create an account.
2. 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 both the installation program and the files that the installation program creates after you finish installing the cluster.

**IMPORTANT**

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

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

```
$ tar xvf <installation_program>.tar.gz
```

4. From the [Pull Secret](#) page on the Red Hat OpenShift Cluster Manager site, download your installation pull secret as a **.txt** file. 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.

1.2.7. Manually creating the installation configuration file

For installations of OpenShift Container Platform that use user-provisioned infrastructure, you must manually generate your installation configuration file.

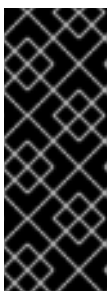
Prerequisites

- Obtain the OpenShift Container Platform installation program and the access token for your cluster.

Procedure

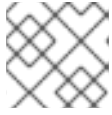
1. Create an installation directory to store your required installation assets in:

```
$ 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 following **install-config.yaml** file template 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.

1.2.7.1. 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
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. 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 host name 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 The pull secret that you obtained from the [Pull Secret](#) page on the Red Hat OpenShift Cluster Manager site. 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 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 on, specify an SSH key that your **ssh-agent** process uses.

1.2.7.2. Network configuration parameters

You can modify your cluster network configuration parameters in the **install-config.yaml** configuration file. The following table describes the parameters.

**NOTE**

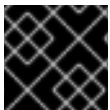
You cannot modify these parameters in the **install-config.yaml** file after installation.

Table 1.9. Required network parameters

Parameter	Description	Value
networking.net workType	The network plug-in to deploy. The OpenShiftSDN plug-in is the only plug-in supported in OpenShift Container Platform 4.2.	The default value is OpenShiftSDN .
networking.clus terNetwork.cidr	A block of IP addresses from which Pod IP addresses are allocated. The OpenShiftSDN network plug-in supports multiple cluster networks. The address blocks for multiple cluster networks must not overlap. Select address pools large enough to fit your anticipated workload.	An IP address allocation in CIDR format. The default value is 10.128.0.0/14 .
networking.clus terNetwork.host Prefix	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 , allowing for 510 ($2^{(32 - 23)} - 2$) Pod IP addresses.	A subnet prefix. The default value is 23 .
networking.serv iceNetwork	A block of IP addresses for services. OpenShiftSDN allows only one serviceNetwork block. The address block must not overlap with any other network block.	An IP address allocation in CIDR format. The default value is 172.30.0.0/16 .
networking.mac hineCIDR	A block of IP addresses used by the OpenShift Container Platform installation program while installing the cluster. The address block must not overlap with any other network block.	An IP address allocation in CIDR format. The default value is 10.0.0.0/16 .

1.2.8. Modifying advanced network configuration parameters

You can modify the advanced network configuration parameters only before you install the cluster. Advanced configuration customization lets you integrate your cluster into your existing network environment by specifying an MTU or VXLAN port, by allowing customization of [kube-proxy](#) settings, and by specifying a different **mode** for the **openshiftSDNConfig** parameter.



IMPORTANT

Modifying the OpenShift Container Platform manifest files directly is not supported.

Prerequisites

- Create the **install-config.yaml** file and complete any modifications to it.
- Create the Ignition config files for your cluster.

Procedure

1. Use the following command to create manifests:

```
$ ./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. Modify the `<installation_directory>/manifests/cluster-scheduler-02-config.yaml` Kubernetes manifest file to prevent Pods from being scheduled on the control plane machines:
 - a. Open the `manifests/cluster-scheduler-02-config.yaml` file.
 - b. Locate the `mastersSchedulable` parameter and set its value to **False**.
 - c. Save and exit the file.

**NOTE**

Currently, due to a [Kubernetes limitation](#), router Pods running on control plane machines will not be reachable by the ingress load balancer.

3. Create a file that is named `cluster-network-03-config.yaml` in the `<installation_directory>/manifests/` directory:

```
$ touch <installation_directory>/manifests/cluster-network-03-config.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-network-*
cluster-network-01-crd.yaml
cluster-network-02-config.yaml
cluster-network-03-config.yaml
```

4. Open the `cluster-network-03-config.yaml` file in an editor and enter a CR that describes the Operator configuration you want:

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec: 1
  clusterNetwork:
    - cidr: 10.128.0.0/14
      hostPrefix: 23
  serviceNetwork:
    - 172.30.0.0/16
  defaultNetwork:
    type: OpenShiftSDN
    openshiftSDNConfig:
      mode: NetworkPolicy
      mtu: 1450
      vxlanPort: 4789
```


- 1 The parameters for the **spec** parameter are only an example. Specify your configuration for the Cluster Network Operator in the CR.

The CNO provides default values for the parameters in the CR, so you must specify only the parameters that you want to change.

5. Save the **cluster-network-03-config.yml** file and quit the text editor.
6. Optional: Back up the **manifests/cluster-network-03-config.yml** file. The installation program deletes the **manifests/** directory when creating the cluster.

1.2.9. Cluster Network Operator custom resource (CR)

The cluster network configuration in the **Network.operator.openshift.io** custom resource (CR) stores the configuration settings for the Cluster Network Operator (CNO). The Operator manages the cluster network.

You can specify the cluster network configuration for your OpenShift Container Platform cluster by setting the parameters for the **defaultNetwork** parameter in the CNO CR. The following CR displays the default configuration for the CNO and explains both the parameters you can configure and valid parameter values:

Cluster Network Operator CR

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  clusterNetwork: 1
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  serviceNetwork: 2
  - 172.30.0.0/16
  defaultNetwork: 3
  ...
  kubeProxyConfig: 4
  iptablesSyncPeriod: 30s 5
  proxyArguments:
    iptables-min-sync-period: 6
    - 30s
```

- 1 2 Specified in the **install-config.yaml** file.
- 3 Configures the software-defined networking (SDN) for the cluster network.
- 4 The parameters for this object specify the **kube-proxy** configuration. If you do not specify the parameter values, the Network Operator applies the displayed default parameter values.
- 5 The refresh period for **iptables** rules. The default value is **30s**. Valid suffixes include **s**, **m**, and **h** and are described in the [Go time package](#) documentation.
- 6 The minimum duration before refreshing **iptables** rules. This parameter ensures that the refresh does not happen too frequently. Valid suffixes include **s**, **m**, and **h** and are described in the [Go time package](#)

`package`

1.2.9.1. Configuration parameters for OpenShift SDN

The following YAML object describes the configuration parameters for OpenShift SDN default CNI network provider:

```

defaultNetwork:
  type: OpenShiftSDN 1
  openshiftSDNConfig: 2
    mode: NetworkPolicy 3
    mtu: 1450 4
    vxlanPort: 4789 5

```

- 1 Specified in the **install-config.yaml** file.
- 2 Specify only if you want to override part of the OpenShift SDN configuration.
- 3 Configures the network isolation mode for **OpenShiftSDN**. The allowed values are **Multitenant**, **Subnet**, or **NetworkPolicy**. The default value is **NetworkPolicy**.
- 4 MTU for the VXLAN overlay network. This value is normally configured automatically, but if the nodes in your cluster do not all use the same MTU, then you must set this explicitly to 50 less than the smallest node MTU value.
- 5 The port to use for all VXLAN packets. The default value is **4789**. 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 VXLAN, since both SDNs use the same default VXLAN port number.

On Amazon Web Services (AWS), you can select an alternate port for the VXLAN between port **9000** and port **9999**.

1.2.9.2. Cluster Network Operator example CR

A complete CR for the CNO is displayed in the following example:

Cluster Network Operator example CR

```

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: OpenShiftSDN
    openshiftSDNConfig:

```

```

mode: NetworkPolicy
mtu: 1450
vxlanPort: 4789
kubeProxyConfig:
  iptablesSyncPeriod: 30s
proxyArguments:
  iptables-min-sync-period:
    - 30s

```

1.2.10. 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. You must complete your cluster installation and keep the cluster running for 24 hours in a non-degraded state to ensure that the first certificate rotation has finished.

Prerequisites

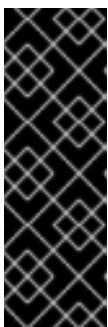
- Obtain the OpenShift Container Platform installation program and the pull secret for your cluster.

Procedure

1. 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

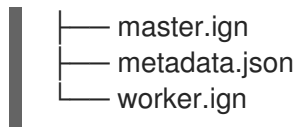
If you created an **install-config.yaml** file, specify the directory that contains it. Otherwise, specify an empty directory. Some installation assets, like bootstrap X.509 certificates have short expiration intervals, so you must not reuse an installation directory. If you want to reuse individual 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:

```

.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
└── bootstrap.ign

```



1.2.11. Creating Red Hat Enterprise Linux CoreOS (RHCOS) machines in vSphere

Before you install a cluster that contains user-provisioned infrastructure on VMware vSphere, you must create RHCOS machines on vSphere hosts for it to use.

Prerequisites

- Obtain the Ignition config files for your cluster.
- Have access to an HTTP server that you can access from your computer and that the machines that you create can access.
- Create 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.
You must host the bootstrap Ignition config file because it is too large to fit in a vApp property.
2. Save the following secondary Ignition config file for your bootstrap node to your computer as **<installation_directory>/append-bootstrap.ign**.

```

{
  "ignition": {
    "config": {
      "append": [
        {
          "source": "<bootstrap_ignition_config_url>", 1
          "verification": {}
        }
      ]
    },
    "timeouts": {},
    "version": "2.1.0"
  },
  "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. Convert the master, worker, and secondary bootstrap Ignition config files to Base64 encoding.

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>/append-bootstrap.ign >
<installation_directory>/append-bootstrap.64
```

4. Obtain the RHCOS OVA image from the [Product Downloads](#) page on the Red Hat customer portal or 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>-<architecture>-vmware.ova**.

5. 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. The folder name must match the cluster name that you specified in the **install-config.yaml** file.
6. In the vSphere Client, create a template for the OVA image.

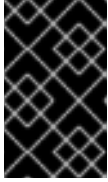


NOTE

In the following steps, you use the same template for all of your cluster machines and provide the location for the Ignition config file for that machine type when you provision the VMs.

- a. From the **Hosts and Clusters** tab, right-click your cluster's name and click **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**, such as 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**.

- 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. If you plan to use the same template for all cluster machine types, do not specify values on the **Customize template** tab.
7. 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 **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: In the event of cluster performance issues, 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 Ignition config file for this machine type.
 - **guestinfo.ignition.config.data.encoding**: Specify **base64**.
 - **disk.EnableUUID**: Specify **TRUE**.
 - Alternatively, prior to powering on the virtual machine add via vApp properties:
 - Navigate to a virtual machine from the vCenter Server inventory.
 - On the **Configure** tab, expand **Settings** and select **vApp options**.
 - Scroll down and under **Properties** apply the configurations from above.
 - 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.
8. Create the rest of the machines for your cluster by following the preceding steps for each machine.

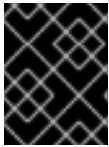


IMPORTANT

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 machine before you install the cluster.

1.2.12. Installing the CLI

You can install the OpenShift CLI (**oc**) in order 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 4.2. Download and install the new version of **oc**.

1.2.12.1. Installing the CLI on Linux

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

Procedure

1. Navigate to the [Infrastructure Provider](#) page on the Red Hat OpenShift Cluster Manager site.
2. Select your infrastructure provider, and, if applicable, your installation type.
3. In the **Command-line interface** section, select **Linux** from the drop-down menu and click **Download command-line tools**.
4. Unpack the archive:

```
$ tar xvzf <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 CLI, it is available using the **oc** command:

```
$ oc <command>
```

1.2.12.2. Installing the CLI on Windows

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

Procedure

1. Navigate to the [Infrastructure Provider](#) page on the Red Hat OpenShift Cluster Manager site.
2. Select your infrastructure provider, and, if applicable, your installation type.

3. In the **Command-line interface** section, select **Windows** from the drop-down menu and click **Download command-line tools**.
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 CLI, it is available using the **oc** command:

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

1.2.12.3. Installing the CLI on macOS

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

Procedure

1. Navigate to the [Infrastructure Provider](#) page on the Red Hat OpenShift Cluster Manager site.
2. Select your infrastructure provider, and, if applicable, your installation type.
3. In the **Command-line interface** section, select **MacOS** from the drop-down menu and click **Download command-line tools**.
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 CLI, it is available using the **oc** command:

```
$ oc <command>
```

1.2.13. Creating the cluster

To create the OpenShift Container Platform cluster, you 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

- Create the required infrastructure for the cluster.
- You obtained the installation program and generated the Ignition config files for your cluster.
- You used the Ignition config files to create RHCOS machines for your cluster.
- Your machines have direct internet access.

Procedure

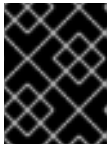
1. Monitor the bootstrap process:

```
$ ./openshift-install --dir=<installation_directory> wait-for bootstrap-complete \ 1
--log-level=info 2
INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...
INFO API v1.14.6+c4799753c up
INFO Waiting up to 30m0s for the bootstrap-complete event...
```

- 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**.

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 machine itself.

1.2.14. Logging in to the cluster

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

- Deploy an OpenShift Container Platform cluster.
- Install 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
system:admin
```

1.2.15. Approving the CSRs for your machines

When you add machines to a cluster, two pending certificates signing request (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself.

Prerequisites

- You added machines to your cluster.

Procedure

- Confirm that the cluster recognizes the machines:

```
$ oc get nodes

NAME      STATUS    ROLES    AGE   VERSION
master-0  Ready     master   63m   v1.14.6+c4799753c
master-1  Ready     master   63m   v1.14.6+c4799753c
master-2  Ready     master   64m   v1.14.6+c4799753c
worker-0  NotReady  worker   76s   v1.14.6+c4799753c
worker-1  NotReady  worker   70s   v1.14.6+c4799753c
```

The output lists all of the machines that you created.

- Review the pending certificate signing requests (CSRs) and ensure that the you see a client and server request with **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr

NAME      AGE   REQUESTOR                                     CONDITION
csr-8b2br  15m   system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper  Pending 1
csr-8vnps  15m   system:serviceaccount:openshift-machine-config-operator:node-
bootstrapper  Pending
csr-bfd72  5m26s system:node:ip-10-0-50-126.us-east-2.compute.internal
Pending 2
csr-c57lv  5m26s system:node:ip-10-0-95-157.us-east-2.compute.internal
Pending
...
```

- A client request CSR.
- A server request CSR.

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 you approve the initial CSRs, the subsequent node client CSRs are automatically approved by the cluster **kube-controller-manager**. You must implement a method of automatically approving the kubelet serving certificate requests.

- 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
```

1.2.16. 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
```

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
authentication	4.2.0	True	False	False	69s
cloud-credential	4.2.0	True	False	False	12m
cluster-autoscaler	4.2.0	True	False	False	11m
console	4.2.0	True	False	False	46s
dns	4.2.0	True	False	False	11m
image-registry	4.2.0	False	True	False	5m26s
ingress	4.2.0	True	False	False	5m36s
kube-apiserver	4.2.0	True	False	False	8m53s
kube-controller-manager	4.2.0	True	False	False	7m24s
kube-scheduler	4.2.0	True	False	False	12m
machine-api	4.2.0	True	False	False	12m
machine-config	4.2.0	True	False	False	7m36s
marketplace	4.2.0	True	False	False	7m54m
monitoring	4.2.0	True	False	False	7h54s
network	4.2.0	True	False	False	5m9s

node-tuning	4.2.0	True	False	False	11m
openshift-apiserver	4.2.0	True	False	False	11m
openshift-controller-manager	4.2.0	True	False	False	5m943s
openshift-samples	4.2.0	True	False	False	3m55s
operator-lifecycle-manager	4.2.0	True	False	False	11m
operator-lifecycle-manager-catalog	4.2.0	True	False	False	11m
service-ca	4.2.0	True	False	False	11m
service-catalog-apiserver	4.2.0	True	False	False	5m26s
service-catalog-controller-manager	4.2.0	True	False	False	5m25s
storage	4.2.0	True	False	False	5m30s

2. Configure the Operators that are not available.

1.2.16.1. Image registry storage configuration

If the **image-registry** Operator is not available, you must configure storage for it. Instructions for both configuring a PersistentVolume, which is required for production clusters, and for configuring an empty directory as the storage location, which is available for only non-production clusters, are shown.

1.2.16.1.1. 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.
- A provisioned persistent volume (PV) with **ReadWriteMany** access mode, such as **NFS**.



IMPORTANT

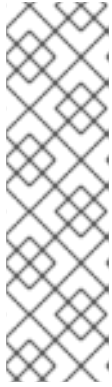
vSphere volumes do not support the **ReadWriteMany** access mode. You must use a different storage backend, such as **NFS**, to configure the registry storage.

- Must have "100Gi" capacity.

Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.
2. Verify you do not have a registry Pod:

```
$ oc get pod -n openshift-image-registry
```

**NOTE**

If the storage type is **emptyDIR**, the replica number cannot be greater than **1**. If the storage type is **NFS**, and you want to scale up the registry Pod by setting **replica>1** you must enable the **no_wdelay** mount option. For example:

```
# cat /etc/exports
/mnt/data *(rw,sync,no_wdelay,no_root_squash,insecure,fsid=0)
sh-4.3# exportfs -rv
exporting */:/mnt/data
```

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io

storage:
pvc:
claim:
```

Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** PVC.

4. Optional: Add a new storage class to a PV:

- a. Create the PV:

```
$ oc create -f -

apiVersion: v1
kind: PersistentVolume
metadata:
  name: image-registry-pv
spec:
  accessModes:
    ReadWriteMany
  capacity:
    storage: 100Gi
  nfs:
    path: /registry
    server: 172.16.231.181
  persistentVolumeReclaimPolicy: Retain
  storageClassName: nfs01
```

```
$ oc get pv
```

- b. Create the PVC:

```
$ oc create -n openshift-image-registry -f -

apiVersion: "v1"
kind: "PersistentVolumeClaim"
metadata:
  name: "image-registry-pvc"
spec:
```

```

accessModes:
  - ReadWriteMany
resources:
  requests:
    storage: 100Gi
storageClassName: nfs01
volumeMode: Filesystem

```

```
$ oc get pvc -n openshift-image-registry
```

Finally, add the name of your PVC:

```
$ oc edit configs.imageregistry.operator.openshift.io -o yaml
```

```

storage:
  pvc:
    claim: image-registry-pvc 1

```

- 1** Creating a custom PVC allows you to leave the **claim** field blank for default automatic creation of an **image-registry-storage** PVC.

5. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```

1.2.16.1.2. 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.

1.2.17. 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:

```
$ watch -n5 oc get clusteroperators
```

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
authentication	4.2.0	True	False	False	10m
cloud-credential	4.2.0	True	False	False	22m
cluster-autoscaler	4.2.0	True	False	False	21m
console	4.2.0	True	False	False	10m
dns	4.2.0	True	False	False	21m
image-registry	4.2.0	True	False	False	16m
ingress	4.2.0	True	False	False	16m
kube-apiserver	4.2.0	True	False	False	19m
kube-controller-manager	4.2.0	True	False	False	18m
kube-scheduler	4.2.0	True	False	False	22m
machine-api	4.2.0	True	False	False	22m
machine-config	4.2.0	True	False	False	18m
marketplace	4.2.0	True	False	False	18m
monitoring	4.2.0	True	False	False	18m
network	4.2.0	True	False	False	16m
node-tuning	4.2.0	True	False	False	21m
openshift-apiserver	4.2.0	True	False	False	21m
openshift-controller-manager	4.2.0	True	False	False	17m
openshift-samples	4.2.0	True	False	False	14m
operator-lifecycle-manager	4.2.0	True	False	False	21m
operator-lifecycle-manager-catalog	4.2.0	True	False	False	21m
service-ca	4.2.0	True	False	False	21m
service-catalog-apiserver	4.2.0	True	False	False	16m
service-catalog-controller-manager	4.2.0	True	False	False	16m
storage	4.2.0	True	False	False	16m

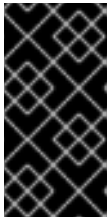
When all of the cluster Operators are **AVAILABLE**, you can complete the installation.

2. Monitor for cluster completion:

```
$ ./openshift-install --dir=<installation_directory> wait-for install-complete 1
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.

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. You must keep the cluster running for 24 hours in a non-degraded state to ensure that the first certificate rotation has finished.

3. 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
```

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.

Next steps

- [Customize your cluster.](#)
- If necessary, you can [opt out of remote health reporting](#).

1.3. INSTALLING A CLUSTER ON VSPHERE IN A RESTRICTED NETWORK

In OpenShift Container Platform version 4.2, you can install a cluster on VMware vSphere infrastructure that you provision in a restricted network.

Prerequisites

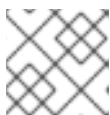
- [Create a registry on your mirror host](#) and obtain the **imageContentSources** data for your version of OpenShift Container Platform.



IMPORTANT

Because the installation media is on the mirror host, you can use that computer to complete all installation steps.

- Provision [persistent storage](#) for your cluster. To deploy a private image registry, your storage must provide ReadWriteMany access modes.
- Review details about the [OpenShift Container Platform installation and update](#) processes.
- If you use a firewall and plan to use telemetry, you must [configure 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.

1.3.1. About installations in restricted networks

In OpenShift Container Platform 4.2, you can perform an installation that does not require an active connection to the internet to obtain software components. You complete an installation in a restricted network on only infrastructure that you provision, not infrastructure that the installation program provisions, so your platform selection is limited.

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 IAM service, require internet access, so you might still 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

Restricted network installations always use user-provisioned infrastructure. 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. Completing this test installation might make it easier to isolate and troubleshoot any issues that might arise during your installation in a restricted network.

1.3.1.1. 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 ImageStreamTags.

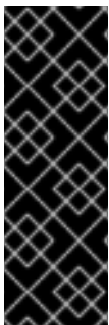
1.3.2. Internet and Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.2, you require access to the internet to obtain the images that are necessary to install your cluster. The Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, also requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to the [Red Hat OpenShift Cluster Manager \(OCM\)](#).

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

You must have internet access to:

- Access the [Red Hat OpenShift Cluster Manager](#) page 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 content that is required and use it to populate a mirror registry with the packages that you need to install a cluster and generate the installation program. 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.

1.3.3. VMware vSphere infrastructure requirements

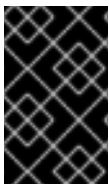
You must install the OpenShift Container Platform cluster on a VMware vSphere version that meets the requirements for the components that you use.

If you use a vSphere version 6.5 instance, consider upgrading to 6.7 before you install OpenShift Container Platform.

Table 1.10. Minimum supported vSphere version for VMware components

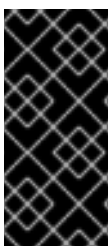
Component	Minimum supported versions	Description
-----------	----------------------------	-------------

Component	Minimum supported versions	Description
Hypervisor	vSphere 6.5 with HW version 13	This version is the minimum version that Red Hat Enterprise Linux CoreOS (RHCOS) supports. See the Red Hat Enterprise Linux 8 supported hypervisors list .
Networking (NSX-T)	n/a	vSphere 6.5 or vSphere 6.7U2+ are required for OpenShift Container Platform. Because previous versions of vSphere with NSX-T are not currently compatible with OpenShift Container Platform, NSX-T is not supported. NSX-T certification is in process and will be supported in a future release.
Storage with in-tree drivers	vSphere 6.5 or vSphere 6.7	This plug-in creates vSphere storage by using the in-tree storage drivers for vSphere included in OpenShift Container Platform and can be used when vSphere CSI drivers are not available.
Storage with vSphere CSI driver	vSphere 6.7U3 and later	This plug-in creates vSphere storage by using the standard Container Storage Interface. The vSphere CSI driver is provided and supported by VMware.



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.



IMPORTANT

A limitation of using VPC is that the Storage Distributed Resource Scheduler (SDRS) is not supported. See [link:https://vmware.github.io/vsphere-storage-for-kubernetes/documentation/faqs.html](https://vmware.github.io/vsphere-storage-for-kubernetes/documentation/faqs.html)[vSphere Storage for Kubernetes FAQs] in the VMware documentation.

1.3.4. 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.

1.3.4.1. Required machines

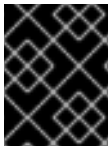
The smallest OpenShift Container Platform clusters require the following hosts:

- One temporary bootstrap machine
- Three control plane, or master, machines
- At least two compute machines, which are also known as worker machines



NOTE

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.



IMPORTANT

To maintain high availability of your cluster, use separate physical hosts for these cluster machines.

The bootstrap, control plane, and compute machines must use the Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system.

Note that RHCOS is based on Red Hat Enterprise Linux 8 and inherits all of its hardware certifications and requirements. See [Red Hat Enterprise Linux technology capabilities and limits](#) .

1.3.4.2. Network connectivity requirements

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require network in **initramfs** during boot to fetch Ignition config files from the Machine Config Server. During the initial boot, the machines require a DHCP server in order to establish a network connection to download their Ignition config files.

1.3.4.3. Minimum resource requirements

Each cluster machine must meet the following minimum requirements:

Machine	Operating System	vCPU	Virtual RAM	Storage
Bootstrap	RHCOS	4	16 GB	120 GB
Control plane	RHCOS	4	16 GB	120 GB
Compute	RHCOS or RHEL 7.6	2	8 GB	120 GB

1.3.4.4. 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.

1.3.5. Creating the user-provisioned infrastructure

Before you deploy an OpenShift Container Platform cluster that uses user-provisioned infrastructure, you must create the underlying infrastructure.

Prerequisites

- Review the [OpenShift Container Platform 4.x Tested Integrations](#) page before you create the supporting infrastructure for your cluster.

Procedure

1. Configure DHCP.
2. Provision the required load balancers.
3. Configure the ports for your machines.
4. Configure DNS.
5. Ensure network connectivity.

1.3.5.1. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require network in **initramfs** during boot to fetch Ignition config from the Machine Config Server.

During the initial boot, the machines require a DHCP server in order to establish a network connection, which allows them to download their Ignition config files.

It is recommended to use the DHCP server to manage the machines for the cluster long-term. Ensure that the DHCP server is configured to provide persistent IP addresses and host names to the cluster machines.

The Kubernetes API server, which runs on each master node after a successful cluster installation, 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.

You must configure the network connectivity between machines to allow cluster components to communicate. Each machine must be able to resolve the host names of all other machines in the cluster.

Table 1.11. All machines to all machines

Protocol	Port	Description
ICMP	N/A	Network reachability tests

Protocol	Port	Description
TCP	9000-9999	Host level services, including the node exporter on ports 9100-9101 and the Cluster Version Operator on port 9099 .
	10250-10259	The default ports that Kubernetes reserves
	10256	openshift-sdn
UDP	4789	VXLAN and GENEVE
	6081	VXLAN and GENEVE
	9000-9999	Host level services, including the node exporter on ports 9100-9101 .
TCP/UDP	30000-32767	Kubernetes NodePort

Table 1.12. All machines to control plane

Protocol	Port	Description
TCP	2379-2380	etcd server, peer, and metrics ports
	6443	Kubernetes API

Network topology requirements

The infrastructure that you provision for your cluster must meet the following network topology requirements.



IMPORTANT

OpenShift Container Platform requires all nodes to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

Load balancers

Before you install OpenShift Container Platform, you must provision two layer-4 load balancers. The API requires one load balancer and the default Ingress Controller needs the second load balancer to provide ingress to applications.

Port	Machines	Internal	External	Description
6443	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	x	x	Kubernetes API server

Port	Machines	Internal	External	Description
22623	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
443	The machines that run the Ingress router pods, compute, or worker, by default.	x	x	HTTPS traffic
80	The machines that run the Ingress router pods, compute, or worker by default.	x	x	HTTP traffic

**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.

1.3.5.2. User-provisioned DNS requirements

The following DNS records are required for an OpenShift Container Platform cluster that uses user-provisioned infrastructure. In each record, **<cluster_name>** is the cluster name and **<base_domain>** is the cluster base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>.<cluster_name>.<base_domain>..**

Table 1.13. Required DNS records

Component	Record	Description
Kubernetes API	api.<cluster_name>.<base_domain>..	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
	api-int.<cluster_name>.<base_domain>.	<p>This DNS A/AAAA or CNAME record must point to the load balancer for the control plane machines. This record must be resolvable from all the nodes within the cluster.</p> <div data-bbox="1040 517 1147 983" style="background-color: black; color: white; padding: 5px; width: fit-content;">  </div> <p>IMPORTANT</p> <p>The API server must be able to resolve the worker nodes by the host names that are recorded in Kubernetes. If it cannot resolve the node names, proxied API calls can fail, and you cannot retrieve logs from Pods.</p>
Routes	*.apps.<cluster_name>.<base_domain>.	<p>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.</p>

Component	Record	Description
etcd	etcd-<code><index></code>.<code><cluster_name></code>.<code><base_domain></code>.	OpenShift Container Platform requires DNS A/AAAA records for each etcd instance to point to the control plane machines that host the instances. The etcd instances are differentiated by <code><index></code> values, which start with 0 and end with <code>n-1</code> , where n is the number of control plane machines in the cluster. The DNS record must resolve to an unicast IPv4 address for the control plane machine, and the records must be resolvable from all the nodes in the cluster.
	_etcd-server-ssl._tcp.<code><cluster_name></code>.<code><base_domain></code>.	<p>For each control plane machine, OpenShift Container Platform also requires a SRV DNS record for etcd server on that machine with priority 0, weight 10 and port 2380. A cluster that uses three control plane machines requires the following records:</p> <pre data-bbox="1040 1151 1439 1921"> # _service._proto.name. TTL class SRV priority weight port target. _etcd-server-ssl._tcp. <cluster_name>. <base_domain>. 86400 IN SRV 0 10 2380 etcd- 0.<cluster_name>. <base_domain> _etcd-server-ssl._tcp. <cluster_name>. <base_domain>. 86400 IN SRV 0 10 2380 etcd- 1.<cluster_name>. <base_domain> _etcd-server-ssl._tcp. <cluster_name>. <base_domain>. 86400 IN SRV 0 10 2380 etcd- 2.<cluster_name>. <base_domain> </pre>

1.3.6. Generating an SSH private key and adding it to the agent

If you want to perform installation debugging or disaster recovery on your cluster, you must provide an SSH key to both your **ssh-agent** and to the installation program.



NOTE

In a production environment, you require disaster recovery and debugging.

You can use this key to SSH into the master nodes as the user **core**. When you deploy the cluster, the key is added to the **core** user's `~/.ssh/authorized_keys` list.



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 SSH key that is configured for password-less authentication on your computer, create one. For example, on a computer that uses a Linux operating system, run the following command:

```
$ ssh-keygen -t rsa -b 4096 -N "" \
-f <path>/<file_name> 1
```

- 1 Specify the path and file name, such as `~/.ssh/id_rsa`, of the SSH key.

Running this command generates an SSH key that does not require a password in the location that you specified.

2. Start the **ssh-agent** process as a background task:

```
$ eval "$(ssh-agent -s)"
Agent pid 31874
```

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

```
$ ssh-add <path>/<file_name> 1
Identity added: /home/<you>/<path>/<file_name> (<computer_name>)
```

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

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 this key to your cluster's machines.

1.3.7. Manually creating the installation configuration file

For installations of OpenShift Container Platform that use user-provisioned infrastructure, you must manually generate your installation configuration file.

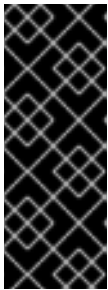
Prerequisites

- Obtain the OpenShift Container Platform installation program and the access token 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.

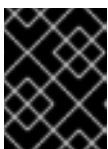
2. Customize the following **install-config.yaml** file template and save it in the **<installation_directory>**.



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.
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.

1.3.7.1. 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.

- 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
- 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 host name 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 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:5000**. For **<credentials>**, specify the base64-encoded user name and password for your mirror registry.
- 15 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 on, specify an SSH key that your **ssh-agent** process uses.

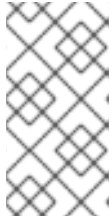
- 16 Provide the contents of the certificate file that you used for your mirror registry.
- 17 Provide the **imageContentSources** section from the output of the command to mirror the repository.

1.3.7.2. 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

- An existing **install-config.yaml** file.
- Review the sites that your cluster requires access to and determine whether any need to bypass the proxy. By default, all cluster egress traffic is proxied, including calls to hosting cloud provider APIs. Add sites to the Proxy object's **spec.noProxy** field to bypass the proxy if necessary.



NOTE

The Proxy object's **status.noProxy** field is populated by default with the instance metadata endpoint (**169.254.169.254**) and with the values of the **networking.machineCIDR**, **networking.clusterNetwork.cidr**, and **networking.serviceNetwork** fields from your installation configuration.

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: http://<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. If this field is not specified, then **httpProxy** is used for both HTTP and HTTPS connections. The URL scheme must be **http**; **https** is currently not supported.
- 3 A comma-separated list of destination domain names, domains, IP addresses, or other network CIDRs to exclude proxying. Preface a domain with **.** to include all subdomains of that domain. Use ***** to bypass proxy for all destinations.
- 4 If provided, the installation program generates a ConfigMap that is named **user-ca-bundle** in the **openshift-config** namespace that contains one or more additional CA certificates that are required for proxying HTTPS connections. The Cluster Network Operator then creates a **trusted-ca-bundle** ConfigMap that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this ConfigMap is referenced in the Proxy object's **trustedCA** field. 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.

1.3.8. 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 make its machines.



IMPORTANT

The Ignition config files that the installation program generates contain certificates that expire after 24 hours. You must complete your cluster installation and keep the cluster running for 24 hours in a non-degraded state to ensure that the first certificate rotation has finished.

Prerequisites

- Obtain the OpenShift Container Platform installation program. For a restricted network installation, these files are on your mirror host.
- Create the **install-config.yaml** installation configuration file.

Procedure

1. Generate the Kubernetes manifests for the cluster:

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

```
WARNING There are no compute nodes specified. The cluster will not fully initialize without compute nodes.
INFO Consuming "Install Config" from target directory
```

- 1** For **<installation_directory>**, specify the installation directory that contains the **install-config.yaml** file you created.

Because you create your own compute machines later in the installation process, you can safely ignore this warning.

2. Modify the **manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file to prevent Pods from being scheduled on the control plane machines:
 - a. Open the **manifests/cluster-scheduler-02-config.yml** file.
 - b. Locate the **mastersSchedulable** parameter and set its value to **False**.
 - c. Save and exit the file.



NOTE

Currently, due to a [Kubernetes limitation](#), router Pods running on control plane machines will not be reachable by the ingress load balancer. This step might not be required in a future minor version of OpenShift Container Platform.

- Obtain the Ignition config files:

```
$ ./openshift-install create ignition-configs --dir=<installation_directory> 1
```

- For **<installation_directory>**, specify the same installation directory.

The following files are generated in the directory:

```
.
├── auth
│   ├── kubeadmin-password
│   └── kubeconfig
├── bootstrap.ign
├── master.ign
├── metadata.json
└── worker.ign
```

1.3.9. Creating Red Hat Enterprise Linux CoreOS (RHCOS) machines in vSphere

Before you install a cluster that contains user-provisioned infrastructure on VMware vSphere, you must create RHCOS machines on vSphere hosts for it to use.

Prerequisites

- Obtain the Ignition config files for your cluster.
- Have access to an HTTP server that you can access from your computer and that the machines that you create can access.
- Create 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.
You must host the bootstrap Ignition config file because it is too large to fit in a vApp property.
- Save the following secondary Ignition config file for your bootstrap node to your computer as **<installation_directory>/append-bootstrap.ign**.

```
{
  "ignition": {
    "config": {
      "append": [
        {
          "source": "<bootstrap_ignition_config_url>", 1
          "verification": {}
        }
      ]
    },
    "timeouts": {},
    "version": "2.1.0"
  }
}
```



```

    },
    "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.

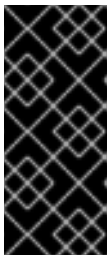
3. Convert the master, worker, and secondary bootstrap Ignition config files to Base64 encoding. For example, if you use a Linux operating system, you can use the **base64** command to encode the files.

```

$ base64 -w0 <installation_directory>/master.ign > <installation_directory>/master.64
$ base64 -w0 <installation_directory>/worker.ign > <installation_directory>/worker.64
$ base64 -w0 <installation_directory>/append-bootstrap.ign >
<installation_directory>/append-bootstrap.64

```

4. Obtain the RHCOS OVA image from the [Product Downloads](#) page on the Red Hat customer portal or 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>-<architecture>-vmware.ova**.

5. 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. The folder name must match the cluster name that you specified in the **install-config.yaml** file.
6. In the vSphere Client, create a template for the OVA image.



NOTE

In the following steps, you use the same template for all of your cluster machines and provide the location for the Ignition config file for that machine type when you provision the VMs.

- a. From the **Hosts and Clusters** tab, right-click your cluster's name and click **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**, such as 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**.
 - 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. If you plan to use the same template for all cluster machine types, do not specify values on the **Customize template** tab.
7. 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 **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: In the event of cluster performance issues, 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 Ignition config file for this machine type.
 - **guestinfo.ignition.config.data.encoding**: Specify **base64**.
 - **disk.EnableUUID**: Specify **TRUE**.
 - Alternatively, prior to powering on the virtual machine add via vApp properties:
 - Navigate to a virtual machine from the vCenter Server inventory.
 - On the **Configure** tab, expand **Settings** and select **vApp options**.

- Scroll down and under **Properties** apply the configurations from above.
 - 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.
8. 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 machine before you install the cluster.

1.3.10. Creating the cluster

To create the OpenShift Container Platform cluster, you 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

- Create the required infrastructure for the cluster.
- You obtained the installation program and generated the Ignition config files for your cluster.
- You used the Ignition config files to create RHCOS machines for your cluster.

Procedure

1. Monitor the bootstrap process:

```
$ ./openshift-install --dir=<installation_directory> wait-for bootstrap-complete \ 1
--log-level=info 2
INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...
INFO API v1.14.6+c4799753c up
INFO Waiting up to 30m0s for the bootstrap-complete event...
```

- 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**.

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 machine itself.

1.3.11. Logging in to the cluster

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

- Deploy an OpenShift Container Platform cluster.
- Install 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
system:admin
```

1.3.12. Approving the CSRs for your machines

When you add machines to a cluster, two pending certificates signing request (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself.

Prerequisites

- You added machines to your cluster.

Procedure

1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes

NAME     STATUS    ROLES    AGE   VERSION
master-0 Ready     master   63m   v1.14.6+c4799753c
master-1 Ready     master   63m   v1.14.6+c4799753c
```

```

master-2 Ready   master 64m v1.14.6+c4799753c
worker-0 NotReady worker 76s v1.14.6+c4799753c
worker-1 NotReady worker 70s v1.14.6+c4799753c

```

The output lists all of the machines that you created.

- Review the pending certificate signing requests (CSRs) and ensure that you see a client and server request with **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

NAME	AGE	REQUESTOR	CONDITION
csr-8b2br	15m	system:serviceaccount:openshift-machine-config-operator:node-bootstrapper	Pending 1
csr-8vnps	15m	system:serviceaccount:openshift-machine-config-operator:node-bootstrapper	Pending
csr-bfd72	5m26s	system:node:ip-10-0-50-126.us-east-2.compute.internal	Pending 2
csr-c57lv	5m26s	system:node:ip-10-0-95-157.us-east-2.compute.internal	Pending
...			

- A client request CSR.
- A server request CSR.

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 you approve the initial CSRs, the subsequent node client CSRs are automatically approved by the cluster **kube-controller-manager**. You must implement a method of automatically approving the kubelet serving certificate requests.

- To approve them individually, run the following command for each valid CSR:

```
$ oc adm certificate approve <csr_name> 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
```

-

1.3.13. 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
```

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
authentication	4.2.0	True	False	False	69s
cloud-credential	4.2.0	True	False	False	12m
cluster-autoscaler	4.2.0	True	False	False	11m
console	4.2.0	True	False	False	46s
dns	4.2.0	True	False	False	11m
image-registry	4.2.0	False	True	False	5m26s
ingress	4.2.0	True	False	False	5m36s
kube-apiserver	4.2.0	True	False	False	8m53s
kube-controller-manager	4.2.0	True	False	False	7m24s
kube-scheduler	4.2.0	True	False	False	12m
machine-api	4.2.0	True	False	False	12m
machine-config	4.2.0	True	False	False	7m36s
marketplace	4.2.0	True	False	False	7m54m
monitoring	4.2.0	True	False	False	7h54s
network	4.2.0	True	False	False	5m9s
node-tuning	4.2.0	True	False	False	11m
openshift-apiserver	4.2.0	True	False	False	11m
openshift-controller-manager	4.2.0	True	False	False	5m943s
openshift-samples	4.2.0	True	False	False	3m55s
operator-lifecycle-manager	4.2.0	True	False	False	11m
operator-lifecycle-manager-catalog	4.2.0	True	False	False	11m
service-ca	4.2.0	True	False	False	11m
service-catalog-apiserver	4.2.0	True	False	False	5m26s
service-catalog-controller-manager	4.2.0	True	False	False	5m25s
storage	4.2.0	True	False	False	5m30s

2. Configure the Operators that are not available.

1.3.13.1. Image registry storage configuration

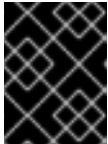
If the **image-registry** Operator is not available, you must configure storage for it. Instructions for both configuring a PersistentVolume, which is required for production clusters, and for configuring an empty directory as the storage location, which is available for only non-production clusters, are shown.

1.3.13.1.1. 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.
- A provisioned persistent volume (PV) with **ReadWriteMany** access mode, such as **NFS**.



IMPORTANT

vSphere volumes do not support the **ReadWriteMany** access mode. You must use a different storage backend, such as **NFS**, to configure the registry storage.

- Must have "100Gi" capacity.

Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.
2. Verify you do not have a registry Pod:

```
$ oc get pod -n openshift-image-registry
```



NOTE

If the storage type is **emptyDIR**, the replica number cannot be greater than **1**. If the storage type is **NFS**, and you want to scale up the registry Pod by setting **replica>1** you must enable the **no_wdelay** mount option. For example:

```
# cat /etc/exports
/mnt/data *(rw,sync,no_wdelay,no_root_squash,insecure,fsid=0)
sh-4.3# exportfs -rv
exporting */mnt/data
```

3. Check the registry configuration:

```
$ oc edit configs.imageregistry.operator.openshift.io

storage:
  pvc:
    claim:
```

Leave the **claim** field blank to allow the automatic creation of an **image-registry-storage** PVC.

4. Optional: Add a new storage class to a PV:
 - a. Create the PV:

```
$ oc create -f -
```

```

apiVersion: v1
kind: PersistentVolume
metadata:
  name: image-registry-pv
spec:
  accessModes:
    ReadWriteMany
  capacity:
    storage: 100Gi
  nfs:
    path: /registry
    server: 172.16.231.181
  persistentVolumeReclaimPolicy: Retain
  storageClassName: nfs01

```

```
$ oc get pv
```

- b. Create the PVC:

```
$ oc create -n openshift-image-registry -f -
```

```

apiVersion: "v1"
kind: "PersistentVolumeClaim"
metadata:
  name: "image-registry-pvc"
spec:
  accessModes:
    - ReadWriteMany
  resources:
    requests:
      storage: 100Gi
  storageClassName: nfs01
  volumeMode: Filesystem

```

```
$ oc get pvc -n openshift-image-registry
```

Finally, add the name of your PVC:

```
$ oc edit configs.imageregistry.operator.openshift.io -o yaml
```

```

storage:
  pvc:
    claim: image-registry-pvc 1

```

- 1** Creating a custom PVC allows you to leave the **claim** field blank for default automatic creation of an **image-registry-storage** PVC.

5. Check the **clusteroperator** status:

```
$ oc get clusteroperator image-registry
```


1.3.13.1.2. 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.

1.3.14. 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:

```
$ watch -n5 oc get clusteroperators
```

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
authentication	4.2.0	True	False	False	10m
cloud-credential	4.2.0	True	False	False	22m
cluster-autoscaler	4.2.0	True	False	False	21m
console	4.2.0	True	False	False	10m
dns	4.2.0	True	False	False	21m
image-registry	4.2.0	True	False	False	16m
ingress	4.2.0	True	False	False	16m

kube-apiserver	4.2.0	True	False	False	19m
kube-controller-manager	4.2.0	True	False	False	18m
kube-scheduler	4.2.0	True	False	False	22m
machine-api	4.2.0	True	False	False	22m
machine-config	4.2.0	True	False	False	18m
marketplace	4.2.0	True	False	False	18m
monitoring	4.2.0	True	False	False	18m
network	4.2.0	True	False	False	16m
node-tuning	4.2.0	True	False	False	21m
openshift-apiserver	4.2.0	True	False	False	21m
openshift-controller-manager	4.2.0	True	False	False	17m
openshift-samples	4.2.0	True	False	False	14m
operator-lifecycle-manager	4.2.0	True	False	False	21m
operator-lifecycle-manager-catalog	4.2.0	True	False	False	21m
service-ca	4.2.0	True	False	False	21m
service-catalog-apiserver	4.2.0	True	False	False	16m
service-catalog-controller-manager	4.2.0	True	False	False	16m
storage	4.2.0	True	False	False	16m

When all of the cluster Operators are **AVAILABLE**, you can complete the installation.

2. Monitor for cluster completion:

```
$ ./openshift-install --dir=<installation_directory> wait-for install-complete 1
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.

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. You must keep the cluster running for 24 hours in a non-degraded state to ensure that the first certificate rotation has finished.

3. 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
```

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
3m			
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.

4. Register your cluster on the [Cluster registration](#) page.

Next steps

- [Customize your cluster](#).
- If necessary, you can [opt out of remote health reporting](#) .