



# OpenShift Container Platform 4.18

## Installing on bare metal

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## Abstract

This document describes how to install OpenShift Container Platform on bare metal.

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# CHAPTER 1. PREPARING FOR BARE METAL CLUSTER INSTALLATION

## 1.1. PREREQUISITES

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

## 1.2. PLANNING A BARE METAL CLUSTER FOR OPENSHIFT VIRTUALIZATION

If you will use OpenShift Virtualization, it is important to be aware of several requirements before you install your bare metal cluster.

- If you want to use live migration features, you must have multiple worker nodes *at the time of cluster installation*. This is because live migration requires the cluster-level high availability (HA) flag to be set to true. The HA flag is set when a cluster is installed and cannot be changed afterwards. If there are fewer than two worker nodes defined when you install your cluster, the HA flag is set to false for the life of the cluster.



### NOTE

You can install OpenShift Virtualization on a single-node cluster, but single-node OpenShift does not support high availability.

- Live migration requires shared storage. Storage for OpenShift Virtualization must support and use the ReadWriteMany (RWX) access mode.
- If you plan to use Single Root I/O Virtualization (SR-IOV), ensure that your network interface controllers (NICs) are supported by OpenShift Container Platform.

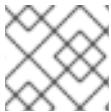
### Additional resources

- [Getting started with OpenShift Virtualization](#)
- [Preparing your cluster for OpenShift Virtualization](#)
- [About Single Root I/O Virtualization \(SR-IOV\) hardware networks](#)
- [Connecting a virtual machine to an SR-IOV network](#)

## 1.3. NIC PARTITIONING FOR SR-IOV DEVICES

OpenShift Container Platform can be deployed on a server with a dual port network interface card (NIC). You can partition a single, high-speed dual port NIC into multiple virtual functions (VFs) and enable SR-IOV.

This feature supports the use of bonds for high availability with the Link Aggregation Control Protocol (LACP).

**NOTE**

Only one LACP can be declared by physical NIC.

An OpenShift Container Platform cluster can be deployed on a bond interface with 2 VFs on 2 physical functions (PFs) using the following methods:

- Agent-based installer

**NOTE**

The minimum required version of **nmstate** is:

- **1.4.2-4** for RHEL 8 versions
- **2.2.7** for RHEL 9 versions

- Installer-provisioned infrastructure installation
- User-provisioned infrastructure installation

#### Additional resources

- [Example: Bonds and SR-IOV dual-nic node network configuration](#)
- [Optional: Configuring host network interfaces for dual port NIC](#)
- [Bonding multiple SR-IOV network interfaces to a dual port NIC interface](#)

## 1.4. CHOOSING A METHOD TO INSTALL OPENSHIFT CONTAINER PLATFORM ON BARE METAL

The OpenShift Container Platform installation program offers four methods for deploying a cluster:

- **Interactive:** You can deploy a cluster with the web-based [Assisted Installer](#). This is the recommended approach for clusters with networks connected to the internet. The Assisted Installer is the easiest way to install OpenShift Container Platform, it provides smart defaults, and it performs pre-flight validations before installing the cluster. It also provides a RESTful API for automation and advanced configuration scenarios.
- **Local Agent-based:** You can deploy a cluster locally with the [agent-based installer](#) for air-gapped or restricted networks. It provides many of the benefits of the Assisted Installer, but you must download and configure the [agent-based installer](#) first. Configuration is done with a commandline interface. This approach is ideal for air-gapped or restricted networks.
- **Automated:** You can [deploy a cluster on installer-provisioned infrastructure](#) and the cluster it maintains. The installer uses each cluster host's baseboard management controller (BMC) for provisioning. You can deploy clusters with both connected or air-gapped or restricted networks.
- **Full control:** You can deploy a cluster on [infrastructure that you prepare and maintain](#), which provides maximum customizability. You can deploy clusters with both connected or air-gapped or restricted networks.

The clusters have the following characteristics:

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

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

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

You can install a cluster on bare metal infrastructure that is provisioned by the OpenShift Container Platform installation program, by using the following method:

- **Installing an installer-provisioned cluster on bare metal** You can install OpenShift Container Platform on bare metal by using installer provisioning.

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

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

- **Installing a user-provisioned cluster on bare metal** You can install OpenShift Container Platform on bare metal infrastructure that you provision. For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.
- **Installing a user-provisioned bare metal cluster with network customizations** You can install a bare metal cluster on user-provisioned infrastructure with network-customizations. By customizing your network configuration, your cluster can coexist with existing IP address allocations in your environment and integrate with existing MTU and VXLAN configurations. Most of the network customizations must be applied at the installation stage.
- **Installing a user-provisioned bare metal cluster on a restricted network** You can install a user-provisioned bare metal cluster on a restricted or disconnected network by using a mirror registry. You can also use this installation method to ensure that your clusters only use container images that satisfy your organizational controls on external content.

# CHAPTER 2. USER-PROVISIONED INFRASTRUCTURE

## 2.1. INSTALLING A USER-PROVISIONED CLUSTER ON BARE METAL

In OpenShift Container Platform 4.18, you can install a cluster on bare metal infrastructure that you provision.



### IMPORTANT

While you might be able to follow this procedure to deploy a cluster on virtualized or cloud environments, you must be aware of additional considerations for non-bare metal platforms. Review the information in the [guidelines for deploying OpenShift Container Platform on non-tested platforms](#) before you attempt to install an OpenShift Container Platform cluster in such an environment.

### 2.1.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update processes](#).
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- If you use a firewall, you [configured it to allow the sites](#) that your cluster requires access to.



### NOTE

Be sure to also review this site list if you are configuring a proxy.

### 2.1.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.18, you require access to the internet to install your cluster.

You must have internet access to:

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



### IMPORTANT

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

### Additional resources

- See [Installing a user-provisioned bare metal cluster on a restricted network](#) for more information about performing a restricted network installation on bare metal infrastructure that you provision.

### 2.1.3. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

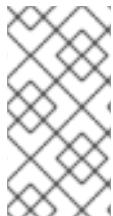
This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

#### 2.1.3.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

**Table 2.1. Minimum required hosts**

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.



#### NOTE

As an exception, you can run zero compute machines in a bare metal cluster that consists of three control plane machines only. This provides smaller, more resource efficient clusters for cluster administrators and developers to use for testing, development, and production. Running one compute machine is not supported.



#### IMPORTANT

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

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 8.6 and later.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 9.2 and inherits all of its hardware certifications and requirements. See [Red Hat Enterprise Linux technology capabilities and limits](#).

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

Each cluster machine must meet the following minimum requirements:

**Table 2.2. Minimum resource requirements**

Machine	Operating System	CPU [1]	RAM	Storage	Input/Output Per Second (IOPS) [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 8.6 and later [3]	2	8 GB	100 GB	300

1. One CPU is equivalent to one physical core when simultaneous multithreading (SMT), or Hyper-Threading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = CPUs.
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and has been removed in OpenShift Container Platform 4.10 and later.



## NOTE

For OpenShift Container Platform version 4.18, RHCOS is based on RHEL version 9.4, which updates the micro-architecture requirements. The following list contains the minimum instruction set architectures (ISA) that each architecture requires:

- x86-64 architecture requires x86-64-v2 ISA
- ARM64 architecture requires ARMv8.0-A ISA
- IBM Power architecture requires Power 9 ISA
- s390x architecture requires z14 ISA

For more information, see [Architectures](#) (RHEL documentation).

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

## Additional resources

- [Optimizing storage](#)

### 2.1.3.3. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

#### Additional resources

- See [Configuring a three-node cluster](#) for details about deploying three-node clusters in bare metal environments.
- See [Approving the certificate signing requests for your machines](#) for more information about approving cluster certificate signing requests after installation.

### 2.1.3.4. Requirements for baremetal clusters on vSphere

Ensure you enable the **disk.EnableUUID** parameter on all virtual machines in your cluster.

#### Additional resources

- See [Installing RHCOS and starting the OpenShift Container Platform bootstrap process](#) for details on setting the **disk.EnableUUID** parameter's value to **TRUE** on VMware vSphere for user-provisioned infrastructure.

### 2.1.3.5. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.



#### NOTE

- It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.
- If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API

servers and worker nodes are in different zones, you can configure a default DNS search zone to allow the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

#### 2.1.3.5.1. Setting the cluster node hostnames through DHCP

On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

#### 2.1.3.5.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.



#### IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

**Table 2.3. Ports used for all-machine to all-machine communications**

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	<b>1936</b>	Metrics
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> and the Cluster Version Operator on port <b>9099</b> .
	<b>10250-10259</b>	The default ports that Kubernetes reserves
UDP	<b>4789</b>	VXLAN
	<b>6081</b>	Geneve
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> .
	<b>500</b>	IPsec IKE packets

Protocol	Port	Description
	<b>4500</b>	IPsec NAT-T packets
	<b>123</b>	Network Time Protocol (NTP) on UDP port <b>123</b>  If an external NTP time server is configured, you must open UDP port <b>123</b> .
TCP/UDP	<b>30000-32767</b>	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

**Table 2.4.** Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	<b>6443</b>	Kubernetes API

**Table 2.5.** Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	<b>2379-2380</b>	etcd server and peer ports

### NTP configuration for user-provisioned infrastructure

OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service*.

If a DHCP server provides NTP server information, the chrony time service on the Red Hat Enterprise Linux CoreOS (RHCOS) machines read the information and can sync the clock with the NTP servers.

### Additional resources

- [Configuring chrony time service](#)

#### 2.1.3.6. User-provisioned DNS requirements

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API
- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines

Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.



### NOTE

It is recommended to use a DHCP server to provide the hostnames to each cluster node. See the *DHCP recommendations for user-provisioned infrastructure* section for more information.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, **<cluster\_name>** is the cluster name and **<base\_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>. <cluster\_name>. <base\_domain>..**

**Table 2.6. Required DNS records**

Component	Record	Description
Kubernetes API	<b>api.&lt;cluster_name&gt;. &lt;base_domain&gt;.</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
	<b>api-int.&lt;cluster_name&gt;. &lt;base_domain&gt;.</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster.
Routes	<b>*.apps.&lt;cluster_name&gt;. &lt;base_domain&gt;.</b>	<p><b>IMPORTANT</b></p> <p>The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.</p> <p>A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.</p> <p>For example, <b>console-openshift-console.apps. &lt;cluster_name&gt;. &lt;base_domain&gt;</b> is used as a wildcard route to the OpenShift Container Platform console.</p>

Component	Record	Description
Bootstrap machine	<b>bootstrap.&lt;cluster_name&gt;. &lt;base_domain&gt;.</b>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.
Control plane machines	<b>&lt;control_plane&gt;&lt;n&gt;. &lt;cluster_name&gt;. &lt;base_domain&gt;.</b>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.
Compute machines	<b>&lt;compute&gt;&lt;n&gt;. &lt;cluster_name&gt;. &lt;base_domain&gt;.</b>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.



## NOTE

In OpenShift Container Platform 4.4 and later, you do not need to specify etcd host and SRV records in your DNS configuration.

## TIP

You can use the **dig** command to verify name and reverse name resolution. See the section on [Validating DNS resolution for user-provisioned infrastructure](#) for detailed validation steps.

### 2.1.3.6.1. Example DNS configuration for user-provisioned clusters

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is **ocp4** and the base domain is **example.com**.

#### Example DNS A record configuration for a user-provisioned cluster

The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

##### Example 2.1. Sample DNS zone database

```
$TTL 1W
@ IN SOA ns1.example.com. root (
    2019070700 ; serial
    3H ; refresh (3 hours)
    30M ; retry (30 minutes)
    2W ; expiry (2 weeks)
    1W ) ; minimum (1 week)
IN NS ns1.example.com.
IN MX 10 smtp.example.com.
```

```

;
;
ns1.example.com. IN A 192.168.1.5
smtp.example.com. IN A 192.168.1.5
;
helper.example.com. IN A 192.168.1.5
helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com. IN A 192.168.1.5 ①
api-int.ocp4.example.com. IN A 192.168.1.5 ②
;
*.apps.ocp4.example.com. IN A 192.168.1.5 ③
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 ④
;
control-plane0.ocp4.example.com. IN A 192.168.1.97 ⑤
control-plane1.ocp4.example.com. IN A 192.168.1.98 ⑥
control-plane2.ocp4.example.com. IN A 192.168.1.99 ⑦
;
compute0.ocp4.example.com. IN A 192.168.1.11 ⑧
compute1.ocp4.example.com. IN A 192.168.1.7 ⑨
;
;EOF

```

- ① Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.
- ② Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.
- ③ Provides name resolution for the wildcard routes. The record refers to the IP address of the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



#### NOTE

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

- ④ Provides name resolution for the bootstrap machine.
- ⑤ ⑥ ⑦ Provides name resolution for the control plane machines.
- ⑧ ⑨ Provides name resolution for the compute machines.

#### Example DNS PTR record configuration for a user-provisioned cluster

The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

### Example 2.2. Sample DNS zone database for reverse records

```
$TTL 1W
@ IN SOA ns1.example.com. root (
    2019070700 ; serial
    3H ; refresh (3 hours)
    30M ; retry (30 minutes)
    2W ; expiry (2 weeks)
    1W ) ; minimum (1 week)
IN NS ns1.example.com.
;
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. ①
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. ②
;
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. ③
;
97.1.168.192.in-addr.arpa. IN PTR control-plane0.ocp4.example.com. ④
98.1.168.192.in-addr.arpa. IN PTR control-plane1.ocp4.example.com. ⑤
99.1.168.192.in-addr.arpa. IN PTR control-plane2.ocp4.example.com. ⑥
;
11.1.168.192.in-addr.arpa. IN PTR compute0.ocp4.example.com. ⑦
7.1.168.192.in-addr.arpa. IN PTR compute1.ocp4.example.com. ⑧
;
:EOF
```

- ① Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.
- ② Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.
- ③ Provides reverse DNS resolution for the bootstrap machine.
- ④ ⑤ ⑥ Provides reverse DNS resolution for the control plane machines.
- ⑦ ⑧ Provides reverse DNS resolution for the compute machines.



#### NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard.

#### Additional resources

- [Validating DNS resolution for user-provisioned infrastructure](#)

#### 2.1.3.7. Load balancing requirements for user-provisioned infrastructure

Before you install OpenShift Container Platform, you must provision the API and application Ingress load balancing infrastructure. In production scenarios, you can deploy the API and application Ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.



## NOTE

If you want to deploy the API and application Ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer:** Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:
  - Layer 4 load balancing only. This can be referred to as Raw TCP or SSL Passthrough mode.
  - A stateless load balancing algorithm. The options vary based on the load balancer implementation.



## IMPORTANT

Do not configure session persistence for an API load balancer. Configuring session persistence for a Kubernetes API server might cause performance issues from excess application traffic for your OpenShift Container Platform cluster and the Kubernetes API that runs inside the cluster.

Configure the following ports on both the front and back of the load balancers:

**Table 2.7. API load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
<b>6443</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the <b>/readyz</b> endpoint for the API server health check probe.	X	X	Kubernetes API server
<b>22623</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server



## NOTE

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the **/readyz** endpoint to the removal of the API server instance from the pool. Within the time frame after **/readyz** returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application Ingress load balancer.** Provides an ingress point for application traffic flowing in from outside the cluster. A working configuration for the Ingress router is required for an OpenShift Container Platform cluster.

Configure the following conditions:

- Layer 4 load balancing only. This can be referred to as Raw TCP or SSL Passthrough mode.
- A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

## TIP

If the true IP address of the client can be seen by the application Ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

Configure the following ports on both the front and back of the load balancers:

**Table 2.8. Application Ingress load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
<b>443</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic
<b>80</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic



## NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

### 2.1.3.7.1. Example load balancer configuration for user-provisioned clusters

This section provides an example API and application Ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an `/etc/haproxy/haproxy.cfg` configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing one load balancing solution over another.

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.



## NOTE

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running `setsebool -P haproxy_connect_any=1`.

### Example 2.3. Sample API and application Ingress load balancer configuration

```

global
  log    127.0.0.1 local2
  pidfile /var/run/haproxy.pid
  maxconn 4000
  daemon
defaults
  mode      http
  log       global
  option    dontlognull
  option    http-server-close
  option    redispatch
  retries   3
  timeout  http-request 10s
  timeout  queue     1m
  timeout  connect   10s
  timeout  client    1m
  timeout  server    1m
  timeout  http-keep-alive 10s
  timeout  check     10s
  maxconn  3000
listen api-server-6443 ①
  bind *:6443
  mode tcp
  option httpchk GET /readyz HTTP/1.0
  option log-health-checks
  balance roundrobin
  server bootstrap bootstrap.ocp4.example.com:6443 verify none check check-ssl inter 10s fall 2
rise 3 backup ②
  server master0 master0.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
  server master1 master1.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
  server master2 master2.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
listen machine-config-server-22623 ③
  bind *:22623
  mode tcp
  server bootstrap bootstrap.ocp4.example.com:22623 check inter 1s backup ④
  server master0 master0.ocp4.example.com:22623 check inter 1s
  server master1 master1.ocp4.example.com:22623 check inter 1s
  server master2 master2.ocp4.example.com:22623 check inter 1s
listen ingress-router-443 ⑤
  bind *:443
  mode tcp
  balance source
  server compute0 compute0.ocp4.example.com:443 check inter 1s
  server compute1 compute1.ocp4.example.com:443 check inter 1s
listen ingress-router-80 ⑥
  bind *:80
  mode tcp
  balance source
  server compute0 compute0.ocp4.example.com:80 check inter 1s
  server compute1 compute1.ocp4.example.com:80 check inter 1s

```

- 1** Port **6443** handles the Kubernetes API traffic and points to the control plane machines.
- 2** The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.
- 3** Port **22623** handles the machine config server traffic and points to the control plane machines.
- 5** Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.
- 6** Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



#### NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

#### TIP

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltpu** on the HAProxy node.

#### 2.1.4. Creating a manifest object that includes a customized **br-ex** bridge

As an alternative to using the **configure-ovs.sh** shell script to set a **br-ex** bridge on a bare-metal platform, you can create a **MachineConfig** object that includes an NMState configuration file. The NMState configuration file creates a customized **br-ex** bridge network configuration on each node in your cluster.

Consider the following use cases for creating a manifest object that includes a customized **br-ex** bridge:

- You want to make postinstallation changes to the bridge, such as changing the Open vSwitch (OVS) or OVN-Kubernetes **br-ex** bridge network. The **configure-ovs.sh** shell script does not support making postinstallation changes to the bridge.
- You want to deploy the bridge on a different interface than the interface available on a host or server IP address.
- You want to make advanced configurations to the bridge that are not possible with the **configure-ovs.sh** shell script. Using the script for these configurations might result in the bridge failing to connect multiple network interfaces and facilitating data forwarding between the interfaces.



#### NOTE

If you require an environment with a single network interface controller (NIC) and default network settings, use the **configure-ovs.sh** shell script.

After you install Red Hat Enterprise Linux CoreOS (RHCOS) and the system reboots, the Machine

Config Operator injects Ignition configuration files into each node in your cluster, so that each node received the **br-ex** bridge network configuration. To prevent configuration conflicts, the **configure-ovs.sh** shell script receives a signal to not configure the **br-ex** bridge.

## Prerequisites

- Optional: You have installed the **nmstate** API so that you can validate the NMState configuration.

## Procedure

- 1 Create a NMState configuration file that has decoded base64 information for your customized **br-ex** bridge network:

### Example of an NMState configuration for a customized **br-ex** bridge network

```
interfaces:
- name: enp2s0 ①
  type: ethernet ②
  state: up ③
  ipv4:
    enabled: false ④
  ipv6:
    enabled: false
- name: br-ex
  type: ovs-bridge
  state: up
  ipv4:
    enabled: false
    dhcp: false
  ipv6:
    enabled: false
    dhcp: false
  bridge:
    options:
      mcast-snooping-enable: true
    port:
      - name: enp2s0 ⑤
      - name: br-ex
        - name: br-ex
          type: ovs-interface
          state: up
          copy-mac-from: enp2s0
        ipv4:
          enabled: true
          dhcp: true
        ipv6:
          enabled: false
          dhcp: false
# ...
```

① Name of the interface.

② The type of ethernet.

- 3 The requested state for the interface after creation.
- 4 Disables IPv4 and IPv6 in this example.
- 5 The node NIC to which the bridge attaches.

2. Use the **cat** command to base64-encode the contents of the NMState configuration:

```
$ cat <nmstate_configuration>.yaml | base64 1
```

- 1 Replace **<nmstate\_configuration>** with the name of your NMState resource YAML file.

3. Create a **MachineConfig** manifest file and define a customized **br-ex** bridge network configuration analogous to the following example:

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker 1
  name: 10-br-ex-worker 2
spec:
  config:
    ignition:
      version: 3.2.0
    storage:
      files:
        - contents:
            source: data:text/plain;charset=utf-8;base64,
<base64_encoded_nmstate_configuration> 3
          mode: 0644
          overwrite: true
          path: /etc/nmstate/openshift/cluster.yaml
# ...
```

- 1 For each node in your cluster, specify the hostname path to your node and the base-64 encoded Ignition configuration file data for the machine type. If you have a single global configuration specified in an **/etc/nmstate/openshift/cluster.yaml** configuration file that you want to apply to all nodes in your cluster, you do not need to specify the hostname path for each node. The **worker** role is the default role for nodes in your cluster. The **.yaml** extension does not work when specifying the hostname path for each node or all nodes in the **MachineConfig** manifest file.
- 2 The name of the policy.
- 3 Writes the encoded base64 information to the specified path.

#### 2.1.4.1. Scaling each machine set to compute nodes

To apply a customized **br-ex** bridge configuration to all compute nodes in your OpenShift Container Platform cluster, you must edit your **MachineConfig** custom resource (CR) and modify its roles. Additionally, you must create a **BareMetalHost** CR that defines information for your bare-metal

machine, such as hostname, credentials, and so on.

After you configure these resources, you must scale machine sets, so that the machine sets can apply the resource configuration to each compute node and reboot the nodes.

## Prerequisites

- You created a **MachineConfig** manifest object that includes a customized **br-ex** bridge configuration.

## Procedure

1. Edit the **MachineConfig** CR by entering the following command:

```
$ oc edit mc <machineconfig_custom_resource_name>
```

2. Add each compute node configuration to the CR, so that the CR can manage roles for each defined compute node in your cluster.
3. Create a **Secret** object named **extraworker-secret** that has a minimal static IP configuration.
4. Apply the **extraworker-secret** secret to each node in your cluster by entering the following command. This step provides each compute node access to the Ignition config file.

```
$ oc apply -f ./extraworker-secret.yaml
```

5. Create a **BareMetalHost** resource and specify the network secret in the **preprovisioningNetworkDataName** parameter:

### Example **BareMetalHost** resource with an attached network secret

```
apiVersion: metal3.io/v1alpha1
kind: BareMetalHost
spec:
# ...
  preprovisioningNetworkDataName: ostest-extraworker-0-network-config-secret
# ...
```

6. To manage the **BareMetalHost** object within the **openshift-machine-api** namespace of your cluster, change to the namespace by entering the following command:

```
$ oc project openshift-machine-api
```

7. Get the machine sets:

```
$ oc get machinesets
```

8. Scale each machine set by entering the following command. You must run this command for each machine set.

```
$ oc scale machineset <machineset_name> --replicas=<n> ①
```

- 1** Where <machineset\_name> is the name of the machine set and <n> is the number of compute nodes.

## 2.1.5. Preparing the user-provisioned infrastructure

Before you install OpenShift Container Platform on user-provisioned infrastructure, you must prepare the underlying infrastructure.

This section provides details about the high-level steps required to set up your cluster infrastructure in preparation for an OpenShift Container Platform installation. This includes configuring IP networking and network connectivity for your cluster nodes, enabling the required ports through your firewall, and setting up the required DNS and load balancing infrastructure.

After preparation, your cluster infrastructure must meet the requirements outlined in the *Requirements for a cluster with user-provisioned infrastructure* section.

### Prerequisites

- You have reviewed the [OpenShift Container Platform 4.x Tested Integrations](#) page.
- You have reviewed the infrastructure requirements detailed in the *Requirements for a cluster with user-provisioned infrastructure* section.

### Procedure

1. If you are using DHCP to provide the IP networking configuration to your cluster nodes, configure your DHCP service.
  - a. Add persistent IP addresses for the nodes to your DHCP server configuration. In your configuration, match the MAC address of the relevant network interface to the intended IP address for each node.
  - b. When you use DHCP to configure IP addressing for the cluster machines, the machines also obtain the DNS server information through DHCP. Define the persistent DNS server address that is used by the cluster nodes through your DHCP server configuration.



#### NOTE

If you are not using a DHCP service, you must provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

- c. Define the hostnames of your cluster nodes in your DHCP server configuration. See the *Setting the cluster node hostnames through DHCP* section for details about hostname considerations.



#### NOTE

If you are not using a DHCP service, the cluster nodes obtain their hostname through a reverse DNS lookup.

2. Ensure that your network infrastructure provides the required network connectivity between the cluster components. See the *Networking requirements for user-provisioned infrastructure* section for details about the requirements.
3. Configure your firewall to enable the ports required for the OpenShift Container Platform cluster components to communicate. See *Networking requirements for user-provisioned infrastructure* section for details about the ports that are required.



### IMPORTANT

By default, port **1936** is accessible for an OpenShift Container Platform cluster, because each control plane node needs access to this port.

Avoid using the Ingress load balancer to expose this port, because doing so might result in the exposure of sensitive information, such as statistics and metrics, related to Ingress Controllers.

4. Setup the required DNS infrastructure for your cluster.
  - a. Configure DNS name resolution for the Kubernetes API, the application wildcard, the bootstrap machine, the control plane machines, and the compute machines.
  - b. Configure reverse DNS resolution for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

See the *User-provisioned DNS requirements* section for more information about the OpenShift Container Platform DNS requirements.
5. Validate your DNS configuration.
  - a. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses in the responses correspond to the correct components.
  - b. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names in the responses correspond to the correct components.

See the *Validating DNS resolution for user-provisioned infrastructure* section for detailed DNS validation steps.
6. Provision the required API and application ingress load balancing infrastructure. See the *Load balancing requirements for user-provisioned infrastructure* section for more information about the requirements.



### NOTE

Some load balancing solutions require the DNS name resolution for the cluster nodes to be in place before the load balancing is initialized.

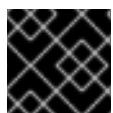
## Additional resources

- [Requirements for a cluster with user-provisioned infrastructure](#)
- [Installing RHCOS and starting the OpenShift Container Platform bootstrap process](#)
- [Setting the cluster node hostnames through DHCP](#)

- Advanced RHCOS installation configuration
- Networking requirements for user-provisioned infrastructure
- User-provisioned DNS requirements
- Validating DNS resolution for user-provisioned infrastructure
- Load balancing requirements for user-provisioned infrastructure

### 2.1.6. Validating DNS resolution for user-provisioned infrastructure

You can validate your DNS configuration before installing OpenShift Container Platform on user-provisioned infrastructure.



#### IMPORTANT

The validation steps detailed in this section must succeed before you install your cluster.

#### Prerequisites

- You have configured the required DNS records for your user-provisioned infrastructure.

#### Procedure

1. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses contained in the responses correspond to the correct components.
  - a. Perform a lookup against the Kubernetes API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api.<cluster_name>.<base_domain> ①
```

- ① Replace **<nameserver\_ip>** with the IP address of the nameserver, **<cluster\_name>** with your cluster name, and **<base\_domain>** with your base domain name.

#### Example output

```
api.ocp4.example.com. 604800 IN A 192.168.1.5
```

- b. Perform a lookup against the Kubernetes internal API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api-int.<cluster_name>.<base_domain>
```

#### Example output

```
api-int.ocp4.example.com. 604800 IN A 192.168.1.5
```

- c. Test an example **\*.apps.<cluster\_name>.<base\_domain>** DNS wildcard lookup. All of the application wildcard lookups must resolve to the IP address of the application ingress load balancer:

```
$ dig +noall +answer @<nameserver_ip> random.apps.<cluster_name>.<base_domain>
```

#### Example output

```
random.apps.ocp4.example.com. 604800 IN A 192.168.1.5
```



#### NOTE

In the example outputs, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

You can replace **random** with another wildcard value. For example, you can query the route to the OpenShift Container Platform console:

```
$ dig +noall +answer @<nameserver_ip> console-openshift-console.apps.<cluster_name>.<base_domain>
```

#### Example output

```
console-openshift-console.apps.ocp4.example.com. 604800 IN A 192.168.1.5
```

- d. Run a lookup against the bootstrap DNS record name. Check that the result points to the IP address of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> bootstrap.<cluster_name>.<base_domain>
```

#### Example output

```
bootstrap.ocp4.example.com. 604800 IN A 192.168.1.96
```

- e. Use this method to perform lookups against the DNS record names for the control plane and compute nodes. Check that the results correspond to the IP addresses of each node.

2. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names contained in the responses correspond to the correct components.

- a. Perform a reverse lookup against the IP address of the API load balancer. Check that the response includes the record names for the Kubernetes API and the Kubernetes internal API:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.5
```

#### Example output

5.1.168.192.in-addr.arpa. 604800 IN PTR api-int.ocp4.example.com. ①  
 5.1.168.192.in-addr.arpa. 604800 IN PTR api.ocp4.example.com. ②

- ① Provides the record name for the Kubernetes internal API.
- ② Provides the record name for the Kubernetes API.



### NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard. No validation step is needed for reverse DNS resolution against the IP address of the application ingress load balancer.

- b. Perform a reverse lookup against the IP address of the bootstrap node. Check that the result points to the DNS record name of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.96
```

### Example output

```
96.1.168.192.in-addr.arpa. 604800 IN PTR bootstrap.ocp4.example.com.
```

- c. Use this method to perform reverse lookups against the IP addresses for the control plane and compute nodes. Check that the results correspond to the DNS record names of each node.

### Additional resources

- [User-provisioned DNS requirements](#)
- [Load balancing requirements for user-provisioned infrastructure](#)

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

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

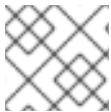
After the key is passed to the nodes, you can use the key pair to SSH in to the RHCOS nodes as the user `core`. To access the nodes through SSH, the private key identity must be managed by SSH for your local user.

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



### IMPORTANT

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

**NOTE**

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

**Procedure**

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

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

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

**NOTE**

If you plan to install an OpenShift Container Platform cluster that uses the RHEL cryptographic libraries that have been submitted to NIST for FIPS 140-2/140-3 Validation on only the **x86\_64**, **ppc64le**, and **s390x** architectures, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

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

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

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

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

**NOTE**

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

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

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

**Example output**

```
Agent pid 31874
```

**NOTE**

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

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

**\$ ssh-add <path>/<file\_name>** ①

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

**Example output**

Identity added: /home/<you>/<path>/<file\_name> (<computer\_name>)

**Next steps**

- When you install OpenShift Container Platform, provide the SSH public key to the installation program. If you install a cluster on infrastructure that you provision, you must provide the key to the installation program.

**Additional resources**

- [Verifying node health](#)

**2.1.8. Obtaining the installation program**

Before you install OpenShift Container Platform, download the installation file on the host you are using for installation.

**Prerequisites**

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

**Procedure**

1. Go to the [Cluster Type](#) page on the Red Hat Hybrid Cloud Console. If you have a Red Hat account, log in with your credentials. If you do not, create an account.

**TIP**

You can also [download the binaries for a specific OpenShift Container Platform release](#).

2. Select your infrastructure provider from the **Run it yourself** section of the page.
3. Select your host operating system and architecture from the dropdown menus under **OpenShift Installer** and click **Download Installer**.
4. Place the downloaded file in the directory where you want to store the installation configuration files.



## IMPORTANT

- The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both of the files are required to delete the cluster.
- Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

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

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

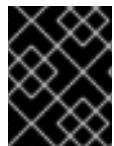
6. Download your installation [pull secret from Red Hat OpenShift Cluster Manager](#). This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.

## TIP

Alternatively, you can retrieve the installation program from the [Red Hat Customer Portal](#), where you can specify a version of the installation program to download. However, you must have an active subscription to access this page.

### 2.1.9. Installing the OpenShift CLI

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



## IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.18. Download and install the new version of **oc**.

#### Installing the OpenShift CLI on Linux

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

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the architecture from the **Product Variant** drop-down list.
3. Select the appropriate version from the **Version** drop-down list.
4. Click **Download Now** next to the **OpenShift v4.18 Linux Clients** entry and save the file.
5. Unpack the archive:

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

6. Place the **oc** binary in a directory that is on your **PATH**.

To check your **PATH**, execute the following command:

```
$ echo $PATH
```

## Verification

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

```
$ oc <command>
```

## Installing the OpenShift CLI on Windows

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

### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version from the **Version** drop-down list.
3. Click **Download Now** next to the **OpenShift v4.18 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.

To check your **PATH**, open the command prompt and execute the following command:

```
C:> path
```

## Verification

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

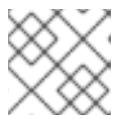
```
C:> oc <command>
```

## Installing the OpenShift CLI on macOS

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

### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version from the **Version** drop-down list.
3. Click **Download Now** next to the **OpenShift v4.18 macOS Clients** entry and save the file.

**NOTE**

For macOS arm64, choose the [OpenShift v4.18 macOS arm64 Cliententry](#).

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
```

**Verification**

- Verify your installation by using an **oc** command:

```
$ oc <command>
```

### 2.1.10. Manually creating the installation configuration file

Installing the cluster requires that you manually create the installation configuration file.

**Prerequisites**

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

**Procedure**

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

```
$ mkdir <installation_directory>
```

**IMPORTANT**

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

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation\_directory>**.

**NOTE**

You must name this configuration file **install-config.yaml**.

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.

#### Additional resources

- [Installation configuration parameters for bare metal](#)

##### 2.1.10.1. Sample **install-config.yaml** file for bare metal

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

```
apiVersion: v1
baseDomain: example.com 1
compute: 2
- hyperthreading: Enabled 3
  name: worker
  replicas: 0 4
controlPlane: 5
  hyperthreading: Enabled 6
  name: master
  replicas: 3 7
metadata:
  name: test 8
networking:
  clusterNetwork:
    - cidr: 10.128.0.0/14 9
      hostPrefix: 23 10
  networkType: OVNKubernetes 11
  serviceNetwork:
    - 172.30.0.0/16
platform:
  none: {} 13
  fips: false 14
pullSecret: '{"auths": ...}' 15
sshKey: 'ssh-ed25519 AAAA...' 16
```

**1** The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.

**2** **5** The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. Only one control plane pool is used.

**3** **6** Specifies whether to enable or disable simultaneous multithreading (SMT), or hyperthreading. By default, SMT is enabled to increase the performance of the cores in your machines. You can disable it by setting the parameter value to **Disabled**. If you disable SMT, you must disable it in all cluster machines; this includes both control plane and compute machines.



## NOTE

Simultaneous multithreading (SMT) is enabled by default. If SMT is not enabled in your BIOS settings, the **hyperthreading** parameter has no effect.



## IMPORTANT

If you disable **hyperthreading**, whether in the BIOS or in the **install-config.yaml** file, ensure that your capacity planning accounts for the dramatically decreased machine performance.

- 4 You must set this value to **0** when you install OpenShift Container Platform on user-provisioned infrastructure. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. In user-provisioned installations, you must manually deploy the compute machines before you finish installing the cluster.



## NOTE

If you are installing a three-node cluster, do not deploy any compute machines when you install the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

- 7 The number of control plane machines that you add to the cluster. Because the cluster uses these values as the number of etcd endpoints in the cluster, the value must match the number of control plane machines that you deploy.
- 8 The cluster name that you specified in your DNS records.
- 9 A block of IP addresses from which pod IP addresses are allocated. This block must not overlap with existing physical networks. These IP addresses are used for the pod network. If you need to access the pods from an external network, you must configure load balancers and routers to manage the traffic.



## NOTE

Class E CIDR range is reserved for a future use. To use the Class E CIDR range, you must ensure your networking environment accepts the IP addresses within the Class E CIDR range.

- 10 The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23**, then each node is assigned a /**23** subnet out of the given **cidr**, which allows for 510 ( $2^{(32 - 23)} - 2$ ) pod IP addresses. If you are required to provide access to nodes from an external network, configure load balancers and routers to manage the traffic.
- 11 The cluster network plugin to install. The default value **OVNKubernetes** is the only supported value.
- 12 The IP address pool to use for service IP addresses. You can enter only one IP address pool. This block must not overlap with existing physical networks. If you need to access the services from an external network, configure load balancers and routers to manage the traffic.
- 13 You must set the platform to **none**. You cannot provide additional platform configuration variables for your platform.



## IMPORTANT

Clusters that are installed with the platform type **none** are unable to use some features, such as managing compute machines with the Machine API. This limitation applies even if the compute machines that are attached to the cluster are installed on a platform that would normally support the feature. This parameter cannot be changed after installation.

- 14 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.



## IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see [Switching RHEL to FIPS mode](#).

When running Red Hat Enterprise Linux (RHEL) or Red Hat Enterprise Linux CoreOS (RHCOS) booted in FIPS mode, OpenShift Container Platform core components use the RHEL cryptographic libraries that have been submitted to NIST for FIPS 140-2/140-3 Validation on only the x86\_64, ppc64le, and s390x architectures.

- 15 The [pull secret from Red Hat OpenShift Cluster Manager](#). This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.
- 16 The SSH public key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).



## NOTE

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

## Additional resources

- See [Load balancing requirements for user-provisioned infrastructure](#) for more information on the API and application ingress load balancing requirements.
- See [Cluster capabilities](#) for more information on enabling cluster capabilities that were disabled before installation.
- See [Optional cluster capabilities in OpenShift Container Platform 4.18](#) for more information about the features provided by each capability.

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

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



### NOTE

For bare metal installations, if you do not assign node IP addresses from the range that is specified in the **networking.machineNetwork[].cidr** field in the **install-config.yaml** file, you must include them in the **proxy.noProxy** field.

## Prerequisites

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



### NOTE

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

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

## Procedure

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

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> ①
  httpsProxy: https://<username>:<pswd>@<ip>:<port> ②
  noProxy: example.com ③
  additionalTrustBundle: | ④
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
additionalTrustBundlePolicy: <policy_to_add_additionalTrustBundle> ⑤
```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with **.** to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use **\*** to bypass the proxy for all

destinations.

- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace 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** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.
- 5 Optional: The policy to determine the configuration of the **Proxy** object to reference the **user-ca-bundle** config map in the **trustedCA** field. The allowed values are **Proxyonly** and **Always**. Use **Proxyonly** to reference the **user-ca-bundle** config map only when **http/https** proxy is configured. Use **Always** to always reference the **user-ca-bundle** config map. The default value is **Proxyonly**.



#### NOTE

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



#### NOTE

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

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.

### 2.1.10.3. Configuring a three-node cluster

Optionally, you can deploy zero compute machines in a bare metal cluster that consists of three control plane machines only. This provides smaller, more resource efficient clusters for cluster administrators and developers to use for testing, development, and production.

In three-node OpenShift Container Platform environments, the three control plane machines are schedulable, which means that your application workloads are scheduled to run on them.

#### Prerequisites

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

#### Procedure

- Ensure that the number of compute replicas is set to **0** in your **install-config.yaml** file, as shown in the following **compute** stanza:

```
compute:  
  - name: worker  
    platform: {}  
    replicas: 0
```



#### NOTE

You must set the value of the **replicas** parameter for the compute machines to **0** when you install OpenShift Container Platform on user-provisioned infrastructure, regardless of the number of compute machines you are deploying. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. This does not apply to user-provisioned installations, where the compute machines are deployed manually.

For three-node cluster installations, follow these next steps:

- If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes. See the *Load balancing requirements for user-provisioned infrastructure* section for more information.
- When you create the Kubernetes manifest files in the following procedure, ensure that the **mastersSchedulable** parameter in the **<installation\_directory>/manifests/cluster-scheduler-02-config.yaml** file is set to **true**. This enables your application workloads to run on the control plane nodes.
- Do not deploy any compute nodes when you create the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

### 2.1.11. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.



## IMPORTANT

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

## Prerequisites

- You obtained the OpenShift Container Platform installation program.
- You created the **install-config.yaml** installation configuration file.

## Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

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

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



### WARNING

If you are installing a three-node cluster, skip the following step to allow the control plane nodes to be schedulable.



## IMPORTANT

When you configure control plane nodes from the default unschedulable to schedulable, additional subscriptions are required. This is because control plane nodes then become compute nodes.

2. Check that the **mastersSchedulable** parameter in the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:
  - a. Open the **<installation\_directory>/manifests/cluster-scheduler-02-config.yml** file.

- b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.
  - c. Save and exit the file.
3. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

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

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

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the **./<installation\_directory>/auth** directory:



## Additional resources

- See [Recovering from expired control plane certificates](#) for more information about recovering kubelet certificates.

### 2.1.12. Installing RHCOS and starting the OpenShift Container Platform bootstrap process

To install OpenShift Container Platform on bare metal infrastructure that you provision, you must install Red Hat Enterprise Linux CoreOS (RHCOS) on the machines. When you install RHCOS, you must provide the Ignition config file that was generated by the OpenShift Container Platform installation program for the type of machine you are installing. If you have configured suitable networking, DNS, and load balancing infrastructure, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS machines have rebooted.

To install RHCOS on the machines, follow either the steps to use an ISO image or network PXE booting.



#### NOTE

The compute node deployment steps included in this installation document are RHCOS-specific. If you choose instead to deploy RHEL-based compute nodes, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Only RHEL 8 compute machines are supported.

You can configure RHCOS during ISO and PXE installations by using the following methods:

- Kernel arguments: You can use kernel arguments to provide installation-specific information. For example, you can specify the locations of the RHCOS installation files that you uploaded to

your HTTP server and the location of the Ignition config file for the type of node you are installing. For a PXE installation, you can use the **APPEND** parameter to pass the arguments to the kernel of the live installer. For an ISO installation, you can interrupt the live installation boot process to add the kernel arguments. In both installation cases, you can use special **coreos.inst.\*** arguments to direct the live installer, as well as standard installation boot arguments for turning standard kernel services on or off.

- Ignition configs: OpenShift Container Platform Ignition config files (**\*.ign**) are specific to the type of node you are installing. You pass the location of a bootstrap, control plane, or compute node Ignition config file during the RHCOS installation so that it takes effect on first boot. In special cases, you can create a separate, limited Ignition config to pass to the live system. That Ignition config could do a certain set of tasks, such as reporting success to a provisioning system after completing installation. This special Ignition config is consumed by the **coreos-installer** to be applied on first boot of the installed system. Do not provide the standard control plane and compute node Ignition configs to the live ISO directly.
- **coreos-installer**: You can boot the live ISO installer to a shell prompt, which allows you to prepare the permanent system in a variety of ways before first boot. In particular, you can run the **coreos-installer** command to identify various artifacts to include, work with disk partitions, and set up networking. In some cases, you can configure features on the live system and copy them to the installed system.

Whether to use an ISO or PXE install depends on your situation. A PXE install requires an available DHCP service and more preparation, but can make the installation process more automated. An ISO install is a more manual process and can be inconvenient if you are setting up more than a few machines.

### 2.1.12.1. Installing RHCOS by using an ISO image

You can use an ISO image to install RHCOS on the machines.

#### Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have an HTTP server that can be accessed from your computer, and from the machines that you create.
- You have reviewed the *Advanced RHCOS installation configuration* section for different ways to configure features, such as networking and disk partitioning.

#### Procedure

1. Obtain the SHA512 digest for each of your Ignition config files. For example, you can use the following on a system running Linux to get the SHA512 digest for your **bootstrap.ign** Ignition config file:

```
$ sha512sum <installation_directory>/bootstrap.ign
```

The digests are provided to the **coreos-installer** in a later step to validate the authenticity of the Ignition config files on the cluster nodes.

2. Upload the bootstrap, control plane, and compute node Ignition config files that the installation program created to your HTTP server. Note the URLs of these files.



## IMPORTANT

You can add or change configuration settings in your Ignition configs before saving them to your HTTP server. If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

- From the installation host, validate that the Ignition config files are available on the URLs. The following example gets the Ignition config file for the bootstrap node:

```
$ curl -k http://<HTTP_server>/bootstrap.ign ①
```

### Example output

```
% Total % Received % Xferd Average Speed Time Time Time Current
          Dload Upload Total Spent Left Speed
0 0 0 0 0 0 0 0 --:--:--:--:--:--:--:-- 0{"ignition": {"version": "3.2.0"}, "passwd": {"users": [{"name": "core", "sshAuthorizedKeys": ["ssh-rsa..."]}}
```

Replace **bootstrap.ign** with **master.ign** or **worker.ign** in the command to validate that the Ignition config files for the control plane and compute nodes are also available.

- Although it is possible to obtain the RHCOS images that are required for your preferred method of installing operating system instances from the [RHCOS image mirror](#) page, the recommended way to obtain the correct version of your RHCOS images are from the output of **openshift-install** command:

```
$ openshift-install coreos print-stream-json | grep "\.iso[^.]"
```

### Example output

```
"location": "<url>/art/storage/releases/rhcos-4.18-aarch64/<release>/aarch64/rhcos-<release>-live.aarch64.iso",
"location": "<url>/art/storage/releases/rhcos-4.18-ppc64le/<release>/ppc64le/rhcos-<release>-live.ppc64le.iso",
"location": "<url>/art/storage/releases/rhcos-4.18-s390x/<release>/s390x/rhcos-<release>-live.s390x.iso",
"location": "<url>/art/storage/releases/rhcos-4.18/<release>/x86_64/rhcos-<release>-live.x86_64.iso",
```



## IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image versions that match your OpenShift Container Platform version if they are available. Use only ISO images for this procedure. RHCOS qcow2 images are not supported for this installation type.

ISO file names resemble the following example:

**rhcos-<version>-live.<architecture>.iso**

- Use the ISO to start the RHCOS installation. Use one of the following installation options:

- Burn the ISO image to a disk and boot it directly.
  - Use ISO redirection by using a lights-out management (LOM) interface.
6. Boot the RHCOS ISO image without specifying any options or interrupting the live boot sequence. Wait for the installer to boot into a shell prompt in the RHCOS live environment.



### NOTE

It is possible to interrupt the RHCOS installation boot process to add kernel arguments. However, for this ISO procedure you should use the **coreos-installer** command as outlined in the following steps, instead of adding kernel arguments.

7. Run the **coreos-installer** command and specify the options that meet your installation requirements. At a minimum, you must specify the URL that points to the Ignition config file for the node type, and the device that you are installing to:

```
$ sudo coreos-installer install --ignition-url=http://<HTTP_server>/<node_type>.ign <device>
\ ①
--ignition-hash=sha512-<digest> ②
```

**1** You must run the **coreos-installer** command by using **sudo**, because the **core** user does not have the required root privileges to perform the installation.

**2** The **--ignition-hash** option is required when the Ignition config file is obtained through an HTTP URL to validate the authenticity of the Ignition config file on the cluster node. **<digest>** is the Ignition config file SHA512 digest obtained in a preceding step.



### NOTE

If you want to provide your Ignition config files through an HTTPS server that uses TLS, you can add the internal certificate authority (CA) to the system trust store before running **coreos-installer**.

The following example initializes a bootstrap node installation to the **/dev/sda** device. The Ignition config file for the bootstrap node is obtained from an HTTP web server with the IP address 192.168.1.2:

```
$ sudo coreos-installer install --ignition-
url=http://192.168.1.2:80/installation_directory/bootstrap.ign /dev/sda \
--ignition-hash=sha512-
a5a2d43879223273c9b60af66b44202a1d1248fc01cf156c46d4a79f552b6bad47bc8cc78ddf011
6e80c59d2ea9e32ba53bc807afbc581aa059311def2c3e3b
```

8. Monitor the progress of the RHCOS installation on the console of the machine.



### IMPORTANT

Be sure that the installation is successful on each node before commencing with the OpenShift Container Platform installation. Observing the installation process can also help to determine the cause of RHCOS installation issues that might arise.

9. After RHCOS installs, you must reboot the system. During the system reboot, it applies the Ignition config file that you specified.
10. Check the console output to verify that Ignition ran.

### Example command

```
Ignition: ran on 2022/03/14 14:48:33 UTC (this boot)  
Ignition: user-provided config was applied
```

11. Continue to create the other machines for your cluster.



### IMPORTANT

You must create the bootstrap and control plane machines at this time. If the control plane machines are not made schedulable, also create at least two compute machines before you install OpenShift Container Platform.

If the required network, DNS, and load balancer infrastructure are in place, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS nodes have rebooted.



### NOTE

RHCOS nodes do not include a default password for the **core** user. You can access the nodes by running **ssh core@<node>. <cluster\_name>**.

**<base\_domain>** as a user with access to the SSH private key that is paired to the public key that you specified in your **install\_config.yaml** file. OpenShift Container Platform 4 cluster nodes running RHCOS are immutable and rely on Operators to apply cluster changes. Accessing cluster nodes by using SSH is not recommended. However, when investigating installation issues, if the OpenShift Container Platform API is not available, or the kubelet is not properly functioning on a target node, SSH access might be required for debugging or disaster recovery.

#### 2.1.12.2. Installing RHCOS by using PXE or iPXE booting

You can use PXE or iPXE booting to install RHCOS on the machines.

##### Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have configured suitable PXE or iPXE infrastructure.
- You have an HTTP server that can be accessed from your computer, and from the machines that you create.
- You have reviewed the *Advanced RHCOS installation configuration* section for different ways to configure features, such as networking and disk partitioning.

##### Procedure

1. Upload the bootstrap, control plane, and compute node Ignition config files that the installation program created to your HTTP server. Note the URLs of these files.



## IMPORTANT

You can add or change configuration settings in your Ignition configs before saving them to your HTTP server. If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

2. From the installation host, validate that the Ignition config files are available on the URLs. The following example gets the Ignition config file for the bootstrap node:

```
$ curl -k http://<HTTP_server>/bootstrap.ign ①
```

### Example output

```
% Total % Received % Xferd Average Speed Time Time Time Current
          Dload Upload Total Spent Left Speed
0 0 0 0 0 0 0 --:--:--:--:--:-- 0{"ignition": {"version": "3.2.0"}, "passwd": {"users": [{"name": "core", "sshAuthorizedKeys": ["ssh-rsa..."]}}
```

Replace **bootstrap.ign** with **master.ign** or **worker.ign** in the command to validate that the Ignition config files for the control plane and compute nodes are also available.

3. Although it is possible to obtain the RHCOS **kernel**, **initramfs** and **rootfs** files that are required for your preferred method of installing operating system instances from the [RHCOS image mirror](#) page, the recommended way to obtain the correct version of your RHCOS files are from the output of **openshift-install** command:

```
$ openshift-install coreos print-stream-json | grep -Eo "'https.*(kernel|initramfs|rootfs.)\w+\.img'?"
```

### Example output

```
"<url>/art/storage/releases/rhcos-4.18-aarch64/<release>/aarch64/rhcos-<release>-live-kernel-aarch64"
"<url>/art/storage/releases/rhcos-4.18-aarch64/<release>/aarch64/rhcos-<release>-live-initramfs.aarch64.img"
"<url>/art/storage/releases/rhcos-4.18-aarch64/<release>/aarch64/rhcos-<release>-live-rootfs.aarch64.img"
"<url>/art/storage/releases/rhcos-4.18-ppc64le/49.84.202110081256-0/ppc64le/rhcos-<release>-live-kernel-ppc64le"
"<url>/art/storage/releases/rhcos-4.18-ppc64le/<release>/ppc64le/rhcos-<release>-live-initramfs.ppc64le.img"
"<url>/art/storage/releases/rhcos-4.18-ppc64le/<release>/ppc64le/rhcos-<release>-live-rootfs.ppc64le.img"
"<url>/art/storage/releases/rhcos-4.18-s390x/<release>/s390x/rhcos-<release>-live-kernel-s390x"
"<url>/art/storage/releases/rhcos-4.18-s390x/<release>/s390x/rhcos-<release>-live-initramfs.s390x.img"
"<url>/art/storage/releases/rhcos-4.18-s390x/<release>/s390x/rhcos-<release>-live-rootfs.s390x.img"
"<url>/art/storage/releases/rhcos-4.18/<release>/x86_64/rhcos-<release>-live-kernel-
```

```
x86_64"
"<url>/art/storage/releases/rhcos-4.18/<release>/x86_64/rhcos-<release>-live-
initramfs.x86_64.img"
"<url>/art/storage/releases/rhcos-4.18/<release>/x86_64/rhcos-<release>-live-
rootfs.x86_64.img"
```



### IMPORTANT

The RHCOS artifacts might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Only use the appropriate **kernel**, **initramfs**, and **rootfs** artifacts described below for this procedure. RHCOS QCOW2 images are not supported for this installation type.

The file names contain the OpenShift Container Platform version number. They resemble the following examples:

- **kernel: rhcos-<version>-live-kernel-<architecture>**
- **initramfs: rhcos-<version>-live-initramfs.<architecture>.img**
- **rootfs: rhcos-<version>-live-rootfs.<architecture>.img**

4. Upload the **rootfs**, **kernel**, and **initramfs** files to your HTTP server.



### IMPORTANT

If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

5. Configure the network boot infrastructure so that the machines boot from their local disks after RHCOS is installed on them.
6. Configure PXE or iPXE installation for the RHCOS images and begin the installation. Modify one of the following example menu entries for your environment and verify that the image and Ignition files are properly accessible:

- For PXE (**x86\_64**):

```
DEFAULT pxeboot
TIMEOUT 20
PROMPT 0
LABEL pxeboot
  KERNEL http://<HTTP_server>/rhcos-<version>-live-kernel-<architecture> ①
  APPEND initrd=http://<HTTP_server>/rhcos-<version>-live-initramfs.
<architecture>.img coreos.live.rootfs_url=http://<HTTP_server>/rhcos-<version>-live-
rootfs.<architecture>.img coreos.inst.install_dev=/dev/sda
coreos.inst.ignition_url=http://<HTTP_server>/bootstrap.ign ② ③
```

① ① Specify the location of the live **kernel** file that you uploaded to your HTTP server. The URL must be HTTP, TFTP, or FTP; HTTPS and NFS are not supported.

② ② If you use multiple NICs, specify a single interface in the **ip** option. For example, to use DHCP on a NIC that is named `enp1` set `ip=enp1-dhcp`.

DHIC: ORGANIC THAT IS NAMED ENO1, SET IP=ENO1:DHCPC.

- 3 Specify the locations of the RHCOS files that you uploaded to your HTTP server. The **initrd** parameter value is the location of the **initramfs** file, the **coreos.live.rootfs\_url** parameter value is the location of the **rootfs** file, and the **coreos.inst.ignition\_url** parameter value is the location of the bootstrap Ignition config file. You can also add more kernel arguments to the **APPEND** line to configure networking or other boot options.



### NOTE

This configuration does not enable serial console access on machines with a graphical console. To configure a different console, add one or more **console=** arguments to the **APPEND** line. For example, add **console=tty0** **console=ttyS0** to set the first PC serial port as the primary console and the graphical console as a secondary console. For more information, see [How does one set up a serial terminal and/or console in Red Hat Enterprise Linux?](#) and "Enabling the serial console for PXE and ISO installation" in the "Advanced RHCOS installation configuration" section.

- For iPXE (**x86\_64 + aarch64**):

```
kernel http://<HTTP_server>/rhcos-<version>-live-kernel-<architecture> initrd=main
coreos.live.rootfs_url=http://<HTTP_server>/rhcos-<version>-live-rootfs.
<architecture>.img coreos.inst.install_dev=/dev/sda
coreos.inst.ignition_url=http://<HTTP_server>/bootstrap.ign ① ②
initrd --name main http://<HTTP_server>/rhcos-<version>-live-initramfs.
<architecture>.img ③
boot
```

- 1 Specify the locations of the RHCOS files that you uploaded to your HTTP server. The **kernel** parameter value is the location of the **kernel** file, the **initrd=main** argument is needed for booting on UEFI systems, the **coreos.live.rootfs\_url** parameter value is the location of the **rootfs** file, and the **coreos.inst.ignition\_url** parameter value is the location of the bootstrap Ignition config file.
- 2 If you use multiple NICs, specify a single interface in the **ip** option. For example, to use DHCP on a NIC that is named **eno1**, set **ip=eno1:dhcp**.
- 3 Specify the location of the **initramfs** file that you uploaded to your HTTP server.



### NOTE

This configuration does not enable serial console access on machines with a graphical console. To configure a different console, add one or more **console=** arguments to the **kernel** line. For example, add **console=tty0** **console=ttyS0** to set the first PC serial port as the primary console and the graphical console as a secondary console. For more information, see [How does one set up a serial terminal and/or console in Red Hat Enterprise Linux?](#) and "Enabling the serial console for PXE and ISO installation" in the "Advanced RHCOS installation configuration" section.



## NOTE

To network boot the CoreOS **kernel** on **aarch64** architecture, you need to use a version of iPXE build with the **IMAGE\_GZIP** option enabled. See [IMAGE\\_GZIP option in iPXE](#).

- For PXE (with UEFI and Grub as second stage) on **aarch64**:

```
menuentry 'Install CoreOS' {
    linux rhcos-<version>-live-kernel-<architecture>
    coreos.live.rootfs_url=http://<HTTP_server>/rhcos-<version>-live-rootfs.
    <architecture>.img coreos.inst.install_dev=/dev/sda
    coreos.inst.ignition_url=http://<HTTP_server>/bootstrap.ign ① ②
    initrd rhcos-<version>-live-initramfs.<architecture>.img ③
}
```

- Specify the locations of the RHCOS files that you uploaded to your HTTP/TFTP server. The **kernel** parameter value is the location of the **kernel** file on your TFTP server. The **coreos.live.rootfs\_url** parameter value is the location of the **rootfs** file, and the **coreos.inst.ignition\_url** parameter value is the location of the bootstrap Ignition config file on your HTTP Server.
- If you use multiple NICs, specify a single interface in the **ip** option. For example, to use DHCP on a NIC that is named **eno1**, set **ip=eno1:dhcp**.
- Specify the location of the **initramfs** file that you uploaded to your TFTP server.

- Monitor the progress of the RHCOS installation on the console of the machine.



## IMPORTANT

Be sure that the installation is successful on each node before commencing with the OpenShift Container Platform installation. Observing the installation process can also help to determine the cause of RHCOS installation issues that might arise.

- After RHCOS installs, the system reboots. During reboot, the system applies the Ignition config file that you specified.
- Check the console output to verify that Ignition ran.

### Example command

```
Ignition: ran on 2022/03/14 14:48:33 UTC (this boot)
Ignition: user-provided config was applied
```

- Continue to create the machines for your cluster.



## IMPORTANT

You must create the bootstrap and control plane machines at this time. If the control plane machines are not made schedulable, also create at least two compute machines before you install the cluster.

If the required network, DNS, and load balancer infrastructure are in place, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS nodes have rebooted.



### NOTE

RHCOS nodes do not include a default password for the **core** user. You can access the nodes by running `ssh core@<node>.<cluster_name>`.

<**base\_domain**> as a user with access to the SSH private key that is paired to the public key that you specified in your **install\_config.yaml** file. OpenShift Container Platform 4 cluster nodes running RHCOS are immutable and rely on Operators to apply cluster changes. Accessing cluster nodes by using SSH is not recommended. However, when investigating installation issues, if the OpenShift Container Platform API is not available, or the kubelet is not properly functioning on a target node, SSH access might be required for debugging or disaster recovery.

#### 2.1.12.3. Advanced RHCOS installation configuration

A key benefit for manually provisioning the Red Hat Enterprise Linux CoreOS (RHCOS) nodes for OpenShift Container Platform is to be able to do configuration that is not available through default OpenShift Container Platform installation methods. This section describes some of the configurations that you can do using techniques that include:

- Passing kernel arguments to the live installer
- Running **coreos-installer** manually from the live system
- Customizing a live ISO or PXE boot image

The advanced configuration topics for manual Red Hat Enterprise Linux CoreOS (RHCOS) installations detailed in this section relate to disk partitioning, networking, and using Ignition configs in different ways.

##### 2.1.12.3.1. Using advanced networking options for PXE and ISO installations

Networking for OpenShift Container Platform nodes uses DHCP by default to gather all necessary configuration settings. To set up static IP addresses or configure special settings, such as bonding, you can do one of the following:

- Pass special kernel parameters when you boot the live installer.
- Use a machine config to copy networking files to the installed system.
- Configure networking from a live installer shell prompt, then copy those settings to the installed system so that they take effect when the installed system first boots.

To configure a PXE or iPXE installation, use one of the following options:

- See the "Advanced RHCOS installation reference" tables.
- Use a machine config to copy networking files to the installed system.

To configure an ISO installation, use the following procedure.

#### Procedure

1. Boot the ISO installer.
2. From the live system shell prompt, configure networking for the live system using available RHEL tools, such as **nmcli** or **nmtui**.
3. Run the **coreos-installer** command to install the system, adding the **--copy-network** option to copy networking configuration. For example:

```
$ sudo coreos-installer install --copy-network \
--ignition-url=http://host/worker.ign /dev/disk/by-id/scsi-<serial_number>
```



#### IMPORTANT

The **--copy-network** option only copies networking configuration found under **/etc/NetworkManager/system-connections**. In particular, it does not copy the system hostname.

4. Reboot into the installed system.

### Additional resources

- See [Getting started with nmcli](#) and [Getting started with nmtui](#) in the RHEL 8 documentation for more information about the **nmcli** and **nmtui** tools.

#### 2.1.12.3.2. Disk partitioning

Disk partitions are created on OpenShift Container Platform cluster nodes during the Red Hat Enterprise Linux CoreOS (RHCOS) installation. Each RHCOS node of a particular architecture uses the same partition layout, unless you override the default partitioning configuration. During the RHCOS installation, the size of the root file system is increased to use any remaining available space on the target device.



#### IMPORTANT

The use of a custom partition scheme on your node might result in OpenShift Container Platform not monitoring or alerting on some node partitions. If you override the default partitioning, see [Understanding OpenShift File System Monitoring \(eviction conditions\)](#) for more information about how OpenShift Container Platform monitors your host file systems.

OpenShift Container Platform monitors the following two filesystem identifiers:

- **nodefs**, which is the filesystem that contains **/var/lib/kubelet**
- **imagefs**, which is the filesystem that contains **/var/lib/containers**

For the default partition scheme, **nodefs** and **imagefs** monitor the same root filesystem, **/**.

To override the default partitioning when installing RHCOS on an OpenShift Container Platform cluster node, you must create separate partitions. Consider a situation where you want to add a separate storage partition for your containers and container images. For example, by mounting **/var/lib/containers** in a separate partition, the kubelet separately monitors **/var/lib/containers** as the **imagefs** directory and the root file system as the **nodefs** directory.



## IMPORTANT

If you have resized your disk size to host a larger file system, consider creating a separate **/var/lib/containers** partition. Consider resizing a disk that has an **xfs** format to reduce CPU time issues caused by a high number of allocation groups.

### 2.1.12.3.2.1. Creating a separate /var partition

In general, you should use the default disk partitioning that is created during the RHCOS installation. However, there are cases where you might want to create a separate partition for a directory that you expect to grow.

OpenShift Container Platform supports the addition of a single partition to attach storage to either the **/var** directory or a subdirectory of **/var**. For example:

- **/var/lib/containers**: Holds container-related content that can grow as more images and containers are added to a system.
- **/var/lib/etcd**: Holds data that you might want to keep separate for purposes such as performance optimization of etcd storage.
- **/var**: Holds data that you might want to keep separate for purposes such as auditing.



## IMPORTANT

For disk sizes larger than 100GB, and especially larger than 1TB, create a separate **/var** partition.

Storing the contents of a **/var** directory separately makes it easier to grow storage for those areas as needed and reinstall OpenShift Container Platform at a later date and keep that data intact. With this method, you will not have to pull all your containers again, nor will you have to copy massive log files when you update systems.

The use of a separate partition for the **/var** directory or a subdirectory of **/var** also prevents data growth in the partitioned directory from filling up the root file system.

The following procedure sets up a separate **/var** partition by adding a machine config manifest that is wrapped into the Ignition config file for a node type during the preparation phase of an installation.

## Procedure

1. On your installation host, change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

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

2. Create a Butane config that configures the additional partition. For example, name the file **\$HOME/clusterconfig/98-var-partition.bu**, change the disk device name to the name of the storage device on the **worker** systems, and set the storage size as appropriate. This example places the **/var** directory on a separate partition:

```
variant: openshift
version: 4.18.0
metadata:
  labels:
```

```

machineconfiguration.openshift.io/role: worker
name: 98-var-partition
storage:
disks:
- device: /dev/disk/by-id/<device_name> ①
partitions:
- label: var
  start_mib: <partition_start_offset> ②
  size_mib: <partition_size> ③
  number: 5
filesystems:
- device: /dev/disk/by-partlabel/var
  path: /var
  format: xfs
  mount_options: [defaults, prjquota] ④
  with_mount_unit: true

```

- ① The storage device name of the disk that you want to partition.
- ② When adding a data partition to the boot disk, a minimum offset value of 25000 mebibytes is recommended. The root file system is automatically resized to fill all available space up to the specified offset. If no offset value is specified, or if the specified value is smaller than the recommended minimum, the resulting root file system will be too small, and future reinstalls of RHCOS might overwrite the beginning of the data partition.
- ③ The size of the data partition in mebibytes.
- ④ The **prjquota** mount option must be enabled for filesystems used for container storage.



#### NOTE

When creating a separate **/var** partition, you cannot use different instance types for compute nodes, if the different instance types do not have the same device name.

3. Create a manifest from the Butane config and save it to the **clusterconfig/openshift** directory. For example, run the following command:

```
$ butane $HOME/clusterconfig/98-var-partition.bu -o $HOME/clusterconfig/openshift/98-var-partition.yaml
```

4. Create the Ignition config files:

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

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

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory:

```

.
└── auth

```



The files in the `<installation_directory>/manifest` and `<installation_directory>/openshift` directories are wrapped into the Ignition config files, including the file that contains the **98-var-partition** custom **MachineConfig** object.

## Next steps

- You can apply the custom disk partitioning by referencing the Ignition config files during the RHCOS installations.

### 2.1.12.3.2.2. Retaining existing partitions

For an ISO installation, you can add options to the **coreos-installer** command that cause the installer to maintain one or more existing partitions. For a PXE installation, you can add **coreos.inst.\*** options to the **APPEND** parameter to preserve partitions.

Saved partitions might be data partitions from an existing OpenShift Container Platform system. You can identify the disk partitions you want to keep either by partition label or by number.



#### NOTE

If you save existing partitions, and those partitions do not leave enough space for RHCOS, the installation will fail without damaging the saved partitions.

### Retaining existing partitions during an ISO installation

This example preserves any partition in which the partition label begins with **data (data\*)**:

```
# coreos-installer install --ignition-url http://10.0.2.2:8080/user.ign \
--save-partlabel 'data*' \
/dev/disk/by-id/scsi-<serial_number>
```

The following example illustrates running the **coreos-installer** in a way that preserves the sixth (6) partition on the disk:

```
# coreos-installer install --ignition-url http://10.0.2.2:8080/user.ign \
--save-partindex 6 /dev/disk/by-id/scsi-<serial_number>
```

This example preserves partitions 5 and higher:

```
# coreos-installer install --ignition-url http://10.0.2.2:8080/user.ign \
--save-partindex 5- /dev/disk/by-id/scsi-<serial_number>
```

In the previous examples where partition saving is used, **coreos-installer** recreates the partition immediately.

### Retaining existing partitions during a PXE installation

This **APPEND** option preserves any partition in which the partition label begins with 'data' ('data\*'):

```
coreos.inst.save_partlabel=data*
```

This **APPEND** option preserves partitions 5 and higher:

```
coreos.inst.save_partindex=5-
```

This **APPEND** option preserves partition 6:

```
coreos.inst.save_partindex=6
```

#### 2.1.12.3.3. Identifying Ignition configs

When doing an RHCOS manual installation, there are two types of Ignition configs that you can provide, with different reasons for providing each one:

- **Permanent install Ignition config:** Every manual RHCOS installation needs to pass one of the Ignition config files generated by **openshift-installer**, such as **bootstrap.ign**, **master.ign** and **worker.ign**, to carry out the installation.



#### IMPORTANT

It is not recommended to modify these Ignition config files directly. You can update the manifest files that are wrapped into the Ignition config files, as outlined in examples in the preceding sections.

For PXE installations, you pass the Ignition configs on the **APPEND** line using the **coreos.inst.ignition\_url** option. For ISO installations, after the ISO boots to the shell prompt, you identify the Ignition config on the **coreos-installer** command line with the **--ignition-url** option. In both cases, only HTTP and HTTPS protocols are supported.

- **Live install Ignition config:** This type can be created by using the **coreos-installer customize** subcommand and its various options. With this method, the Ignition config passes to the live install medium, runs immediately upon booting, and performs setup tasks before or after the RHCOS system installs to disk. This method should only be used for performing tasks that must be done once and not applied again later, such as with advanced partitioning that cannot be done using a machine config.  
For PXE or ISO boots, you can create the Ignition config and **APPEND** the **ignition.config.url** option to identify the location of the Ignition config. You also need to append **ignition.firstboot ignition.platform.id=metal** or the **ignition.config.url** option will be ignored.

#### 2.1.12.3.4. Default console configuration

Red Hat Enterprise Linux CoreOS (RHCOS) nodes installed from an OpenShift Container Platform 4.18 boot image use a default console that is meant to accommodate most virtualized and bare metal setups. Different cloud and virtualization platforms may use different default settings depending on the chosen architecture. Bare metal installations use the kernel default settings which typically means the graphical console is the primary console and the serial console is disabled.

The default consoles may not match your specific hardware configuration or you might have specific needs that require you to adjust the default console. For example:

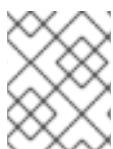
- You want to access the emergency shell on the console for debugging purposes.

- Your cloud platform does not provide interactive access to the graphical console, but provides a serial console.
- You want to enable multiple consoles.

Console configuration is inherited from the boot image. This means that new nodes in existing clusters are unaffected by changes to the default console.

You can configure the console for bare metal installations in the following ways:

- Using **coreos-installer** manually on the command line.
- Using the **coreos-installer iso customize** or **coreos-installer pxe customize** subcommands with the **--dest-console** option to create a custom image that automates the process.



#### NOTE

For advanced customization, perform console configuration using the **coreos-installer iso** or **coreos-installer pxe** subcommands, and not kernel arguments.

##### 2.1.12.3.5. Enabling the serial console for PXE and ISO installations

By default, the Red Hat Enterprise Linux CoreOS (RHCOS) serial console is disabled and all output is written to the graphical console. You can enable the serial console for an ISO installation and reconfigure the bootloader so that output is sent to both the serial console and the graphical console.

#### Procedure

1. Boot the ISO installer.
2. Run the **coreos-installer** command to install the system, adding the **--console** option once to specify the graphical console, and a second time to specify the serial console:

```
$ coreos-installer install \
--console=tty0 \①
--console=ttyS0,<options> \②
--ignition-url=http://host/worker.ign /dev/disk/by-id/scsi-<serial_number>
```

- 1 The desired secondary console. In this case, the graphical console. Omitting this option will disable the graphical console.
- 2 The desired primary console. In this case the serial console. The **options** field defines the baud rate and other settings. A common value for this field is **11520n8**. If no options are provided, the default kernel value of **9600n8** is used. For more information on the format of this option, see [Linux kernel serial console](#) documentation.

3. Reboot into the installed system.



#### NOTE

A similar outcome can be obtained by using the **coreos-installer install --append-karg** option, and specifying the console with **console=**. However, this will only set the console for the kernel and not the bootloader.

To configure a PXE installation, make sure the **coreos.inst.install\_dev** kernel command-line option is omitted, and use the shell prompt to run **coreos-installer** manually using the above ISO installation procedure.

#### 2.1.12.3.6. Customizing a live RHCOS ISO or PXE install

You can use the live ISO image or PXE environment to install RHCOS by injecting an Ignition config file directly into the image. This creates a customized image that you can use to provision your system.

For an ISO image, the mechanism to do this is the **coreos-installer iso customize** subcommand, which modifies the **.iso** file with your configuration. Similarly, the mechanism for a PXE environment is the **coreos-installer pxe customize** subcommand, which creates a new **initramfs** file that includes your customizations.

The **customize** subcommand is a general purpose tool that can embed other types of customizations as well. The following tasks are examples of some of the more common customizations:

- Inject custom CA certificates for when corporate security policy requires their use.
- Configure network settings without the need for kernel arguments.
- Embed arbitrary preinstall and post-install scripts or binaries.

#### 2.1.12.3.7. Customizing a live RHCOS ISO image

You can customize a live RHCOS ISO image directly with the **coreos-installer iso customize** subcommand. When you boot the ISO image, the customizations are applied automatically.

You can use this feature to configure the ISO image to automatically install RHCOS.

#### Procedure

1. Download the **coreos-installer** binary from the [coreos-installer image mirror](#) page.
2. Retrieve the RHCOS ISO image from the [RHCOS image mirror](#) page and the Ignition config file, and then run the following command to inject the Ignition config directly into the ISO image:

```
$ coreos-installer iso customize rhcos-<version>-live.x86_64.iso \
--dest-ignition bootstrap.ign \ ①
--dest-device /dev/disk/by-id/scsi-<serial_number> ②
```

- 1 The Ignition config file that is generated from the **openshift-installer** installation program.
- 2 When you specify this option, the ISO image automatically runs an installation. Otherwise, the image remains configured for installation, but does not install automatically unless you specify the **coreos.inst.install\_dev** kernel argument.

3. Optional: To remove the ISO image customizations and return the image to its pristine state, run:

```
$ coreos-installer iso reset rhcos-<version>-live.x86_64.iso
```

You can now re-customize the live ISO image or use it in its pristine state.

Applying your customizations affects every subsequent boot of RHCOS.

#### 2.1.12.3.7.1. Modifying a live install ISO image to enable the serial console

On clusters installed with OpenShift Container Platform 4.12 and above, the serial console is disabled by default and all output is written to the graphical console. You can enable the serial console with the following procedure.

#### Procedure

- 1 Download the **coreos-installer** binary from the [coreos-installer image mirror](#) page.
- 2 Retrieve the RHCOS ISO image from the [RHCOS image mirror](#) page and run the following command to customize the ISO image to enable the serial console to receive output:

```
$ coreos-installer iso customize rhcos-<version>-live.x86_64.iso \
--dest-ignition <path> \ ①
--dest-console tty0 \ ②
--dest-console ttyS0,<options> \ ③
--dest-device /dev/disk/by-id/scsi-<serial_number> \ ④
```

- ① The location of the Ignition config to install.
- ② The desired secondary console. In this case, the graphical console. Omitting this option will disable the graphical console.
- ③ The desired primary console. In this case, the serial console. The **options** field defines the baud rate and other settings. A common value for this field is **115200n8**. If no options are provided, the default kernel value of **9600n8** is used. For more information on the format of this option, see the [Linux kernel serial console](#) documentation.
- ④ The specified disk to install to. If you omit this option, the ISO image automatically runs the installation program which will fail unless you also specify the **coreos.inst.install\_dev** kernel argument.



#### NOTE

The **--dest-console** option affects the installed system and not the live ISO system. To modify the console for a live ISO system, use the **--live-karg-append** option and specify the console with **console=**.

Your customizations are applied and affect every subsequent boot of the ISO image.

- 3 Optional: To remove the ISO image customizations and return the image to its original state, run the following command:

```
$ coreos-installer iso reset rhcos-<version>-live.x86_64.iso
```

You can now recustomize the live ISO image or use it in its original state.

#### 2.1.12.3.7.2. Modifying a live install ISO image to use a custom certificate authority

You can provide certificate authority (CA) certificates to Ignition with the **--ignition-ca** flag of the **customize** subcommand. You can use the CA certificates during both the installation boot and when provisioning the installed system.



### NOTE

Custom CA certificates affect how Ignition fetches remote resources but they do not affect the certificates installed onto the system.

### Procedure

1. Download the **coreos-installer** binary from the [coreos-installer image mirror](#) page.
2. Retrieve the RHCOS ISO image from the [RHCOS image mirror](#) page and run the following command to customize the ISO image for use with a custom CA:

```
$ coreos-installer iso customize rhcos-<version>-live.x86_64.iso --ignition-ca cert.pem
```



### IMPORTANT

The **coreos.inst.ignition\_url** kernel parameter does not work with the **--ignition-ca** flag. You must use the **--dest-ignition** flag to create a customized image for each cluster.

Applying your custom CA certificate affects every subsequent boot of RHCOS.

#### 2.1.12.3.7.3. Modifying a live install ISO image with customized network settings

You can embed a NetworkManager keyfile into the live ISO image and pass it through to the installed system with the **--network-keyfile** flag of the **customize** subcommand.



### WARNING

When creating a connection profile, you must use a **.nmconnection** filename extension in the filename of the connection profile. If you do not use a **.nmconnection** filename extension, the cluster will apply the connection profile to the live environment, but it will not apply the configuration when the cluster first boots up the nodes, resulting in a setup that does not work.

### Procedure

1. Download the **coreos-installer** binary from the [coreos-installer image mirror](#) page.
2. Create a connection profile for a bonded interface. For example, create the **bond0.nmconnection** file in your local directory with the following content:

```
[connection]
id=bond0
type=bond
interface-name=bond0
```

```

multi-connect=1

[bond]
miimon=100
mode=active-backup

[ipv4]
method=auto

[ipv6]
method=auto

```

3. Create a connection profile for a secondary interface to add to the bond. For example, create the **bond0-proxy-em1.nmconnection** file in your local directory with the following content:

```

[connection]
id=em1
type=ethernet
interface-name=em1
master=bond0
multi-connect=1
slave-type=bond

```

4. Create a connection profile for a secondary interface to add to the bond. For example, create the **bond0-proxy-em2.nmconnection** file in your local directory with the following content:

```

[connection]
id=em2
type=ethernet
interface-name=em2
master=bond0
multi-connect=1
slave-type=bond

```

5. Retrieve the RHCOS ISO image from the [RHCOS image mirror](#) page and run the following command to customize the ISO image with your configured networking:

```

$ coreos-installer iso customize rhcos-<version>-live.x86_64.iso \
--network-keyfile bond0.nmconnection \
--network-keyfile bond0-proxy-em1.nmconnection \
--network-keyfile bond0-proxy-em2.nmconnection

```

Network settings are applied to the live system and are carried over to the destination system.

#### 2.1.12.3.7.4. Customizing a live install ISO image for an iSCSI boot device

You can set the iSCSI target and initiator values for automatic mounting, booting and configuration using a customized version of the live RHCOS image.

##### Prerequisites

1. You have an iSCSI target you want to install RHCOS on.

##### Procedure

1. Download the **coreos-installer** binary from the [coreos-installer image mirror](#) page.
2. Retrieve the RHCOS ISO image from the [RHCOS image mirror](#) page and run the following command to customize the ISO image with the following information:

```
$ coreos-installer iso customize \
--pre-install mount-iscsi.sh \ ①
--post-install unmount-iscsi.sh \ ②
--dest-device /dev/disk/by-path/<IP_address>:<port>-iscsi-<target_iqn>-lun-<lun> \ ③
--dest-ignition config.ign \ ④
--dest-karg-append rd.iscsi.initiator=<initiator_iqn> \ ⑤
--dest-karg-append netroot=<target_iqn> \ ⑥
-o custom.iso rhcos-<version>-live.x86_64.iso
```

- 1 The script that gets run before installation. It should contain the **iscsiadm** commands for mounting the iSCSI target and any commands enabling multipathing.
- 2 The script that gets run after installation. It should contain the command **iscsiadm --mode node --logout=all**.
- 3 The location of the destination system. You must provide the IP address of the target portal, the associated port number, the target iSCSI node in IQN format, and the iSCSI logical unit number (LUN).
- 4 The Ignition configuration for the destination system.
- 5 The iSCSI initiator, or client, name in IQN format. The initiator forms a session to connect to the iSCSI target.
- 6 The the iSCSI target, or server, name in IQN format.

For more information about the iSCSI options supported by **dracut**, see the [dracut.cmdline manual page](#).

#### 2.1.12.3.7.5. Customizing a live install ISO image for an iSCSI boot device with iBFT

You can set the iSCSI target and initiator values for automatic mounting, booting and configuration using a customized version of the live RHCOS image.

##### Prerequisites

1. You have an iSCSI target you want to install RHCOS on.
2. Optional: you have multipathed your iSCSI target.

##### Procedure

1. Download the **coreos-installer** binary from the [coreos-installer image mirror](#) page.
2. Retrieve the RHCOS ISO image from the [RHCOS image mirror](#) page and run the following command to customize the ISO image with the following information:

```
$ coreos-installer iso customize \
--pre-install mount-iscsi.sh \ ①
```

```
--post-install unmount-iscsi.sh \ ②
--dest-device /dev/mapper/mpatha \ ③
--dest-ignition config.ign \ ④
--dest-karg-append rd.iscsi.firmware=1 \ ⑤
--dest-karg-append rd.multipath=default \ ⑥
-o custom.iso rhcos-<version>-live.x86_64.iso
```

- ① The script that gets run before installation. It should contain the **iscsiadm** commands for mounting the iSCSI target and any commands enabling multipathing.
- ② The script that gets run after installation. It should contain the command **iscsiadm --mode node --logout=all**.
- ③ The path to the device. If you are using multipath, the multipath device, **/dev/mapper/mpatha**. If there are multiple multipath devices connected, or to be explicit, you can use the World Wide Name (WWN) symlink available in **/dev/disk/by-path**.
- ④ The Ignition configuration for the destination system.
- ⑤ The iSCSI parameter is read from the BIOS firmware.
- ⑥ Optional: include this parameter if you are enabling multipathing.

For more information about the iSCSI options supported by **dracut**, see the [dracut.cmdline manual page](#).

#### 2.1.12.3.8. Customizing a live RHCOS PXE environment

You can customize a live RHCOS PXE environment directly with the **coreos-installer pxe customize** subcommand. When you boot the PXE environment, the customizations are applied automatically.

You can use this feature to configure the PXE environment to automatically install RHCOS.

##### Procedure

1. Download the **coreos-installer** binary from the [coreos-installer image mirror](#) page.
2. Retrieve the RHCOS **kernel**, **initramfs** and **rootfs** files from the [RHCOS image mirror](#) page and the Ignition config file, and then run the following command to create a new **initramfs** file that contains the customizations from your Ignition config:

```
$ coreos-installer pxe customize rhcos-<version>-live-initramfs.x86_64.img \
--dest-ignition bootstrap.ign \ ①
--dest-device /dev/disk/by-id/scsi-<serial_number> \ ②
-o rhcos-<version>-custom-initramfs.x86_64.img ③
```

- ① The Ignition config file that is generated from **openshift-installer**.
- ② When you specify this option, the PXE environment automatically runs an install. Otherwise, the image remains configured for installing, but does not do so automatically unless you specify the **coreos.inst.install\_dev** kernel argument.
- ③ Use the customized **initramfs** file in your PXE configuration. Add the **ignition.firstboot** and **ignition.platform.id=metal** kernel arguments if they are not already present.

Applying your customizations affects every subsequent boot of RHCOS.

#### 2.1.12.3.8.1. Modifying a live install PXE environment to enable the serial console

On clusters installed with OpenShift Container Platform 4.12 and above, the serial console is disabled by default and all output is written to the graphical console. You can enable the serial console with the following procedure.

#### Procedure

- 1 Download the **coreos-installer** binary from the [coreos-installer](#) image mirror page.
- 2 Retrieve the RHCOS **kernel**, **initramfs** and **rootfs** files from the [RHCOS image mirror](#) page and the Ignition config file, and then run the following command to create a new customized **initramfs** file that enables the serial console to receive output:

```
$ coreos-installer pxe customize rhcos-<version>-live-initramfs.x86_64.img \
--dest-ignition <path> \①
--dest-console tty0 \②
--dest-console ttyS0,<options> \③
--dest-device /dev/disk/by-id/scsi-<serial_number> \④
-o rhcos-<version>-custom-initramfs.x86_64.img \⑤
```

- 1 The location of the Ignition config to install.
- 2 The desired secondary console. In this case, the graphical console. Omitting this option will disable the graphical console.
- 3 The desired primary console. In this case, the serial console. The **options** field defines the baud rate and other settings. A common value for this field is **115200n8**. If no options are provided, the default kernel value of **9600n8** is used. For more information on the format of this option, see the [Linux kernel serial console](#) documentation.
- 4 The specified disk to install to. If you omit this option, the PXE environment automatically runs the installer which will fail unless you also specify the **coreos.inst.install\_dev** kernel argument.
- 5 Use the customized **initramfs** file in your PXE configuration. Add the **ignition.firstboot** and **ignition.platform.id=metal** kernel arguments if they are not already present.

Your customizations are applied and affect every subsequent boot of the PXE environment.

#### 2.1.12.3.8.2. Modifying a live install PXE environment to use a custom certificate authority

You can provide certificate authority (CA) certificates to Ignition with the **--ignition-ca** flag of the **customize** subcommand. You can use the CA certificates during both the installation boot and when provisioning the installed system.



#### NOTE

Custom CA certificates affect how Ignition fetches remote resources but they do not affect the certificates installed onto the system.

## Procedure

1. Download the **coreos-installer** binary from the [coreos-installer](#) image mirror page.
2. Retrieve the RHCOS **kernel**, **initramfs** and **rootfs** files from the [RHCOS image mirror](#) page and run the following command to create a new customized **initramfs** file for use with a custom CA:

```
$ coreos-installer pxe customize rhcos-<version>-live-initramfs.x86_64.img \
--ignition-ca cert.pem \
-o rhcos-<version>-custom-initramfs.x86_64.img
```

3. Use the customized **initramfs** file in your PXE configuration. Add the **ignition.firstboot** and **ignition.platform.id=metal** kernel arguments if they are not already present.



### IMPORTANT

The **coreos.inst.ignition\_url** kernel parameter does not work with the **--ignition-ca** flag. You must use the **--dest-ignition** flag to create a customized image for each cluster.

Applying your custom CA certificate affects every subsequent boot of RHCOS.

#### 2.1.12.3.8.3. Modifying a live install PXE environment with customized network settings

You can embed a NetworkManager keyfile into the live PXE environment and pass it through to the installed system with the **--network-keyfile** flag of the **customize** subcommand.



### WARNING

When creating a connection profile, you must use a **.nmconnection** filename extension in the filename of the connection profile. If you do not use a **.nmconnection** filename extension, the cluster will apply the connection profile to the live environment, but it will not apply the configuration when the cluster first boots up the nodes, resulting in a setup that does not work.

## Procedure

1. Download the **coreos-installer** binary from the [coreos-installer](#) image mirror page.
2. Create a connection profile for a bonded interface. For example, create the **bond0.nmconnection** file in your local directory with the following content:

```
[connection]
id=bond0
type=bond
interface-name=bond0
multi-connect=1

[bond]
miimon=100
mode=active-backup
```

```
[ipv4]
method=auto

[ipv6]
method=auto
```

3. Create a connection profile for a secondary interface to add to the bond. For example, create the **bond0-proxy-em1.nmconnection** file in your local directory with the following content:

```
[connection]
id=em1
type=ethernet
interface-name=em1
master=bond0
multi-connect=1
slave-type=bond
```

4. Create a connection profile for a secondary interface to add to the bond. For example, create the **bond0-proxy-em2.nmconnection** file in your local directory with the following content:

```
[connection]
id=em2
type=ethernet
interface-name=em2
master=bond0
multi-connect=1
slave-type=bond
```

5. Retrieve the RHCOS **kernel**, **initramfs** and **rootfs** files from the [RHCOS image mirror](#) page and run the following command to create a new customized **initramfs** file that contains your configured networking:

```
$ coreos-installer pxe customize rhcos-<version>-live-initramfs.x86_64.img \
--network-keyfile bond0.nmconnection \
--network-keyfile bond0-proxy-em1.nmconnection \
--network-keyfile bond0-proxy-em2.nmconnection \
-o rhcos-<version>-custom-initramfs.x86_64.img
```

6. Use the customized **initramfs** file in your PXE configuration. Add the **ignition.firstboot** and **ignition.platform.id=metal** kernel arguments if they are not already present. Network settings are applied to the live system and are carried over to the destination system.

#### 2.1.12.3.8.4. Customizing a live install PXE environment for an iSCSI boot device

You can set the iSCSI target and initiator values for automatic mounting, booting and configuration using a customized version of the live RHCOS image.

##### Prerequisites

1. You have an iSCSI target you want to install RHCOS on.

##### Procedure

1. Download the **coreos-installer** binary from the [coreos-installer image mirror](#) page.
2. Retrieve the RHCOS **kernel**, **initramfs** and **rootfs** files from the [RHCOS image mirror](#) page and run the following command to create a new customized **initramfs** file with the following information:

```
$ coreos-installer pxe customize \
--pre-install mount-iscsi.sh \ ①
--post-install unmount-iscsi.sh \ ②
--dest-device /dev/disk/by-path/<IP_address>:<port>-iscsi-<target_iqn>-lun-<lun> \ ③
--dest-ignition config.ign \ ④
--dest-karg-append rd.iscsi.initiator=<initiator_iqn> \ ⑤
--dest-karg-append netroot=<target_iqn> \ ⑥
-o custom.img rhcos-<version>-live-initramfs.x86_64.img
```

- 1 The script that gets run before installation. It should contain the **iscsiadm** commands for mounting the iSCSI target and any commands enabling multipathing.
- 2 The script that gets run after installation. It should contain the command **iscsiadm --mode node --logout=all**.
- 3 The location of the destination system. You must provide the IP address of the target portal, the associated port number, the target iSCSI node in IQN format, and the iSCSI logical unit number (LUN).
- 4 The Ignition configuration for the destination system.
- 5 The iSCSI initiator, or client, name in IQN format. The initiator forms a session to connect to the iSCSI target.
- 6 The the iSCSI target, or server, name in IQN format.

For more information about the iSCSI options supported by **dracut**, see the [dracut.cmdline manual page](#).

#### 2.1.12.3.8.5. Customizing a live install PXE environment for an iSCSI boot device with iBFT

You can set the iSCSI target and initiator values for automatic mounting, booting and configuration using a customized version of the live RHCOS image.

##### Prerequisites

1. You have an iSCSI target you want to install RHCOS on.
2. Optional: you have multipathed your iSCSI target.

##### Procedure

1. Download the **coreos-installer** binary from the [coreos-installer image mirror](#) page.
2. Retrieve the RHCOS **kernel**, **initramfs** and **rootfs** files from the [RHCOS image mirror](#) page and run the following command to create a new customized **initramfs** file with the following information:

```
$ coreos-installer pxe customize \
--pre-install mount-iscsi.sh \ ①
--post-install umount-iscsi.sh \ ②
--dest-device /dev/mapper/mpatha \ ③
--dest-ignition config.ign \ ④
--dest-karg-append rd.iscsi.firmware=1 \ ⑤
--dest-karg-append rd.multipath=default \ ⑥
-o custom.img rhcos-<version>-live-initramfs.x86_64.img
```

- ① The script that gets run before installation. It should contain the **iscsiadm** commands for mounting the iSCSI target.
- ② The script that gets run after installation. It should contain the command **iscsiadm --mode node --logout=all**.
- ③ The path to the device. If you are using multipath, the multipath device, **/dev/mapper/mpatha**. If there are multiple multipath devices connected, or to be explicit, you can use the World Wide Name (WWN) symlink available in **/dev/disk/by-path**.
- ④ The Ignition configuration for the destination system.
- ⑤ The iSCSI parameter is read from the BIOS firmware.
- ⑥ Optional: include this parameter if you are enabling multipathing.

For more information about the iSCSI options supported by **dracut**, see the [dracut.cmdline manual page](#).

#### 2.1.12.3.9. Advanced RHCOS installation reference

This section illustrates the networking configuration and other advanced options that allow you to modify the Red Hat Enterprise Linux CoreOS (RHCOS) manual installation process. The following tables describe the kernel arguments and command-line options you can use with the RHCOS live installer and the **coreos-installer** command.

##### 2.1.12.3.9.1. Networking and bonding options for ISO installations

If you install RHCOS from an ISO image, you can add kernel arguments manually when you boot the image to configure networking for a node. If no networking arguments are specified, DHCP is activated in the initramfs when RHCOS detects that networking is required to fetch the Ignition config file.



#### IMPORTANT

When adding networking arguments manually, you must also add the **rd.neednet=1** kernel argument to bring the network up in the initramfs.

The following information provides examples for configuring networking and bonding on your RHCOS nodes for ISO installations. The examples describe how to use the **ip=**, **nameserver=**, and **bond=** kernel arguments.



## NOTE

Ordering is important when adding the kernel arguments: **ip=**, **nameserver=**, and then **bond=**.

The networking options are passed to the **dracut** tool during system boot. For more information about the networking options supported by **dracut**, see the [dracut cmdline manual page](#).

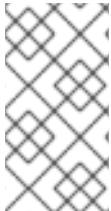
The following examples are the networking options for ISO installation.

Configuring DHCP or static IP addresses

To configure an IP address, either use DHCP (**ip=dhcp**) or set an individual static IP address (**ip=<host\_ip>**). If setting a static IP, you must then identify the DNS server IP address (**nameserver=<dns\_ip>**) on each node. The following example sets:

- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The hostname to **core0.example.com**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
nameserver=4.4.4.41
```



## NOTE

When you use DHCP to configure IP addressing for the RHCOS machines, the machines also obtain the DNS server information through DHCP. For DHCP-based deployments, you can define the DNS server address that is used by the RHCOS nodes through your DHCP server configuration.

Configuring an IP address without a static hostname

You can configure an IP address without assigning a static hostname. If a static hostname is not set by the user, it will be picked up and automatically set by a reverse DNS lookup. To configure an IP address without a static hostname refer to the following example:

- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0::enp1s0:none
nameserver=4.4.4.41
```

### Specifying multiple network interfaces

You can specify multiple network interfaces by setting multiple **ip=** entries.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=10.10.10.3::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

### Configuring default gateway and route

Optional: You can configure routes to additional networks by setting an **rd.route=** value.



#### NOTE

When you configure one or more networks, one default gateway is required. If the additional network gateway is different from the primary network gateway, the default gateway must be the primary network gateway.

- Run the following command to configure the default gateway:

```
ip=:10.10.10.254::
```

- Enter the following command to configure the route for the additional network:

```
rd.route=20.20.20.0/24:20.20.20.254:enp2s0
```

### Disabling DHCP on a single interface

You can disable DHCP on a single interface, such as when there are two or more network interfaces and only one interface is being used. In the example, the **enp1s0** interface has a static networking configuration and DHCP is disabled for **enp2s0**, which is not used:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip::::core0.example.com:enp2s0:none
```

### Combining DHCP and static IP configurations

You can combine DHCP and static IP configurations on systems with multiple network interfaces, for example:

```
ip=enp1s0:dhcp
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

### Configuring VLANs on individual interfaces

Optional: You can configure VLANs on individual interfaces by using the **vlan=** parameter.

- To configure a VLAN on a network interface and use a static IP address, run the following command:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0.100:none
vlan=enp2s0.100:enp2s0
```

- To configure a VLAN on a network interface and to use DHCP, run the following command:

```
ip=enp2s0.100:dhcp
vlan=enp2s0.100:enp2s0
```

Providing multiple DNS servers

You can provide multiple DNS servers by adding a **nameserver=** entry for each server, for example:

```
nameserver=1.1.1.1
nameserver=8.8.8.8
```

Bonding multiple network interfaces to a single interface

Optional: You can bond multiple network interfaces to a single interface by using the **bond=** option. Refer to the following examples:

- The syntax for configuring a bonded interface is: **bond=<name>[:<network\_interfaces>] [:options]**  
**<name>** is the bonding device name (**bond0**), **<network\_interfaces>** represents a comma-separated list of physical (ethernet) interfaces (**em1,em2**), and *options* is a comma-separated list of bonding options. Enter **modinfo bonding** to see available options.
- When you create a bonded interface using **bond=**, you must specify how the IP address is assigned and other information for the bonded interface.
  - To configure the bonded interface to use DHCP, set the bond's IP address to **dhcp**. For example:

```
bond=bond0:em1,em2:mode=active-backup
ip=bond0:dhcp
```

- To configure the bonded interface to use a static IP address, enter the specific IP address you want and related information. For example:

```
bond=bond0:em1,em2:mode=active-backup
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0:none
```

Bonding multiple SR-IOV network interfaces to a dual port NIC interface

Optional: You can bond multiple SR-IOV network interfaces to a dual port NIC interface by using the **bond=** option.

On each node, you must perform the following tasks:

- Create the SR-IOV virtual functions (VFs) following the guidance in [Managing SR-IOV devices](#). Follow the procedure in the "Attaching SR-IOV networking devices to virtual machines" section.
- Create the bond, attach the desired VFs to the bond and set the bond link state up following the guidance in [Configuring network bonding](#). Follow any of the described procedures to create the bond.

The following examples illustrate the syntax you must use:

- The syntax for configuring a bonded interface is **bond=<name>[:<network\_interfaces>] [:options]**.  
**<name>** is the bonding device name (**bond0**), **<network\_interfaces>** represents the virtual functions (VFs) by their known name in the kernel and shown in the output of the **ip link** command (**eno1f0, eno2f0**), and *options* is a comma-separated list of bonding options. Enter **modinfo bonding** to see available options.

- When you create a bonded interface using **bond=**, you must specify how the IP address is assigned and other information for the bonded interface.
  - To configure the bonded interface to use DHCP, set the bond's IP address to **dhcp**. For example:

```
bond=bond0:eno1f0,eno2f0:mode=active-backup
ip=bond0:dhcp
```

- To configure the bonded interface to use a static IP address, enter the specific IP address you want and related information. For example:

```
bond=bond0:eno1f0,eno2f0:mode=active-backup
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0:none
```

## Using network teaming

Optional: You can use a network teaming as an alternative to bonding by using the **team=** parameter:

- The syntax for configuring a team interface is: **team=name[:network\_interfaces]**  
*name* is the team device name (**team0**) and *network\_interfaces* represents a comma-separated list of physical (ethernet) interfaces (**em1, em2**).



### NOTE

Teaming is planned to be deprecated when RHCOS switches to an upcoming version of RHEL. For more information, see this [Red Hat Knowledgebase Article](#).

Use the following example to configure a network team:

```
team=team0:em1,em2
ip=team0:dhcp
```

### 2.1.12.3.9.2. coreos-installer options for ISO and PXE installations

You can install RHCOS by running **coreos-installer install <options> <device>** at the command prompt, after booting into the RHCOS live environment from an ISO image.

The following table shows the subcommands, options, and arguments you can pass to the **coreos-installer** command.

**Table 2.9. coreos-installer subcommands, command-line options, and arguments**

coreos-installer install subcommand	
Subcommand	Description
<b>\$ coreos-installer install &lt;options&gt; &lt;device&gt;</b>	Embed an Ignition config in an ISO image.
coreos-installer install subcommand options	
Option	Description

<b>-u, --image-url &lt;url&gt;</b>	Specify the image URL manually.
<b>-f, --image-file &lt;path&gt;</b>	Specify a local image file manually. Used for debugging.
<b>-i, --ignition-file &lt;path&gt;</b>	Embed an Ignition config from a file.
<b>-l, --ignition-url &lt;URL&gt;</b>	Embed an Ignition config from a URL.
<b>--ignition-hash &lt;digest&gt;</b>	Digest <b>type-value</b> of the Ignition config.
<b>-p, --platform &lt;name&gt;</b>	Override the Ignition platform ID for the installed system.
<b>--console &lt;spec&gt;</b>	Set the kernel and bootloader console for the installed system. For more information about the format of <b>&lt;spec&gt;</b> , see the <a href="#">Linux kernel serial console</a> documentation.
<b>--append-karg &lt;arg&gt;...</b>	Append a default kernel argument to the installed system.
<b>--delete-karg &lt;arg&gt;...</b>	Delete a default kernel argument from the installed system.
<b>-n, --copy-network</b>	Copy the network configuration from the install environment.
<p><b>IMPORTANT</b></p>  <p>The <b>--copy-network</b> option only copies networking configuration found under <b>/etc/NetworkManager/system-connections</b>. In particular, it does not copy the system hostname.</p>	
<b>--network-dir &lt;path&gt;</b>	For use with <b>-n</b> . Default is <b>/etc/NetworkManager/system-connections/</b> .
<b>--save-partlabel &lt;lx&gt;..</b>	Save partitions with this label glob.
<b>--save-partindex &lt;id&gt;...</b>	Save partitions with this number or range.
<b>--insecure</b>	Skip RHCOS image signature verification.
<b>--insecure-ignition</b>	Allow Ignition URL without HTTPS or hash.

--architecture <name>	Target CPU architecture. Valid values are <b>x86_64</b> and <b>aarch64</b> .
--preserve-on-error	Do not clear partition table on error.
-h, --help	Print help information.

**coreos-installer install** subcommand argument

<i>Argument</i>	<i>Description</i>
<device>	The destination device.

**coreos-installer ISO** subcommands

<i>Subcommand</i>	<i>Description</i>
\$ coreos-installer iso customize <options> <ISO_image>	Customize a RHCOS live ISO image.
coreos-installer iso reset <options> <ISO_image>	Restore a RHCOS live ISO image to default settings.
coreos-installer iso ignition remove <options> <ISO_image>	Remove the embedded Ignition config from an ISO image.

**coreos-installer ISO customize** subcommand options

<i>Option</i>	<i>Description</i>
--dest-ignition <path>	Merge the specified Ignition config file into a new configuration fragment for the destination system.
--dest-console <spec>	Specify the kernel and bootloader console for the destination system.
--dest-device <path>	Install and overwrite the specified destination device.
--dest-karg-append <arg>	Add a kernel argument to each boot of the destination system.
--dest-karg-delete <arg>	Delete a kernel argument from each boot of the destination system.
--network-keyfile <path>	Configure networking by using the specified NetworkManager keyfile for live and destination systems.

<b>--ignition-ca &lt;path&gt;</b>	Specify an additional TLS certificate authority to be trusted by Ignition.
<b>--pre-install &lt;path&gt;</b>	Run the specified script before installation.
<b>--post-install &lt;path&gt;</b>	Run the specified script after installation.
<b>--installer-config &lt;path&gt;</b>	Apply the specified installer configuration file.
<b>--live-ignition &lt;path&gt;</b>	Merge the specified Ignition config file into a new configuration fragment for the live environment.
<b>--live-karg-append &lt;arg&gt;</b>	Add a kernel argument to each boot of the live environment.
<b>--live-karg-delete &lt;arg&gt;</b>	Delete a kernel argument from each boot of the live environment.
<b>--live-karg-replace &lt;k=o=n&gt;</b>	Replace a kernel argument in each boot of the live environment, in the form <b>key=old=new</b> .
<b>-f, --force</b>	Overwrite an existing Ignition config.
<b>-o, --output &lt;path&gt;</b>	Write the ISO to a new output file.
<b>-h, --help</b>	Print help information.

**coreos-installer PXE subcommands**

<i>Subcommand</i>	<i>Description</i>
Note that not all of these options are accepted by all subcommands.	
<b>coreos-installer pxe customize &lt;options&gt; &lt;path&gt;</b>	Customize a RHCOS live PXE boot config.
<b>coreos-installer pxe ignition wrap &lt;options&gt;</b>	Wrap an Ignition config in an image.
<b>coreos-installer pxe ignition unwrap &lt;options&gt; &lt;image_name&gt;</b>	Show the wrapped Ignition config in an image.

**coreos-installer PXE customize subcommand options**

<i>Option</i>	<i>Description</i>
Note that not all of these options are accepted by all subcommands.	

<b>--dest-ignition &lt;path&gt;</b>	Merge the specified Ignition config file into a new configuration fragment for the destination system.
<b>--dest-console &lt;spec&gt;</b>	Specify the kernel and bootloader console for the destination system.
<b>--dest-device &lt;path&gt;</b>	Install and overwrite the specified destination device.
<b>--network-keyfile &lt;path&gt;</b>	Configure networking by using the specified NetworkManager keyfile for live and destination systems.
<b>--ignition-ca &lt;path&gt;</b>	Specify an additional TLS certificate authority to be trusted by Ignition.
<b>--pre-install &lt;path&gt;</b>	Run the specified script before installation.
<b>post-install &lt;path&gt;</b>	Run the specified script after installation.
<b>--installer-config &lt;path&gt;</b>	Apply the specified installer configuration file.
<b>--live-ignition &lt;path&gt;</b>	Merge the specified Ignition config file into a new configuration fragment for the live environment.
<b>-o, --output &lt;path&gt;</b>	Write the initramfs to a new output file.
<b>-h, --help</b>	<p> <b>NOTE</b></p> <p>This option is required for PXE environments.</p>

#### 2.1.12.3.9.3. **coreos.inst** boot options for ISO or PXE installations

You can automatically invoke **coreos-installer** options at boot time by passing **coreos.inst** boot arguments to the RHCOS live installer. These are provided in addition to the standard boot arguments.

- For ISO installations, the **coreos.inst** options can be added by interrupting the automatic boot at the bootloader menu. You can interrupt the automatic boot by pressing **TAB** while the **RHEL CoreOS (Live)** menu option is highlighted.
- For PXE or iPXE installations, the **coreos.inst** options must be added to the **APPEND** line before the RHCOS live installer is booted.

The following table shows the RHCOS live installer **coreos.inst** boot options for ISO and PXE installations.

**Table 2.10. coreos.inst boot options**

Argument	Description
<b>coreos.inst.install_dev</b>	<p>Required. The block device on the system to install to.</p> <p> <b>NOTE</b></p> <p>It is recommended to use the full path, such as <b>/dev/sda</b>, although <b>sda</b> is allowed.</p>
<b>coreos.inst.ignition_url</b>	<p>Optional: The URL of the Ignition config to embed into the installed system. If no URL is specified, no Ignition config is embedded. Only HTTP and HTTPS protocols are supported.</p>
<b>coreos.inst.save_partlabel</b>	<p>Optional: Comma-separated labels of partitions to preserve during the install. Glob-style wildcards are permitted. The specified partitions do not need to exist.</p>
<b>coreos.inst.save_partindex</b>	<p>Optional: Comma-separated indexes of partitions to preserve during the install. Ranges <b>m-n</b> are permitted, and either <b>m</b> or <b>n</b> can be omitted. The specified partitions do not need to exist.</p>
<b>coreos.inst.insecure</b>	<p>Optional: Permits the OS image that is specified by <b>coreos.inst.image_url</b> to be unsigned.</p>
<b>coreos.inst.image_url</b>	<p>Optional: Download and install the specified RHCOS image.</p> <ul style="list-style-type: none"> <li>● This argument should not be used in production environments and is intended for debugging purposes only.</li> <li>● While this argument can be used to install a version of RHCOS that does not match the live media, it is recommended that you instead use the media that matches the version you want to install.</li> <li>● If you are using <b>coreos.inst.image_url</b>, you must also use <b>coreos.inst.insecure</b>. This is because the bare-metal media are not GPG-signed for OpenShift Container Platform.</li> <li>● Only HTTP and HTTPS protocols are supported.</li> </ul>

Argument	Description
<b>coreos.inst.skip_reboot</b>	<p>Optional: The system will not reboot after installing. After the install finishes, you will receive a prompt that allows you to inspect what is happening during installation. This argument should not be used in production environments and is intended for debugging purposes only.</p>
<b>coreos.inst.platform_id</b>	<p>Optional: The Ignition platform ID of the platform the RHCOS image is being installed on. Default is <b>metal</b>. This option determines whether or not to request an Ignition config from the cloud provider, such as VMware. For example:</p> <p><b>coreos.inst.platform_id=vmware</b>.</p>
<b>ignition.config.url</b>	<p>Optional: The URL of the Ignition config for the live boot. For example, this can be used to customize how <b>coreos-installer</b> is invoked, or to run code before or after the installation. This is different from <b>coreos.inst.ignition_url</b>, which is the Ignition config for the installed system.</p>

#### 2.1.12.4. Enabling multipathing with kernel arguments on RHCOS

RHCOS supports multipathing on the primary disk, allowing stronger resilience to hardware failure to achieve higher host availability.

You can enable multipathing at installation time for nodes that were provisioned in OpenShift Container Platform 4.8 or later. While postinstallation support is available by activating multipathing via the machine config, enabling multipathing during installation is recommended.

In setups where any I/O to non-optimized paths results in I/O system errors, you must enable multipathing at installation time.



#### IMPORTANT

On IBM Z® and IBM® LinuxONE, you can enable multipathing only if you configured your cluster for it during installation. For more information, see "Installing RHCOS and starting the OpenShift Container Platform bootstrap process" in *Installing a cluster with z/VM on IBM Z® and IBM® LinuxONE*.

The following procedure enables multipath at installation time and appends kernel arguments to the **coreos-installer install** command so that the installed system itself will use multipath beginning from the first boot.



#### NOTE

OpenShift Container Platform does not support enabling multipathing as a day-2 activity on nodes that have been upgraded from 4.6 or earlier.

## Prerequisites

- You have created the Ignition config files for your cluster.
- You have reviewed *Installing RHCOS and starting the OpenShift Container Platform bootstrap process*.

## Procedure

1. To enable multipath and start the **multipathd** daemon, run the following command on the installation host:
 

```
$ mpathconf --enable && systemctl start multipathd.service
```

  - Optional: If booting the PXE or ISO, you can instead enable multipath by adding **rd.multipath=default** from the kernel command line.
2. Append the kernel arguments by invoking the **coreos-installer** program:
  - If there is only one multipath device connected to the machine, it should be available at path **/dev/mapper/mpatha**. For example:

```
$ coreos-installer install /dev/mapper/mpatha \①
--ignition-url=http://host/worker.ign \
--append-karg rd.multipath=default \
--append-karg root=/dev/disk/by-label/dm-mpath-root \
--append-karg rw
```

① Indicates the path of the single multipathed device.

- If there are multiple multipath devices connected to the machine, or to be more explicit, instead of using **/dev/mapper/mpatha**, it is recommended to use the World Wide Name (WWN) symlink available in **/dev/disk/by-id**. For example:

```
$ coreos-installer install /dev/disk/by-id/wwn-<wwn_ID> \①
--ignition-url=http://host/worker.ign \
--append-karg rd.multipath=default \
--append-karg root=/dev/disk/by-label/dm-mpath-root \
--append-karg rw
```

① Indicates the WWN ID of the target multipathed device. For example, **0xx194e957fcedb4841**.

This symlink can also be used as the **coreos.inst.install\_dev** kernel argument when using special **coreos.inst.\*** arguments to direct the live installer. For more information, see "Installing RHCOS and starting the OpenShift Container Platform bootstrap process".

3. Reboot into the installed system.
4. Check that the kernel arguments worked by going to one of the worker nodes and listing the kernel command-line arguments (in **/proc/cmdline** on the host):
 

```
$ oc debug node/ip-10-0-141-105.ec2.internal
```

## Example output

```
Starting pod/ip-10-0-141-105ec2internal-debug ...
To use host binaries, run `chroot /host`

sh-4.2# cat /host/proc/cmdline
...
rd.multipath=default root=/dev/disk/by-label/dm-mpath-root
...
sh-4.2# exit
```

You should see the added kernel arguments.

### 2.1.12.4.1. Enabling multipathing on secondary disks

RHCOS also supports multipathing on a secondary disk. Instead of kernel arguments, you use Ignition to enable multipathing for the secondary disk at installation time.

#### Prerequisites

- You have read the section *Disk partitioning*.
- You have read *Enabling multipathing with kernel arguments on RHCOS*.
- You have installed the Butane utility.

#### Procedure

1. Create a Butane config with information similar to the following:

## Example multipath-config.bu

```
variant: openshift
version: 4.18.0
systemd:
units:
- name: mpath-configure.service
  enabled: true
  contents: |
    [Unit]
    Description=Configure Multipath on Secondary Disk
    ConditionFirstBoot=true
    ConditionPathExists=!/etc/multipath.conf
    Before=multipathd.service ①
    DefaultDependencies=no

    [Service]
    Type=oneshot
    ExecStart=/usr/sbin/mpathconf --enable ②

    [Install]
    WantedBy=multi-user.target
    - name: mpath-var-lib-container.service
```

```

enabled: true
contents: |
[Unit]
Description=Set Up Multipath On /var/lib/containers
ConditionFirstBoot=true ③
Requires=dev-mapper-mpatha.device
After=dev-mapper-mpatha.device
After=ostree-remount.service
Before=kubelet.service
DefaultDependencies=no

[Service] ④
Type=oneshot
ExecStart=/usr/sbin/mkfs.xfs -L containers -m reflink=1 /dev/mapper/mpatha
ExecStart=/usr/bin/mkdir -p /var/lib/containers

[Install]
WantedBy=multi-user.target
- name: var-lib-containers.mount
  enabled: true
  contents: |
    [Unit]
    Description=Mount /var/lib/containers
    After=mpath-var-lib-containers.service
    Before=kubelet.service ⑤

[Mount] ⑥
What=/dev/disk/by-label/dm-mpath-containers
Where=/var/lib/containers
Type=xfs

[Install]
WantedBy=multi-user.target

```

- 1 The configuration must be set before launching the multipath daemon.
- 2 Starts the **mpathconf** utility.
- 3 This field must be set to the value **true**.
- 4 Creates the filesystem and directory **/var/lib/containers**.
- 5 The device must be mounted before starting any nodes.
- 6 Mounts the device to the **/var/lib/containers** mount point. This location cannot be a symlink.

2. Create the Ignition configuration by running the following command:

```
$ butane --pretty --strict multipath-config.bu > multipath-config.ign
```

3. Continue with the rest of the first boot RHCOS installation process.



## IMPORTANT

Do not add the **rd.multipath** or **root** kernel arguments on the command-line during installation unless the primary disk is also multipathed.

### 2.1.12.5. Installing RHCOS manually on an iSCSI boot device

You can manually install RHCOS on an iSCSI target.

#### Prerequisites

1. You are in the RHCOS live environment.
2. You have an iSCSI target that you want to install RHCOS on.

#### Procedure

1. Mount the iSCSI target from the live environment by running the following command:

```
$ iscsiamd \
--mode discovery \
--type sendtargets \
--portal <IP_address> \ ①
--login
```

- ① The IP address of the target portal.

2. Install RHCOS onto the iSCSI target by running the following command and using the necessary kernel arguments, for example:

```
$ coreos-installer install \
/dev/disk/by-path/ip-<IP_address>:<port>-iscsi-<target_iqn>-lun-<lun> \ ①
--append-karg rd.iscsi.initiator=<initiator_iqn> \ ②
--append.karg netroot=<target_iqn> \ ③
--console ttyS0,115200n8
--ignition-file <path_to_file>
```

- ① The location you are installing to. You must provide the IP address of the target portal, the associated port number, the target iSCSI node in IQN format, and the iSCSI logical unit number (LUN).
- ② The iSCSI initiator, or client, name in IQN format. The initiator forms a session to connect to the iSCSI target.
- ③ The the iSCSI target, or server, name in IQN format.

For more information about the iSCSI options supported by **dracut**, see the [dracut.cmdline manual page](#).

3. Unmount the iSCSI disk with the following command:

```
$ iscsiamd --mode node --logoutall=all
```

This procedure can also be performed using the **coreos-installer iso customize** or **coreos-installer pxe customize** subcommands.

### 2.1.12.6. Installing RHCOS on an iSCSI boot device using iBFT

On a completely diskless machine, the iSCSI target and initiator values can be passed through iBFT. iSCSI multipathing is also supported.

#### Prerequisites

1. You are in the RHCOS live environment.
2. You have an iSCSI target you want to install RHCOS on.
3. Optional: you have multipathed your iSCSI target.

#### Procedure

1. Mount the iSCSI target from the live environment by running the following command:

```
$ iscsiadm \
--mode discovery \
--type sendtargets \
--portal <IP_address> \ ①
--login
```

- ① The IP address of the target portal.

2. Optional: enable multipathing and start the daemon with the following command:

```
$ mpathconf --enable && systemctl start multipathd.service
```

3. Install RHCOS onto the iSCSI target by running the following command and using the necessary kernel arguments, for example:

```
$ coreos-installer install \
/dev/mapper/mpatha \ ①
--append-karg rd.iscsi.firmware=1 \ ②
--append-karg rd.multipath=default \ ③
--console ttyS0 \
--ignition-file <path_to_file>
```

- ① The path of a single multipathed device. If there are multiple multipath devices connected, or to be explicit, you can use the World Wide Name (WWN) symlink available in **/dev/disk/by-path**.
- ② The iSCSI parameter is read from the BIOS firmware.
- ③ Optional: include this parameter if you are enabling multipathing.

For more information about the iSCSI options supported by **dracut**, see the [dracut.cmdline manual page](#).

#### 4. Unmount the iSCSI disk:

```
$ iscsidadm --mode node --logout=all
```

This procedure can also be performed using the **coreos-installer iso customize** or **coreos-installer pxe customize** subcommands.

#### Additional resources

- See [Installing RHCOS and starting the OpenShift Container Platform bootstrap process](#) for more information on using special **coreos.inst.\*** arguments to direct the live installer.

### 2.1.13. Waiting for the bootstrap process to complete

The OpenShift Container Platform bootstrap process begins after the cluster nodes first boot into the persistent RHCOS environment that has been installed to disk. The configuration information provided through the Ignition config files is used to initialize the bootstrap process and install OpenShift Container Platform on the machines. You must wait for the bootstrap process to complete.

#### Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have obtained the installation program and generated the Ignition config files for your cluster.
- You installed RHCOS on your cluster machines and provided the Ignition config files that the OpenShift Container Platform installation program generated.
- Your machines have direct internet access or have an HTTP or HTTPS proxy available.

#### Procedure

1. Monitor the bootstrap process:

```
$ ./openshift-install --dir <installation_directory> wait-for bootstrap-complete \ ①
--log-level=info ②
```

- 1 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.
- 2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

#### Example output

```
INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...
INFO API v1.31.3 up
INFO Waiting up to 30m0s for bootstrapping to complete...
INFO It is now safe to remove the bootstrap resources
```

The command succeeds when the Kubernetes API server signals that it has been bootstrapped on the control plane machines.

- After the bootstrap process is complete, remove the bootstrap machine from the load balancer.



### IMPORTANT

You must remove the bootstrap machine from the load balancer at this point. You can also remove or reformat the bootstrap machine itself.

#### Additional resources

- See [Monitoring installation progress](#) for more information about monitoring the installation logs and retrieving diagnostic data if installation issues arise.

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

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

#### Prerequisites

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

#### Procedure

- Export the **kubeadmin** credentials:

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

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

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

```
$ oc whoami
```

#### Example output

```
system:admin
```

### 2.1.15. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

#### Prerequisites

- You added machines to your cluster.

## Procedure

1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

### Example output

NAME	STATUS	ROLES	AGE	VERSION
master-0	Ready	master	63m	v1.31.3
master-1	Ready	master	63m	v1.31.3
master-2	Ready	master	64m	v1.31.3

The output lists all of the machines that you created.



### NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

2. Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

### Example output

NAME	AGE	REQUESTOR	CONDITION
csr-8b2br	15m	system:serviceaccount:openshift-machine-config-operator:node-bootstrapper	Pending
csr-8vnps	15m	system:serviceaccount:openshift-machine-config-operator:node-bootstrapper	Pending
...			

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

3. If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:



### NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.



## NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

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

```
$ oc adm certificate approve <csr_name> ①
```

① **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}\n{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```



## NOTE

Some Operators might not become available until some CSRs are approved.

4. Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

### Example output

NAME	AGE	REQUESTOR	CONDITION
csr-bfd72	5m26s	system:node:ip-10-0-50-126.us-east-2.compute.internal	Pending
csr-c57lv	5m26s	system:node:ip-10-0-95-157.us-east-2.compute.internal	Pending
...			

5. If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

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

```
$ oc adm certificate approve <csr_name> ①
```

① **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}\n{{end}}{{end}}' | xargs oc adm certificate approve
```

6. After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

### Example output

NAME	STATUS	ROLES	AGE	VERSION
master-0	Ready	master	73m	v1.31.3
master-1	Ready	master	73m	v1.31.3
master-2	Ready	master	74m	v1.31.3
worker-0	Ready	worker	11m	v1.31.3
worker-1	Ready	worker	11m	v1.31.3



### NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

### Additional information

- [Certificate Signing Requests](#)

## 2.1.16. Initial Operator configuration

After the control plane initializes, you must immediately configure some Operators so that they all become available.

### Prerequisites

- Your control plane has initialized.

### Procedure

1. Watch the cluster components come online:

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

### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED
SINCE				
authentication	4.18.0	True	False	False
baremetal	4.18.0	True	False	False
cloud-credential	4.18.0	True	False	False
cluster-autoscaler	4.18.0	True	False	False
config-operator	4.18.0	True	False	False

console	4.18.0	True	False	False	26m
csi-snapshot-controller	4.18.0	True	False	False	37m
dns	4.18.0	True	False	False	37m
etcd	4.18.0	True	False	False	36m
image-registry	4.18.0	True	False	False	31m
ingress	4.18.0	True	False	False	30m
insights	4.18.0	True	False	False	31m
kube-apiserver	4.18.0	True	False	False	26m
kube-controller-manager	4.18.0	True	False	False	36m
kube-scheduler	4.18.0	True	False	False	36m
kube-storage-version-migrator	4.18.0	True	False	False	37m
machine-api	4.18.0	True	False	False	29m
machine approver	4.18.0	True	False	False	37m
machine-config	4.18.0	True	False	False	36m
marketplace	4.18.0	True	False	False	37m
monitoring	4.18.0	True	False	False	29m
network	4.18.0	True	False	False	38m
node-tuning	4.18.0	True	False	False	37m
openshift-apiserver	4.18.0	True	False	False	32m
openshift-controller-manager	4.18.0	True	False	False	30m
openshift-samples	4.18.0	True	False	False	32m
operator-lifecycle-manager	4.18.0	True	False	False	37m
operator-lifecycle-manager-catalog	4.18.0	True	False	False	37m
operator-lifecycle-manager-packageserver	4.18.0	True	False	False	32m
service-ca	4.18.0	True	False	False	38m
storage	4.18.0	True	False	False	37m

- Configure the Operators that are not available.

## Additional resources

- See [Gathering logs from a failed installation](#) for details about gathering data in the event of a failed OpenShift Container Platform installation.
- See [Troubleshooting Operator issues](#) for steps to check Operator pod health across the cluster and gather Operator logs for diagnosis.

### 2.1.16.1. Image registry removed during installation

On platforms that do not provide shareable object storage, the OpenShift Image Registry Operator bootstraps itself as **Removed**. This allows **openshift-installer** to complete installations on these platform types.

After installation, you must edit the Image Registry Operator configuration to switch the **managementState** from **Removed** to **Managed**. When this has completed, you must configure storage.

### 2.1.16.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

### 2.1.16.2.1. Configuring registry storage for bare metal and other manual installations

As a cluster administrator, following installation you must configure your registry to use storage.

#### Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.
- You have a cluster that uses manually-provisioned Red Hat Enterprise Linux CoreOS (RHCOS) nodes, such as bare metal.
- You have provisioned persistent storage for your cluster, such as Red Hat OpenShift Data Foundation.



#### IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have 100Gi capacity.

#### Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.



#### NOTE

When you use shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

#### Example output

```
No resources found in openshift-image-registry namespace
```



#### NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

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

### Example output

```
storage:  
pvc:  
claim:
```

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

4. Check the **clusteroperator** status:

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

### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
MESSAGE					
image-registry	4.18	True	False	False	6h50m

5. Ensure that your registry is set to managed to enable building and pushing of images.

- Run:

```
$ oc edit configs.imageregistry/cluster
```

Then, change the line

```
managementState: Removed
```

to

```
managementState: Managed
```

#### 2.1.16.2.2. Configuring storage for the image registry in non-production clusters

You must configure storage for the Image Registry Operator. For non-production clusters, you can set the image registry to an empty directory. If you do so, all images are lost if you restart the registry.

#### Procedure

- To set the image registry storage to an empty directory:

```
$ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec": {"storage":{"emptyDir":{}}}}'
```

**WARNING**

Configure this option for only non-production clusters.

If you run this command before the Image Registry Operator initializes its components, the **oc patch** command fails with the following error:

Error from server (NotFound): configs.imageregistry.operator.openshift.io "cluster" not found

Wait a few minutes and run the command again.

#### 2.1.16.2.3. Configuring block registry storage for bare metal

To allow the image registry to use block storage types during upgrades as a cluster administrator, you can use the **Recreate** rollout strategy.

**IMPORTANT**

Block storage volumes, or block persistent volumes, are supported but not recommended for use with the image registry on production clusters. An installation where the registry is configured on block storage is not highly available because the registry cannot have more than one replica.

If you choose to use a block storage volume with the image registry, you must use a filesystem persistent volume claim (PVC).

#### Procedure

- Enter the following command to set the image registry storage as a block storage type, patch the registry so that it uses the **Recreate** rollout strategy, and runs with only one (**1**) replica:

```
$ oc patch config.imageregistry.operator.openshift.io/cluster --type=merge -p '{"spec": {"rolloutStrategy":"Recreate","replicas":1}}'
```

- Provision the PV for the block storage device, and create a PVC for that volume. The requested block volume uses the ReadWriteOnce (RWO) access mode.
  - Create a **pvc.yaml** file with the following contents to define a VMware vSphere **PersistentVolumeClaim** object:

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: image-registry-storage 1
  namespace: openshift-image-registry 2
spec:
  accessModes:
    - ReadWriteOnce 3
```

```
resources:
requests:
storage: 100Gi ④
```

- ① A unique name that represents the **PersistentVolumeClaim** object.
- ② The namespace for the **PersistentVolumeClaim** object, which is **openshift-image-registry**.
- ③ The access mode of the persistent volume claim. With **ReadWriteOnce**, the volume can be mounted with read and write permissions by a single node.
- ④ The size of the persistent volume claim.

b. Enter the following command to create the **PersistentVolumeClaim** object from the file:

```
$ oc create -f pvc.yaml -n openshift-image-registry
```

3. Enter the following command to edit the registry configuration so that it references the correct PVC:

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

#### Example output

```
storage:
pvc:
claim: ①
```

- ① By creating a custom PVC, you can leave the **claim** field blank for the default automatic creation of an **image-registry-storage** PVC.

### 2.1.17. Completing installation on user-provisioned infrastructure

After you complete the Operator configuration, you can finish installing the cluster on infrastructure that you provide.

#### Prerequisites

- Your control plane has initialized.
- You have completed the initial Operator configuration.

#### Procedure

1. Confirm that all the cluster components are online with the following command:

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

#### Example output

NAME SINCE	VERSION	AVAILABLE	PROGRESSING	DEGRADED
authentication	4.18.0	True	False	False 19m
baremetal	4.18.0	True	False	False 37m
cloud-credential	4.18.0	True	False	False 40m
cluster-autoscaler	4.18.0	True	False	False 37m
config-operator	4.18.0	True	False	False 38m
console	4.18.0	True	False	False 26m
csi-snapshot-controller	4.18.0	True	False	False 37m
dns	4.18.0	True	False	False 37m
etcd	4.18.0	True	False	False 36m
image-registry	4.18.0	True	False	False 31m
ingress	4.18.0	True	False	False 30m
insights	4.18.0	True	False	False 31m
kube-apiserver	4.18.0	True	False	False 26m
kube-controller-manager	4.18.0	True	False	False 36m
kube-scheduler	4.18.0	True	False	False 36m
kube-storage-version-migrator	4.18.0	True	False	False 37m
machine-api	4.18.0	True	False	False 29m
machine approver	4.18.0	True	False	False 37m
machine-config	4.18.0	True	False	False 36m
marketplace	4.18.0	True	False	False 37m
monitoring	4.18.0	True	False	False 29m
network	4.18.0	True	False	False 38m
node-tuning	4.18.0	True	False	False 37m
openshift-apiserver	4.18.0	True	False	False 32m
openshift-controller-manager	4.18.0	True	False	False 30m
openshift-samples	4.18.0	True	False	False 32m
operator-lifecycle-manager	4.18.0	True	False	False 37m
operator-lifecycle-manager-catalog	4.18.0	True	False	False 37m
operator-lifecycle-manager-packageserver	4.18.0	True	False	False 32m
service-ca	4.18.0	True	False	False 38m
storage	4.18.0	True	False	False 37m

Alternatively, the following command notifies you when all of the clusters are available. It also retrieves and displays credentials:

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

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

### Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

The command succeeds when the Cluster Version Operator finishes deploying the OpenShift Container Platform cluster from Kubernetes API server.



## IMPORTANT

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

2. Confirm that the Kubernetes API server is communicating with the pods.

a. To view a list of all pods, use the following command:

```
$ oc get pods --all-namespaces
```

### Example output

NAMESPACE	NAME	READY	STATUS
RESTARTS	AGE		
openshift-apiserver-operator	openshift-apiserver-operator-85cb746d55-zqhs8	1/1	
Running 1 9m			
openshift-apiserver	apiserver-67b9g	1/1	Running 0
3m			
openshift-apiserver	apiserver-ljcmx	1/1	Running 0
1m			
openshift-apiserver	apiserver-z25h4	1/1	Running 0
2m			
openshift-authentication-operator	authentication-operator-69d5d8bf84-vh2n8	1/1	
Running 0 5m			
...			

b. View the logs for a pod that is listed in the output of the previous command by using the following command:

```
$ oc logs <pod_name> -n <namespace> ①
```

① Specify the pod name and namespace, as shown in the output of the previous command.

If the pod logs display, the Kubernetes API server can communicate with the cluster machines.

3. For an installation with Fibre Channel Protocol (FCP), additional steps are required to enable multipathing. Do not enable multipathing during installation.

See "Enabling multipathing with kernel arguments on RHCOS" in the *Postinstallation machine configuration tasks* documentation for more information.

## 2.1.18. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.18, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

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

### Additional resources

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

## 2.1.19. Next steps

- [Validating an installation](#).
- [Customize your cluster](#).
- If necessary, you can [opt out of remote health reporting](#).
- [Set up your registry and configure registry storage](#).

## 2.2. INSTALLING A USER-PROVISIONED BARE METAL CLUSTER WITH NETWORK CUSTOMIZATIONS

In OpenShift Container Platform 4.18, you can install a cluster on bare metal infrastructure that you provision with customized network configuration options. By customizing your network configuration, your cluster can coexist with existing IP address allocations in your environment and integrate with existing MTU and VXLAN configurations.

When you customize OpenShift Container Platform networking, you must set most of the network configuration parameters during installation. You can modify only **kubeProxy** network configuration parameters in a running cluster.

### 2.2.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update processes](#).
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- If you use a firewall and plan to use the Telemetry service, you [configured the firewall to allow the sites](#) that your cluster requires access to.

### 2.2.2. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.18, you require access to the internet to install your cluster.

You must have internet access to:

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



## IMPORTANT

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

### Additional resources

- See [Installing a user-provisioned bare metal cluster on a restricted network](#) for more information about performing a restricted network installation on bare metal infrastructure that you provision.

### 2.2.3. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

#### 2.2.3.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

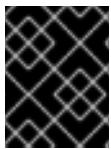
**Table 2.11. Minimum required hosts**

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.



## NOTE

As an exception, you can run zero compute machines in a bare metal cluster that consists of three control plane machines only. This provides smaller, more resource efficient clusters for cluster administrators and developers to use for testing, development, and production. Running one compute machine is not supported.



## IMPORTANT

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

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 8.6 and later.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 9.2 and inherits all of its hardware certifications and requirements. See [Red Hat Enterprise Linux technology capabilities and limits](#).

### 2.2.3.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

**Table 2.12. Minimum resource requirements**

Machine	Operating System	CPU [1]	RAM	Storage	Input/Output Per Second (IOPS) [2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 8.6 and later [3]	2	8 GB	100 GB	300

- One CPU is equivalent to one physical core when simultaneous multithreading (SMT), or Hyper-Threading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = CPUs.
- OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
- As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and has been removed in OpenShift Container Platform 4.10 and later.



## NOTE

For OpenShift Container Platform version 4.18, RHCOS is based on RHEL version 9.4, which updates the micro-architecture requirements. The following list contains the minimum instruction set architectures (ISA) that each architecture requires:

- x86-64 architecture requires x86-64-v2 ISA
- ARM64 architecture requires ARMv8.0-A ISA
- IBM Power architecture requires Power 9 ISA
- s390x architecture requires z14 ISA

For more information, see [Architectures](#) (RHEL documentation).

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

### Additional resources

- [Optimizing storage](#)

#### 2.2.3.3. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

### Additional resources

- See [Configuring a three-node cluster](#) for details about deploying three-node clusters in bare metal environments.
- See [Approving the certificate signing requests for your machines](#) for more information about approving cluster certificate signing requests after installation.

#### 2.2.3.4. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.



## NOTE

- It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.
- If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

### 2.2.3.4.1. Setting the cluster node hostnames through DHCP

On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

### 2.2.3.4.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.



## IMPORTANT

In connected OpenShift Container Platform environments, all nodes are required to have internet access to pull images for platform containers and provide telemetry data to Red Hat.

**Table 2.13. Ports used for all-machine to all-machine communications**

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	<b>1936</b>	Metrics

Protocol	Port	Description
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> and the Cluster Version Operator on port <b>9099</b> .
	<b>10250-10259</b>	The default ports that Kubernetes reserves
UDP	<b>4789</b>	VXLAN
	<b>6081</b>	Geneve
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> .
	<b>500</b>	IPsec IKE packets
	<b>4500</b>	IPsec NAT-T packets
	<b>123</b>	Network Time Protocol (NTP) on UDP port <b>123</b>  If an external NTP time server is configured, you must open UDP port <b>123</b> .
TCP/UDP	<b>30000-32767</b>	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

**Table 2.14. Ports used for all-machine to control plane communications**

Protocol	Port	Description
TCP	<b>6443</b>	Kubernetes API

**Table 2.15. Ports used for control plane machine to control plane machine communications**

Protocol	Port	Description
TCP	<b>2379-2380</b>	etcd server and peer ports

**NTP configuration for user-provisioned infrastructure**

OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for *Configuring chrony time service*.

If a DHCP server provides NTP server information, the chrony time service on the Red Hat Enterprise Linux CoreOS (RHCOS) machines read the information and can sync the clock with the NTP servers.

## Additional resources

- [Configuring chrony time service](#)

### 2.2.3.5. User-provisioned DNS requirements

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API
- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines

Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.



#### NOTE

It is recommended to use a DHCP server to provide the hostnames to each cluster node. See the *DHCP recommendations for user-provisioned infrastructure* section for more information.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, `<cluster_name>` is the cluster name and `<base_domain>` is the base domain that you specify in the `install-config.yaml` file. A complete DNS record takes the form: `<component>.<cluster_name>.<base_domain>..`

**Table 2.16. Required DNS records**

Component	Record	Description
Kubernetes API	<code>api.&lt;cluster_name&gt;.&lt;base_domain&gt;.</code>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.

Component	Record	Description
	<code>api-int.&lt;cluster_name&gt;. &lt;base_domain&gt;.</code>	<p>A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster.</p>  <p><b>IMPORTANT</b></p> <p>The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.</p>
Routes	<code>*.apps.&lt;cluster_name&gt;. &lt;base_domain&gt;.</code>	<p>A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.</p> <p>For example, <code>console-openshift-console.apps. &lt;cluster_name&gt;. &lt;base_domain&gt;</code> is used as a wildcard route to the OpenShift Container Platform console.</p>
Bootstrap machine	<code>bootstrap.&lt;cluster_name&gt;. &lt;base_domain&gt;.</code>	<p>A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.</p>
Control plane machine(s)	<code>&lt;control_plane&gt;&lt;n&gt;. &lt;cluster_name&gt;. &lt;base_domain&gt;.</code>	<p>DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.</p>
Compute machine(s)	<code>&lt;compute&gt;&lt;n&gt;. &lt;cluster_name&gt;. &lt;base_domain&gt;.</code>	<p>DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.</p>



### NOTE

In OpenShift Container Platform 4.4 and later, you do not need to specify etcd host and SRV records in your DNS configuration.

**TIP**

You can use the **dig** command to verify name and reverse name resolution. See the section on *Validating DNS resolution for user-provisioned infrastructure* for detailed validation steps.

#### 2.2.3.5.1. Example DNS configuration for user-provisioned clusters

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is **ocp4** and the base domain is **example.com**.

##### Example DNS A record configuration for a user-provisioned cluster

The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

##### Example 2.4. Sample DNS zone database

```
$TTL 1W
@ IN SOA ns1.example.com. root (
    2019070700 ; serial
    3H ; refresh (3 hours)
    30M ; retry (30 minutes)
    2W ; expiry (2 weeks)
    1W ) ; minimum (1 week)
IN NS ns1.example.com.
IN MX 10 smtp.example.com.
;
;
ns1.example.com. IN A 192.168.1.5
smtp.example.com. IN A 192.168.1.5
;
helper.example.com. IN A 192.168.1.5
helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com. IN A 192.168.1.5 ①
api-int.ocp4.example.com. IN A 192.168.1.5 ②
;
*.apps.ocp4.example.com. IN A 192.168.1.5 ③
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 ④
;
control-plane0.ocp4.example.com. IN A 192.168.1.97 ⑤
control-plane1.ocp4.example.com. IN A 192.168.1.98 ⑥
control-plane2.ocp4.example.com. IN A 192.168.1.99 ⑦
;
compute0.ocp4.example.com. IN A 192.168.1.11 ⑧
compute1.ocp4.example.com. IN A 192.168.1.7 ⑨
;
;EOF
```

**1** Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.

- 2 Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.
- 3 Provides name resolution for the wildcard routes. The record refers to the IP address of the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.

**NOTE**

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

- 4 Provides name resolution for the bootstrap machine.
- 5 6 7 Provides name resolution for the control plane machines.
- 8 9 Provides name resolution for the compute machines.

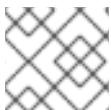
### Example DNS PTR record configuration for a user-provisioned cluster

The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

#### Example 2.5. Sample DNS zone database for reverse records

```
$TTL 1W
@ IN SOA ns1.example.com. root (
    2019070700 ; serial
    3H ; refresh (3 hours)
    30M ; retry (30 minutes)
    2W ; expiry (2 weeks)
    1W ) ; minimum (1 week)
IN NS ns1.example.com.
;
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. ①
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. ②
;
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. ③
;
97.1.168.192.in-addr.arpa. IN PTR control-plane0.ocp4.example.com. ④
98.1.168.192.in-addr.arpa. IN PTR control-plane1.ocp4.example.com. ⑤
99.1.168.192.in-addr.arpa. IN PTR control-plane2.ocp4.example.com. ⑥
;
11.1.168.192.in-addr.arpa. IN PTR compute0.ocp4.example.com. ⑦
7.1.168.192.in-addr.arpa. IN PTR compute1.ocp4.example.com. ⑧
;
;EOF
```

- 1 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.
- 2 Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.
- 3 Provides reverse DNS resolution for the bootstrap machine.
- 4 5 6 Provides reverse DNS resolution for the control plane machines.
- 7 8 Provides reverse DNS resolution for the compute machines.



#### NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard.

- [Validating DNS resolution for user-provisioned infrastructure](#)

#### 2.2.3.6. Load balancing requirements for user-provisioned infrastructure

Before you install OpenShift Container Platform, you must provision the API and application Ingress load balancing infrastructure. In production scenarios, you can deploy the API and application Ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.



#### NOTE

If you want to deploy the API and application Ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer:** Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:
  - Layer 4 load balancing only. This can be referred to as Raw TCP or SSL Passthrough mode.
  - A stateless load balancing algorithm. The options vary based on the load balancer implementation.



#### IMPORTANT

Do not configure session persistence for an API load balancer. Configuring session persistence for a Kubernetes API server might cause performance issues from excess application traffic for your OpenShift Container Platform cluster and the Kubernetes API that runs inside the cluster.

Configure the following ports on both the front and back of the load balancers:

**Table 2.17. API load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
<b>6443</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the <b>/readyz</b> endpoint for the API server health check probe.	X	X	Kubernetes API server
<b>22623</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server



### NOTE

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the **/readyz** endpoint to the removal of the API server instance from the pool. Within the time frame after **/readyz** returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application Ingress load balancer.** Provides an ingress point for application traffic flowing in from outside the cluster. A working configuration for the Ingress router is required for an OpenShift Container Platform cluster.

Configure the following conditions:

- Layer 4 load balancing only. This can be referred to as Raw TCP or SSL Passthrough mode.
- A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

### TIP

If the true IP address of the client can be seen by the application Ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

Configure the following ports on both the front and back of the load balancers:

**Table 2.18. Application Ingress load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
<b>443</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic

Port	Back-end machines (pool members)	Internal	External	Description
<b>80</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic

**NOTE**

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

#### 2.2.3.6.1. Example load balancer configuration for user-provisioned clusters

This section provides an example API and application Ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an **/etc/haproxy/haproxy.cfg** configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing one load balancing solution over another.

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

**NOTE**

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running **setsebool -P haproxy\_connect\_any=1**.

#### Example 2.6. Sample API and application Ingress load balancer configuration

```

global
  log    127.0.0.1 local2
  pidfile /var/run/haproxy.pid
  maxconn 4000
  daemon
defaults
  mode      http
  log       global
  option    dontlognull
  option http-server-close
  option    redispatch
  retries   3
  timeout http-request 10s
  timeout queue     1m
  timeout connect   10s
  timeout client    1m
  timeout server    1m
  timeout http-keep-alive 10s
  timeout check     10s
  maxconn 3000

```

```

listen api-server-6443 ①
  bind *:6443
  mode tcp
  option httpchk GET /readyz HTTP/1.0
  option log-health-checks
  balance roundrobin
  server bootstrap bootstrap.ocp4.example.com:6443 verify none check check-ssl inter 10s fall 2
rise 3 backup ②
  server master0 master0.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
  server master1 master1.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
  server master2 master2.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
listen machine-config-server-22623 ③
  bind *:22623
  mode tcp
  server bootstrap bootstrap.ocp4.example.com:22623 check inter 1s backup ④
    server master0 master0.ocp4.example.com:22623 check inter 1s
    server master1 master1.ocp4.example.com:22623 check inter 1s
    server master2 master2.ocp4.example.com:22623 check inter 1s
listen ingress-router-443 ⑤
  bind *:443
  mode tcp
  balance source
  server compute0 compute0.ocp4.example.com:443 check inter 1s
  server compute1 compute1.ocp4.example.com:443 check inter 1s
listen ingress-router-80 ⑥
  bind *:80
  mode tcp
  balance source
  server compute0 compute0.ocp4.example.com:80 check inter 1s
  server compute1 compute1.ocp4.example.com:80 check inter 1s

```

- ① Port **6443** handles the Kubernetes API traffic and points to the control plane machines.
- ② ④ The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.
- ③ Port **22623** handles the machine config server traffic and points to the control plane machines.
- ⑤ Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.
- ⑥ Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



#### NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

**TIP**

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltpu** on the HAProxy node.

## 2.2.4. Creating a manifest object that includes a customized **br-ex** bridge

As an alternative to using the **configure-ovs.sh** shell script to set a **br-ex** bridge on a bare-metal platform, you can create a **MachineConfig** object that includes an NMState configuration file. The NMState configuration file creates a customized **br-ex** bridge network configuration on each node in your cluster.

Consider the following use cases for creating a manifest object that includes a customized **br-ex** bridge:

- You want to make postinstallation changes to the bridge, such as changing the Open vSwitch (OVS) or OVN-Kubernetes **br-ex** bridge network. The **configure-ovs.sh** shell script does not support making postinstallation changes to the bridge.
- You want to deploy the bridge on a different interface than the interface available on a host or server IP address.
- You want to make advanced configurations to the bridge that are not possible with the **configure-ovs.sh** shell script. Using the script for these configurations might result in the bridge failing to connect multiple network interfaces and facilitating data forwarding between the interfaces.

**NOTE**

If you require an environment with a single network interface controller (NIC) and default network settings, use the **configure-ovs.sh** shell script.

After you install Red Hat Enterprise Linux CoreOS (RHCOS) and the system reboots, the Machine Config Operator injects Ignition configuration files into each node in your cluster, so that each node received the **br-ex** bridge network configuration. To prevent configuration conflicts, the **configure-ovs.sh** shell script receives a signal to not configure the **br-ex** bridge.

### Prerequisites

- Optional: You have installed the **nmstate** API so that you can validate the NMState configuration.

### Procedure

- 1 Create a NMState configuration file that has decoded base64 information for your customized **br-ex** bridge network:

#### Example of an NMState configuration for a customized **br-ex** bridge network

```
interfaces:
  - name: enp2s0 1
    type: ethernet 2
    state: up 3
    ipv4:
```

```

enabled: false 4
ipv6:
  enabled: false
- name: br-ex
  type: ovs-bridge
  state: up
  ipv4:
    enabled: false
    dhcp: false
  ipv6:
    enabled: false
    dhcp: false
  bridge:
    options:
      mcast-snooping-enable: true
    port:
      - name: enp2s0 5
      - name: br-ex
- name: br-ex
  type: ovs-interface
  state: up
  copy-mac-from: enp2s0
  ipv4:
    enabled: true
    dhcp: true
  ipv6:
    enabled: false
    dhcp: false
# ...

```

- 1** Name of the interface.
- 2** The type of ethernet.
- 3** The requested state for the interface after creation.
- 4** Disables IPv4 and IPv6 in this example.
- 5** The node NIC to which the bridge attaches.

2. Use the **cat** command to base64-encode the contents of the NMState configuration:

```
$ cat <nmstate_configuration>.yaml | base64 1
```

- 1** Replace **<nmstate\_configuration>** with the name of your NMState resource YAML file.

3. Create a **MachineConfig** manifest file and define a customized **br-ex** bridge network configuration analogous to the following example:

```

apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker 1

```

```

name: 10-br-ex-worker 2
spec:
config:
ignition:
version: 3.2.0
storage:
files:
- contents:
  source: data:text/plain;charset=utf-8;base64,
<base64_encoded_nmstate_configuration> 3
  mode: 0644
  overwrite: true
  path: /etc/nmstate/openshift/cluster.yml
# ...

```

- 1** For each node in your cluster, specify the hostname path to your node and the base-64 encoded Ignition configuration file data for the machine type. If you have a single global configuration specified in an **/etc/nmstate/openshift/cluster.yml** configuration file that you want to apply to all nodes in your cluster, you do not need to specify the hostname path for each node. The **worker** role is the default role for nodes in your cluster. The **.yaml** extension does not work when specifying the hostname path for each node or all nodes in the **MachineConfig** manifest file.
- 2** The name of the policy.
- 3** Writes the encoded base64 information to the specified path.

#### 2.2.4.1. Scaling each machine set to compute nodes

To apply a customized **br-ex** bridge configuration to all compute nodes in your OpenShift Container Platform cluster, you must edit your **MachineConfig** custom resource (CR) and modify its roles. Additionally, you must create a **BareMetalHost** CR that defines information for your bare-metal machine, such as hostname, credentials, and so on.

After you configure these resources, you must scale machine sets, so that the machine sets can apply the resource configuration to each compute node and reboot the nodes.

#### Prerequisites

- You created a **MachineConfig** manifest object that includes a customized **br-ex** bridge configuration.

#### Procedure

1. Edit the **MachineConfig** CR by entering the following command:

```
$ oc edit mc <machineconfig_custom_resource_name>
```

2. Add each compute node configuration to the CR, so that the CR can manage roles for each defined compute node in your cluster.
3. Create a **Secret** object named **extraworker-secret** that has a minimal static IP configuration.

4. Apply the **extraworker-secret** secret to each node in your cluster by entering the following command. This step provides each compute node access to the Ignition config file.

```
$ oc apply -f ./extraworker-secret.yaml
```

5. Create a **BareMetalHost** resource and specify the network secret in the **preprovisioningNetworkDataName** parameter:

#### Example BareMetalHost resource with an attached network secret

```
apiVersion: metal3.io/v1alpha1
kind: BareMetalHost
spec:
# ...
  preprovisioningNetworkDataName: ostest-extraworker-0-network-config-secret
# ...
```

6. To manage the **BareMetalHost** object within the **openshift-machine-api** namespace of your cluster, change to the namespace by entering the following command:

```
$ oc project openshift-machine-api
```

7. Get the machine sets:

```
$ oc get machinesets
```

8. Scale each machine set by entering the following command. You must run this command for each machine set.

```
$ oc scale machineset <machineset_name> --replicas=<n> ①
```

- ① Where **<machineset\_name>** is the name of the machine set and **<n>** is the number of compute nodes.

### 2.2.5. Preparing the user-provisioned infrastructure

Before you install OpenShift Container Platform on user-provisioned infrastructure, you must prepare the underlying infrastructure.

This section provides details about the high-level steps required to set up your cluster infrastructure in preparation for an OpenShift Container Platform installation. This includes configuring IP networking and network connectivity for your cluster nodes, enabling the required ports through your firewall, and setting up the required DNS and load balancing infrastructure.

After preparation, your cluster infrastructure must meet the requirements outlined in the *Requirements for a cluster with user-provisioned infrastructure* section.

#### Prerequisites

- You have reviewed the [OpenShift Container Platform 4.x Tested Integrations](#) page.
- You have reviewed the infrastructure requirements detailed in the *Requirements for a cluster with user-provisioned infrastructure* section.

## Procedure

1. If you are using DHCP to provide the IP networking configuration to your cluster nodes, configure your DHCP service.
  - a. Add persistent IP addresses for the nodes to your DHCP server configuration. In your configuration, match the MAC address of the relevant network interface to the intended IP address for each node.
  - b. When you use DHCP to configure IP addressing for the cluster machines, the machines also obtain the DNS server information through DHCP. Define the persistent DNS server address that is used by the cluster nodes through your DHCP server configuration.



### NOTE

If you are not using a DHCP service, you must provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

- c. Define the hostnames of your cluster nodes in your DHCP server configuration. See the *Setting the cluster node hostnames through DHCP* section for details about hostname considerations.



### NOTE

If you are not using a DHCP service, the cluster nodes obtain their hostname through a reverse DNS lookup.

2. Ensure that your network infrastructure provides the required network connectivity between the cluster components. See the *Networking requirements for user-provisioned infrastructure* section for details about the requirements.
3. Configure your firewall to enable the ports required for the OpenShift Container Platform cluster components to communicate. See *Networking requirements for user-provisioned infrastructure* section for details about the ports that are required.



### IMPORTANT

By default, port **1936** is accessible for an OpenShift Container Platform cluster, because each control plane node needs access to this port.

Avoid using the Ingress load balancer to expose this port, because doing so might result in the exposure of sensitive information, such as statistics and metrics, related to Ingress Controllers.

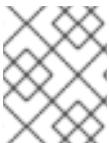
4. Setup the required DNS infrastructure for your cluster.
  - a. Configure DNS name resolution for the Kubernetes API, the application wildcard, the bootstrap machine, the control plane machines, and the compute machines.
  - b. Configure reverse DNS resolution for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

See the *User-provisioned DNS requirements* section for more information about the OpenShift Container Platform DNS requirements.

5. Validate your DNS configuration.

- a. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses in the responses correspond to the correct components.
  - b. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names in the responses correspond to the correct components.
- See the *Validating DNS resolution for user-provisioned infrastructure* section for detailed DNS validation steps.

6. Provision the required API and application ingress load balancing infrastructure. See the *Load balancing requirements for user-provisioned infrastructure* section for more information about the requirements.



**NOTE**

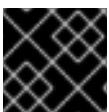
Some load balancing solutions require the DNS name resolution for the cluster nodes to be in place before the load balancing is initialized.

#### Additional resources

- [Requirements for a cluster with user-provisioned infrastructure](#)
- [Installing RHCOS and starting the OpenShift Container Platform bootstrap process](#)
- [Setting the cluster node hostnames through DHCP](#)
- [Advanced RHCOS installation configuration](#)
- [Networking requirements for user-provisioned infrastructure](#)
- [User-provisioned DNS requirements](#)
- [Validating DNS resolution for user-provisioned infrastructure](#)
- [Load balancing requirements for user-provisioned infrastructure](#)

#### 2.2.6. Validating DNS resolution for user-provisioned infrastructure

You can validate your DNS configuration before installing OpenShift Container Platform on user-provisioned infrastructure.



**IMPORTANT**

The validation steps detailed in this section must succeed before you install your cluster.

#### Prerequisites

- You have configured the required DNS records for your user-provisioned infrastructure.

## Procedure

- From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses contained in the responses correspond to the correct components.

- Perform a lookup against the Kubernetes API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api.<cluster_name>.<base_domain> 1
```

- 1 Replace **<nameserver\_ip>** with the IP address of the nameserver, **<cluster\_name>** with your cluster name, and **<base\_domain>** with your base domain name.

### Example output

```
api.ocp4.example.com. 604800 IN A 192.168.1.5
```

- Perform a lookup against the Kubernetes internal API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api-int.<cluster_name>.<base_domain>
```

### Example output

```
api-int.ocp4.example.com. 604800 IN A 192.168.1.5
```

- Test an example **\*.apps.<cluster\_name>.<base\_domain>** DNS wildcard lookup. All of the application wildcard lookups must resolve to the IP address of the application ingress load balancer:

```
$ dig +noall +answer @<nameserver_ip> random.apps.<cluster_name>.<base_domain>
```

### Example output

```
random.apps.ocp4.example.com. 604800 IN A 192.168.1.5
```



### NOTE

In the example outputs, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

You can replace **random** with another wildcard value. For example, you can query the route to the OpenShift Container Platform console:

```
$ dig +noall +answer @<nameserver_ip> console-openshift-console.apps.<cluster_name>.<base_domain>
```

### Example output

console-openshift-console.apps.ocp4.example.com. 604800 IN A 192.168.1.5

- d. Run a lookup against the bootstrap DNS record name. Check that the result points to the IP address of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> bootstrap.<cluster_name>.<base_domain>
```

### Example output

bootstrap.ocp4.example.com. 604800 IN A 192.168.1.96

- e. Use this method to perform lookups against the DNS record names for the control plane and compute nodes. Check that the results correspond to the IP addresses of each node.
2. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names contained in the responses correspond to the correct components.
  - a. Perform a reverse lookup against the IP address of the API load balancer. Check that the response includes the record names for the Kubernetes API and the Kubernetes internal API:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.5
```

### Example output

5.1.168.192.in-addr.arpa. 604800 IN PTR api-int.ocp4.example.com. ①  
 5.1.168.192.in-addr.arpa. 604800 IN PTR api.ocp4.example.com. ②

① Provides the record name for the Kubernetes internal API.

② Provides the record name for the Kubernetes API.



### NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard. No validation step is needed for reverse DNS resolution against the IP address of the application ingress load balancer.

- b. Perform a reverse lookup against the IP address of the bootstrap node. Check that the result points to the DNS record name of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.96
```

### Example output

96.1.168.192.in-addr.arpa. 604800 IN PTR bootstrap.ocp4.example.com.

- c. Use this method to perform reverse lookups against the IP addresses for the control plane and compute nodes. Check that the results correspond to the DNS record names of each node.

## Additional resources

- [User-provisioned DNS requirements](#)
- [Load balancing requirements for user-provisioned infrastructure](#)

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

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

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

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



#### IMPORTANT

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



#### NOTE

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

## Procedure

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

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

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



#### NOTE

If you plan to install an OpenShift Container Platform cluster that uses the RHEL cryptographic libraries that have been submitted to NIST for FIPS 140-2/140-3 Validation on only the **x86\_64**, **ppc64le**, and **s390x** architectures, do not create a key that uses the **ed25519** algorithm. Instead, create a key that uses the **rsa** or **ecdsa** algorithm.

2. View the public SSH key:

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

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

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

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



#### NOTE

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

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

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

#### Example output

```
Agent pid 31874
```



#### NOTE

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

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

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

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

#### Example output

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

### Next steps

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

### Additional resources

- [Verifying node health](#)

## 2.2.8. Obtaining the installation program

Before you install OpenShift Container Platform, download the installation file on the host you are using for installation.

## Prerequisites

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

## Procedure

1. Go to the [Cluster Type](#) page on the Red Hat Hybrid Cloud Console. If you have a Red Hat account, log in with your credentials. If you do not, create an account.

### TIP

You can also [download the binaries for a specific OpenShift Container Platform release](#).

2. Select your infrastructure provider from the **Run it yourself** section of the page.
3. Select your host operating system and architecture from the dropdown menus under **OpenShift Installer** and click **Download Installer**.
4. Place the downloaded file in the directory where you want to store the installation configuration files.



### IMPORTANT

- The installation program creates several files on the computer that you use to install your cluster. You must keep the installation program and the files that the installation program creates after you finish installing the cluster. Both of the files are required to delete the cluster.
- Deleting the files created by the installation program does not remove your cluster, even if the cluster failed during installation. To remove your cluster, complete the OpenShift Container Platform uninstallation procedures for your specific cloud provider.

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

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

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

### TIP

Alternatively, you can retrieve the installation program from the [Red Hat Customer Portal](#), where you can specify a version of the installation program to download. However, you must have an active subscription to access this page.

### 2.2.9. Installing the OpenShift CLI

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



## IMPORTANT

If you installed an earlier version of **oc**, you cannot use it to complete all of the commands in OpenShift Container Platform 4.18. Download and install the new version of **oc**.

### Installing the OpenShift CLI on Linux

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

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the architecture from the **Product Variant** drop-down list.
3. Select the appropriate version from the **Version** drop-down list.
4. Click **Download Now** next to the **OpenShift v4.18 Linux Clients** entry and save the file.
5. Unpack the archive:

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

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

```
$ echo $PATH
```

#### Verification

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

```
$ oc <command>
```

### Installing the OpenShift CLI on Windows

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

#### Procedure

1. Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
2. Select the appropriate version from the **Version** drop-down list.
3. Click **Download Now** next to the **OpenShift v4.18 Windows Client** entry and save the file.
4. Unzip the archive with a ZIP program.
5. Move the **oc** binary to a directory that is on your **PATH**.  
To check your **PATH**, open the command prompt and execute the following command:

```
C:> path
```

## Verification

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

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

### Installing the OpenShift CLI on macOS

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

#### Procedure

- Navigate to the [OpenShift Container Platform downloads page](#) on the Red Hat Customer Portal.
- Select the appropriate version from the **Version** drop-down list.
- Click **Download Now** next to the **OpenShift v4.18 macOS Clients** entry and save the file.



#### NOTE

For macOS arm64, choose the **OpenShift v4.18 macOS arm64 Client** entry.

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

```
$ echo $PATH
```

## Verification

- Verify your installation by using an **oc** command:

```
$ oc <command>
```

### 2.2.10. Manually creating the installation configuration file

Installing the cluster requires that you manually create the installation configuration file.

#### Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.

#### Procedure

- 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.

- Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation\_directory>**.



## NOTE

You must name this configuration file **install-config.yaml**.

- 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.

## Additional resources

- [Installation configuration parameters for bare metal](#)

### 2.2.10.1. Sample **install-config.yaml** file for bare metal

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

```
apiVersion: v1
baseDomain: example.com 1
compute: 2
- hyperthreading: Enabled 3
  name: worker
  replicas: 0 4
controlPlane: 5
  hyperthreading: Enabled 6
  name: master
  replicas: 3 7
metadata:
  name: test 8
networking:
  clusterNetwork:
    - cidr: 10.128.0.0/14 9
      hostPrefix: 23 10
  networkType: OVNKubernetes 11
  serviceNetwork:
    - 172.30.0.0/16
platform:
```

```

none: {} 13
fips: false 14
pullSecret: '{"auths": ...}' 15
sshKey: 'ssh-ed25519 AAAA...' 16

```

- 1** The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.
- 2** **5** The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. Only one control plane pool is used.
- 3** **6** Specifies whether to enable or disable simultaneous multithreading (SMT), or hyperthreading. By default, SMT is enabled to increase the performance of the cores in your machines. You can disable it by setting the parameter value to **Disabled**. If you disable SMT, you must disable it in all cluster machines; this includes both control plane and compute machines.



#### NOTE

Simultaneous multithreading (SMT) is enabled by default. If SMT is not enabled in your BIOS settings, the **hyperthreading** parameter has no effect.



#### IMPORTANT

If you disable **hyperthreading**, whether in the BIOS or in the **install-config.yaml** file, ensure that your capacity planning accounts for the dramatically decreased machine performance.

- 4** You must set this value to **0** when you install OpenShift Container Platform on user-provisioned infrastructure. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. In user-provisioned installations, you must manually deploy the compute machines before you finish installing the cluster.



#### NOTE

If you are installing a three-node cluster, do not deploy any compute machines when you install the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

- 7** The number of control plane machines that you add to the cluster. Because the cluster uses these values as the number of etcd endpoints in the cluster, the value must match the number of control plane machines that you deploy.
- 8** The cluster name that you specified in your DNS records.
- 9** A block of IP addresses from which pod IP addresses are allocated. This block must not overlap with existing physical networks. These IP addresses are used for the pod network. If you need to access the pods from an external network, you must configure load balancers and routers to manage the traffic.



### NOTE

Class E CIDR range is reserved for a future use. To use the Class E CIDR range, you must ensure your networking environment accepts the IP addresses within the Class E CIDR range.

- 10 The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23**, then each node is assigned a /23 subnet out of the given **cidr**, which allows for 510 ( $2^{(32 - 23)} - 2$ ) pod IP addresses. If you are required to provide access to nodes from an external network, configure load balancers and routers to manage the traffic.
- 11 The cluster network plugin to install. The default value **OVNKubernetes** is the only supported value.
- 12 The IP address pool to use for service IP addresses. You can enter only one IP address pool. This block must not overlap with existing physical networks. If you need to access the services from an external network, configure load balancers and routers to manage the traffic.
- 13 You must set the platform to **none**. You cannot provide additional platform configuration variables for your platform.



### IMPORTANT

Clusters that are installed with the platform type **none** are unable to use some features, such as managing compute machines with the Machine API. This limitation applies even if the compute machines that are attached to the cluster are installed on a platform that would normally support the feature. This parameter cannot be changed after installation.

- 14 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.

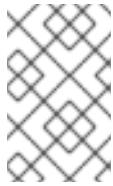


### IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see [Switching RHEL to FIPS mode](#).

When running Red Hat Enterprise Linux (RHEL) or Red Hat Enterprise Linux CoreOS (RHCOS) booted in FIPS mode, OpenShift Container Platform core components use the RHEL cryptographic libraries that have been submitted to NIST for FIPS 140-2/140-3 Validation on only the x86\_64, ppc64le, and s390x architectures.

- 15 The [pull secret from Red Hat OpenShift Cluster Manager](#). This pull secret allows you to authenticate with the services that are provided by the included authorities, including Quay.io, which serves the container images for OpenShift Container Platform components.
- 16 The SSH public key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).

**NOTE**

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

**Additional resources**

- See [Load balancing requirements for user-provisioned infrastructure](#) for more information on the API and application ingress load balancing requirements.

### 2.2.11. Network configuration phases

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

**Phase 1**

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

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

For more information, see "Installation configuration parameters".

**NOTE**

Set the **networking.machineNetwork** to match the Classless Inter-Domain Routing (CIDR) where the preferred subnet is located.

**IMPORTANT**

The CIDR range **172.17.0.0/16** is reserved by **libVirt**. You cannot use any other CIDR range that overlaps with the **172.17.0.0/16** CIDR range for networks in your cluster.

**Phase 2**

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

During phase 2, you cannot override the values that you specified in phase 1 in the **install-config.yaml** file. However, you can customize the network plugin during phase 2.

### 2.2.12. Specifying advanced network configuration

You can use advanced network configuration for your network plugin to integrate your cluster into your existing network environment.

You can specify advanced network configuration only before you install the cluster.



## IMPORTANT

Customizing your network configuration by modifying the OpenShift Container Platform manifest files created by the installation program is not supported. Applying a manifest file that you create, as in the following procedure, is supported.

### Prerequisites

- You have created the **install-config.yaml** file and completed any modifications to it.

### Procedure

1. Change to the directory that contains the installation program and create the manifests:

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

- ① **<installation\_directory>** specifies the name of the directory that contains the **install-config.yaml** file for your cluster.

2. Create a stub manifest file for the advanced network configuration that is named **cluster-network-03-config.yaml** in the **<installation\_directory>/manifests** directory:

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
```

3. Specify the advanced network configuration for your cluster in the **cluster-network-03-config.yaml** file, such as in the following example:

#### Enable IPsec for the OVN-Kubernetes network provider

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  defaultNetwork:
    ovnKubernetesConfig:
      ipsecConfig:
        mode: Full
```

4. Optional: Back up the **manifests/cluster-network-03-config.yaml** file. The installation program consumes the **manifests/** directory when you create the Ignition config files.
5. Remove the Kubernetes manifest files that define the control plane machines and compute **MachineSets**:

```
$ rm -f openshift/99_openshift-cluster-api_master-machines-*.yaml openshift/99_openshift-cluster-api_worker-machineset-*.yaml
```

Because you create and manage these resources yourself, you do not have to initialize them.

- You can preserve the **MachineSet** files to create compute machines by using the machine API, but you must update references to them to match your environment.

### 2.2.13. Cluster Network Operator configuration

The configuration for the cluster network is specified as part of the Cluster Network Operator (CNO) configuration and stored in a custom resource (CR) object that is named **cluster**. The CR specifies the fields for the **Network** API in the **operator.openshift.io** API group.

The CNO configuration inherits the following fields during cluster installation from the **Network** API in the **Network.config.openshift.io** API group:

#### **clusterNetwork**

IP address pools from which pod IP addresses are allocated.

#### **serviceNetwork**

IP address pool for services.

#### **defaultNetwork.type**

Cluster network plugin. **OVNKubernetes** is the only supported plugin during installation.

You can specify the cluster network plugin configuration for your cluster by setting the fields for the **defaultNetwork** object in the CNO object named **cluster**.

#### 2.2.13.1. Cluster Network Operator configuration object

The fields for the Cluster Network Operator (CNO) are described in the following table:

**Table 2.19. Cluster Network Operator configuration object**

Field	Type	Description
<b>metadata.name</b>	<b>string</b>	The name of the CNO object. This name is always <b>cluster</b> .
<b>spec.clusterNetwork</b>	<b>array</b>	A list specifying the blocks of IP addresses from which pod IP addresses are allocated and the subnet prefix length assigned to each individual node in the cluster. For example:  <pre>spec:   clusterNetwork:     - cidr: 10.128.0.0/19       hostPrefix: 23     - cidr: 10.128.32.0/19       hostPrefix: 23</pre>

Field	Type	Description
<b>spec.serviceNetwork</b>	<b>array</b>	<p>A block of IP addresses for services. The OVN-Kubernetes network plugin supports only a single IP address block for the service network. For example:</p> <pre>spec:   serviceNetwork:     - 172.30.0.0/14</pre> <p>You can customize this field only in the <b>install-config.yaml</b> file before you create the manifests. The value is read-only in the manifest file.</p>
<b>spec.defaultNetwork</b>	<b>object</b>	Configures the network plugin for the cluster network.
<b>spec.kubeProxyConfig</b>	<b>object</b>	The fields for this object specify the kube-proxy configuration. If you are using the OVN-Kubernetes cluster network plugin, the kube-proxy configuration has no effect.



## IMPORTANT

For a cluster that needs to deploy objects across multiple networks, ensure that you specify the same value for the **clusterNetwork.hostPrefix** parameter for each network type that is defined in the **install-config.yaml** file. Setting a different value for each **clusterNetwork.hostPrefix** parameter can impact the OVN-Kubernetes network plugin, where the plugin cannot effectively route object traffic among different nodes.

### defaultNetwork object configuration

The values for the **defaultNetwork** object are defined in the following table:

Table 2.20. **defaultNetwork** object

Field	Type	Description
<b>type</b>	<b>string</b>	<p><b>OVNKubernetes.</b> The Red Hat OpenShift Networking network plugin is selected during installation. This value cannot be changed after cluster installation.</p> <p> <b>NOTE</b></p> <p>OpenShift Container Platform uses the OVN-Kubernetes network plugin by default.</p>
<b>ovnKubernetesConfig</b>	<b>object</b>	This object is only valid for the OVN-Kubernetes network plugin.

## Configuration for the OVN-Kubernetes network plugin

The following table describes the configuration fields for the OVN-Kubernetes network plugin:

**Table 2.21. ovnKubernetesConfig object**

Field	Type	Description
<b>mtu</b>	<b>integer</b>	<p>The maximum transmission unit (MTU) for the Geneve (Generic Network Virtualization Encapsulation) overlay network. This is detected automatically based on the MTU of the primary network interface. You do not normally need to override the detected MTU.</p> <p>If the auto-detected value is not what you expect it to be, confirm that the MTU on the primary network interface on your nodes is correct. You cannot use this option to change the MTU value of the primary network interface on the nodes.</p> <p>If your cluster requires different MTU values for different nodes, you must set this value to <b>100</b> less than the lowest MTU value in your cluster. For example, if some nodes in your cluster have an MTU of <b>9001</b>, and some have an MTU of <b>1500</b>, you must set this value to <b>1400</b>.</p>
<b>genevePort</b>	<b>integer</b>	The port to use for all Geneve packets. The default value is <b>6081</b> . This value cannot be changed after cluster installation.
<b>ipsecConfig</b>	<b>object</b>	Specify a configuration object for customizing the IPsec configuration.
<b>ipv4</b>	<b>object</b>	Specifies a configuration object for IPv4 settings.
<b>ipv6</b>	<b>object</b>	Specifies a configuration object for IPv6 settings.
<b>policyAuditConfig</b>	<b>object</b>	Specify a configuration object for customizing network policy audit logging. If unset, the defaults audit log settings are used.
<b>gatewayConfig</b>	<b>object</b>	<p>Optional: Specify a configuration object for customizing how egress traffic is sent to the node gateway. Valid values are <b>Shared</b> and <b>Local</b>. The default value is <b>Shared</b>. In the default setting, the Open vSwitch (OVS) outputs traffic directly to the node IP interface. In the <b>Local</b> setting, it traverses the host network; consequently, it gets applied to the routing table of the host.</p>  <p><b>NOTE</b></p> <p>While migrating egress traffic, you can expect some disruption to workloads and service traffic until the Cluster Network Operator (CNO) successfully rolls out the changes.</p>

Table 2.22. ovnKubernetesConfig.ipv4 object

Field	Type	Description
<b>internalTransitSwitchSubnet</b>	string	If your existing network infrastructure overlaps with the <b>100.88.0.0/16</b> IPv4 subnet, you can specify a different IP address range for internal use by OVN-Kubernetes. The subnet for the distributed transit switch that enables east-west traffic. This subnet cannot overlap with any other subnets used by OVN-Kubernetes or on the host itself. It must be large enough to accommodate one IP address per node in your cluster.  The default value is <b>100.88.0.0/16</b> .
<b>internalJoinSubnet</b>	string	If your existing network infrastructure overlaps with the <b>100.64.0.0/16</b> IPv4 subnet, you can specify a different IP address range for internal use by OVN-Kubernetes. You must ensure that the IP address range does not overlap with any other subnet used by your OpenShift Container Platform installation. The IP address range must be larger than the maximum number of nodes that can be added to the cluster. For example, if the <b>clusterNetwork.cidr</b> value is <b>10.128.0.0/14</b> and the <b>clusterNetwork.hostPrefix</b> value is <b>/23</b> , then the maximum number of nodes is <b>2^(23-14)=512</b> .  The default value is <b>100.64.0.0/16</b> .

Table 2.23. ovnKubernetesConfig.ipv6 object

Field	Type	Description
<b>internalTransitSwitchSubnet</b>	string	If your existing network infrastructure overlaps with the <b>fd97::/64</b> IPv6 subnet, you can specify a different IP address range for internal use by OVN-Kubernetes. The subnet for the distributed transit switch that enables east-west traffic. This subnet cannot overlap with any other subnets used by OVN-Kubernetes or on the host itself. It must be large enough to accommodate one IP address per node in your cluster.  The default value is <b>fd97::/64</b> .
<b>internalJoinSubnet</b>	string	If your existing network infrastructure overlaps with the <b>fd98::/64</b> IPv6 subnet, you can specify a different IP address range for internal use by OVN-Kubernetes. You must ensure that the IP address range does not overlap with any other subnet used by your OpenShift Container Platform installation. The IP address range must be larger than the maximum number of nodes that can be added to the cluster.  The default value is <b>fd98::/64</b> .

Table 2.24. policyAuditConfig object

Field	Type	Description
<b>rateLimit</b>	integer	The maximum number of messages to generate every second per node. The default value is <b>20</b> messages per second.
<b>maxFileSize</b>	integer	The maximum size for the audit log in bytes. The default value is <b>50000000</b> or 50 MB.
<b>maxLogFiles</b>	integer	The maximum number of log files that are retained.
<b>destination</b>	string	<p>One of the following additional audit log targets:</p> <p><b>libc</b>  The libc <b>syslog()</b> function of the journald process on the host.</p> <p><b>udp:&lt;host&gt;:&lt;port&gt;</b>  A syslog server. Replace <b>&lt;host&gt;:&lt;port&gt;</b> with the host and port of the syslog server.</p> <p><b>unix:&lt;file&gt;</b>  A Unix Domain Socket file specified by <b>&lt;file&gt;</b>.</p> <p><b>null</b>  Do not send the audit logs to any additional target.</p>
<b>syslogFacility</b>	string	The syslog facility, such as <b>kern</b> , as defined by RFC5424. The default value is <b>local0</b> .

Table 2.25. **gatewayConfig** object

Field	Type	Description
<b>routingViaHost</b>	<b>boolean</b>	<p>Set this field to <b>true</b> to send egress traffic from pods to the host networking stack. For highly-specialized installations and applications that rely on manually configured routes in the kernel routing table, you might want to route egress traffic to the host networking stack. By default, egress traffic is processed in OVN to exit the cluster and is not affected by specialized routes in the kernel routing table. The default value is <b>false</b>.</p> <p>This field has an interaction with the Open vSwitch hardware offloading feature. If you set this field to <b>true</b>, you do not receive the performance benefits of the offloading because egress traffic is processed by the host networking stack.</p>

Field	Type	Description
<b>ipForwarding</b>	<b>object</b>	<p>You can control IP forwarding for all traffic on OVN-Kubernetes managed interfaces by using the <b>ipForwarding</b> specification in the <b>Network</b> resource. Specify <b>Restricted</b> to only allow IP forwarding for Kubernetes related traffic. Specify <b>Global</b> to allow forwarding of all IP traffic. For new installations, the default is <b>Restricted</b>. For updates to OpenShift Container Platform 4.14 or later, the default is <b>Global</b>.</p>  <p><b>NOTE</b></p> <p>The default value of <b>Restricted</b> sets the IP forwarding to drop.</p>
<b>ipv4</b>	<b>object</b>	<p>Optional: Specify an object to configure the internal OVN-Kubernetes masquerade address for host to service traffic for IPv4 addresses.</p>
<b>ipv6</b>	<b>object</b>	<p>Optional: Specify an object to configure the internal OVN-Kubernetes masquerade address for host to service traffic for IPv6 addresses.</p>

Table 2.26. `gatewayConfig.ipv4` object

Field	Type	Description
<b>internalMasqueradeSubnet</b>	<b>string</b>	<p>The masquerade IPv4 addresses that are used internally to enable host to service traffic. The host is configured with these IP addresses as well as the shared gateway bridge interface. The default value is <b>169.254.169.0/29</b>.</p>  <p><b>IMPORTANT</b></p> <p>For OpenShift Container Platform 4.17 and later versions, clusters use <b>169.254.0.0/17</b> as the default masquerade subnet. For upgraded clusters, there is no change to the default masquerade subnet.</p>

Table 2.27. `gatewayConfig.ipv6` object

Field	Type	Description
-------	------	-------------

Field	Type	Description
<b>internalMasqueradeSubnet</b>	<b>string</b>	<p>The masquerade IPv6 addresses that are used internally to enable host to service traffic. The host is configured with these IP addresses as well as the shared gateway bridge interface. The default value is <b>fd69::/125</b>.</p>  <p><b>IMPORTANT</b></p> <p>For OpenShift Container Platform 4.17 and later versions, clusters use <b>fd69::/112</b> as the default masquerade subnet. For upgraded clusters, there is no change to the default masquerade subnet.</p>

Table 2.28. ipsecConfig object

Field	Type	Description
<b>mode</b>	<b>string</b>	<p>Specifies the behavior of the IPsec implementation. Must be one of the following values:</p> <ul style="list-style-type: none"> <li>• <b>Disabled</b>: IPsec is not enabled on cluster nodes.</li> <li>• <b>External</b>: IPsec is enabled for network traffic with external hosts.</li> <li>• <b>Full</b>: IPsec is enabled for pod traffic and network traffic with external hosts.</li> </ul>

### Example OVN-Kubernetes configuration with IPSec enabled

```
defaultNetwork:
  type: OVNKubernetes
  ovnKubernetesConfig:
    mtu: 1400
    genevePort: 6081
    ipsecConfig:
      mode: Full
```

#### 2.2.14. Creating the Ignition config files

Because you must manually start the cluster machines, you must generate the Ignition config files that the cluster needs to make its machines.



## IMPORTANT

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

## Prerequisites

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

## Procedure

- Obtain the Ignition config files:

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

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



## IMPORTANT

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

The following files are generated in the directory:

```

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

```

## 2.2.15. Installing RHCOS and starting the OpenShift Container Platform bootstrap process

To install OpenShift Container Platform on bare metal infrastructure that you provision, you must install Red Hat Enterprise Linux CoreOS (RHCOS) on the machines. When you install RHCOS, you must provide the Ignition config file that was generated by the OpenShift Container Platform installation program for the type of machine you are installing. If you have configured suitable networking, DNS, and load balancing infrastructure, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS machines have rebooted.

To install RHCOS on the machines, follow either the steps to use an ISO image or network PXE booting.



### NOTE

The compute node deployment steps included in this installation document are RHCOS-specific. If you choose instead to deploy RHEL-based compute nodes, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Only RHEL 8 compute machines are supported.

You can configure RHCOS during ISO and PXE installations by using the following methods:

- Kernel arguments: You can use kernel arguments to provide installation-specific information. For example, you can specify the locations of the RHCOS installation files that you uploaded to your HTTP server and the location of the Ignition config file for the type of node you are installing. For a PXE installation, you can use the **APPEND** parameter to pass the arguments to the kernel of the live installer. For an ISO installation, you can interrupt the live installation boot process to add the kernel arguments. In both installation cases, you can use special **coreos.inst.\*** arguments to direct the live installer, as well as standard installation boot arguments for turning standard kernel services on or off.
- Ignition configs: OpenShift Container Platform Ignition config files (**\*.ign**) are specific to the type of node you are installing. You pass the location of a bootstrap, control plane, or compute node Ignition config file during the RHCOS installation so that it takes effect on first boot. In special cases, you can create a separate, limited Ignition config to pass to the live system. That Ignition config could do a certain set of tasks, such as reporting success to a provisioning system after completing installation. This special Ignition config is consumed by the **coreos-installer** to be applied on first boot of the installed system. Do not provide the standard control plane and compute node Ignition configs to the live ISO directly.
- coreos-installer**: You can boot the live ISO installer to a shell prompt, which allows you to prepare the permanent system in a variety of ways before first boot. In particular, you can run the **coreos-installer** command to identify various artifacts to include, work with disk partitions, and set up networking. In some cases, you can configure features on the live system and copy them to the installed system.

Whether to use an ISO or PXE install depends on your situation. A PXE install requires an available DHCP service and more preparation, but can make the installation process more automated. An ISO install is a more manual process and can be inconvenient if you are setting up more than a few machines.

### 2.2.15.1. Installing RHCOS by using an ISO image

You can use an ISO image to install RHCOS on the machines.

#### Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have an HTTP server that can be accessed from your computer, and from the machines that you create.
- You have reviewed the *Advanced RHCOS installation configuration* section for different ways to configure features, such as networking and disk partitioning.

## Procedure

1. Obtain the SHA512 digest for each of your Ignition config files. For example, you can use the following on a system running Linux to get the SHA512 digest for your **bootstrap.ign** Ignition config file:

```
$ sha512sum <installation_directory>/bootstrap.ign
```

The digests are provided to the **coreos-installer** in a later step to validate the authenticity of the Ignition config files on the cluster nodes.

2. Upload the bootstrap, control plane, and compute node Ignition config files that the installation program created to your HTTP server. Note the URLs of these files.



### IMPORTANT

You can add or change configuration settings in your Ignition configs before saving them to your HTTP server. If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

3. From the installation host, validate that the Ignition config files are available on the URLs. The following example gets the Ignition config file for the bootstrap node:

```
$ curl -k http://<HTTP_server>/bootstrap.ign ①
```

### Example output

```
% Total % Received % Xferd Average Speed Time Time Time Current
          Dload Upload Total Spent Left Speed
0 0 0 0 0 0 0 --:--:--:--:--:--:--:--:-- 0{"ignition": {"version": "3.2.0"}, "passwd": {"users": [{"name": "core", "sshAuthorizedKeys": ["ssh-rsa..."]}}
```

Replace **bootstrap.ign** with **master.ign** or **worker.ign** in the command to validate that the Ignition config files for the control plane and compute nodes are also available.

4. Although it is possible to obtain the RHCOS images that are required for your preferred method of installing operating system instances from the [RHCOS image mirror](#) page, the recommended way to obtain the correct version of your RHCOS images are from the output of **openshift-install** command:

```
$ openshift-install coreos print-stream-json | grep "\.iso[^.]"
```

### Example output

```
"location": "<url>/art/storage/releases/rhcos-4.18-aarch64/<release>/aarch64/rhcos-<release>-live.aarch64.iso",
"location": "<url>/art/storage/releases/rhcos-4.18-ppc64le/<release>/ppc64le/rhcos-<release>-live.ppc64le.iso",
"location": "<url>/art/storage/releases/rhcos-4.18-s390x/<release>/s390x/rhcos-<release>-live.s390x.iso",
"location": "<url>/art/storage/releases/rhcos-4.18/<release>/x86_64/rhcos-<release>-live.x86_64.iso",
```



## IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image versions that match your OpenShift Container Platform version if they are available. Use only ISO images for this procedure. RHCOS qcow2 images are not supported for this installation type.

ISO file names resemble the following example:

**rhcos-<version>-live.<architecture>.iso**

5. Use the ISO to start the RHCOS installation. Use one of the following installation options:
  - Burn the ISO image to a disk and boot it directly.
  - Use ISO redirection by using a lights-out management (LOM) interface.
6. Boot the RHCOS ISO image without specifying any options or interrupting the live boot sequence. Wait for the installer to boot into a shell prompt in the RHCOS live environment.



## NOTE

It is possible to interrupt the RHCOS installation boot process to add kernel arguments. However, for this ISO procedure you should use the **coreos-installer** command as outlined in the following steps, instead of adding kernel arguments.

7. Run the **coreos-installer** command and specify the options that meet your installation requirements. At a minimum, you must specify the URL that points to the Ignition config file for the node type, and the device that you are installing to:

```
$ sudo coreos-installer install --ignition-url=http://<HTTP_server>/<node_type>.ign <device>
\ 1
--ignition-hash=sha512-<digest> 2
```

**1** You must run the **coreos-installer** command by using **sudo**, because the **core** user does not have the required root privileges to perform the installation.

**2** The **--ignition-hash** option is required when the Ignition config file is obtained through an HTTP URL to validate the authenticity of the Ignition config file on the cluster node. **<digest>** is the Ignition config file SHA512 digest obtained in a preceding step.



## NOTE

If you want to provide your Ignition config files through an HTTPS server that uses TLS, you can add the internal certificate authority (CA) to the system trust store before running **coreos-installer**.

The following example initializes a bootstrap node installation to the **/dev/sda** device. The Ignition config file for the bootstrap node is obtained from an HTTP web server with the IP address 192.168.1.2:

```
$ sudo coreos-installer install --ignition-
url=http://192.168.1.2:80/installation_directory/bootstrap.ign /dev/sda \
--ignition-hash=sha512-
a5a2d43879223273c9b60af66b44202a1d1248fc01cf156c46d4a79f552b6bad47bc8cc78ddf011
6e80c59d2ea9e32ba53bc807afbca581aa059311def2c3e3b
```

8. Monitor the progress of the RHCOS installation on the console of the machine.



## IMPORTANT

Be sure that the installation is successful on each node before commencing with the OpenShift Container Platform installation. Observing the installation process can also help to determine the cause of RHCOS installation issues that might arise.

9. After RHCOS installs, you must reboot the system. During the system reboot, it applies the Ignition config file that you specified.
10. Check the console output to verify that Ignition ran.

### Example command

```
Ignition: ran on 2022/03/14 14:48:33 UTC (this boot)
Ignition: user-provided config was applied
```

11. Continue to create the other machines for your cluster.



## IMPORTANT

You must create the bootstrap and control plane machines at this time. If the control plane machines are not made schedulable, also create at least two compute machines before you install OpenShift Container Platform.

If the required network, DNS, and load balancer infrastructure are in place, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS nodes have rebooted.



## NOTE

RHCOS nodes do not include a default password for the **core** user. You can access the nodes by running `ssh core@<node>.<cluster_name>`. **<base\_domain>** as a user with access to the SSH private key that is paired to the public key that you specified in your `install_config.yaml` file. OpenShift Container Platform 4 cluster nodes running RHCOS are immutable and rely on Operators to apply cluster changes. Accessing cluster nodes by using SSH is not recommended. However, when investigating installation issues, if the OpenShift Container Platform API is not available, or the kubelet is not properly functioning on a target node, SSH access might be required for debugging or disaster recovery.

### 2.2.15.2. Installing RHCOS by using PXE or iPXE booting

You can use PXE or iPXE booting to install RHCOS on the machines.

#### Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have configured suitable PXE or iPXE infrastructure.
- You have an HTTP server that can be accessed from your computer, and from the machines that you create.
- You have reviewed the *Advanced RHCOS installation configuration* section for different ways to configure features, such as networking and disk partitioning.

#### Procedure

1. Upload the bootstrap, control plane, and compute node Ignition config files that the installation program created to your HTTP server. Note the URLs of these files.



## IMPORTANT

You can add or change configuration settings in your Ignition configs before saving them to your HTTP server. If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

2. From the installation host, validate that the Ignition config files are available on the URLs. The following example gets the Ignition config file for the bootstrap node:

```
$ curl -k http://<HTTP_server>/bootstrap.ign ①
```

#### Example output

```
% Total % Received % Xferd Average Speed Time Time Time Current
          Dload Upload Total Spent Left Speed
0 0 0 0 0 0 0 --:--:-- --:--:-- --:--:-- 0{"ignition":
{"version":"3.2.0"}, "passwd": {"users": [{"name": "core", "sshAuthorizedKeys": ["ssh-rsa..."]}}]}
```

Replace **bootstrap.ign** with **master.ign** or **worker.ign** in the command to validate that the Ignition config files for the control plane and compute nodes are also available.

3. Although it is possible to obtain the RHCOS **kernel**, **initramfs** and **rootfs** files that are required for your preferred method of installing operating system instances from the [RHCOS image mirror](#) page, the recommended way to obtain the correct version of your RHCOS files are from the output of **openshift-install** command:

```
$ openshift-install coreos print-stream-json | grep -Eo "https.*(kernel|initramfs|rootfs.)\w+\.img?"
```

### Example output

```
"<url>/art/storage/releases/rhcos-4.18-aarch64/<release>/aarch64/rhcos-<release>-live-kernel-aarch64"
"<url>/art/storage/releases/rhcos-4.18-aarch64/<release>/aarch64/rhcos-<release>-live-initramfs.aarch64.img"
"<url>/art/storage/releases/rhcos-4.18-aarch64/<release>/aarch64/rhcos-<release>-live-rootfs.aarch64.img"
"<url>/art/storage/releases/rhcos-4.18-ppc64le/49.84.202110081256-0/ppc64le/rhcos-<release>-live-kernel-ppc64le"
"<url>/art/storage/releases/rhcos-4.18-ppc64le/<release>/ppc64le/rhcos-<release>-live-initramfs.ppc64le.img"
"<url>/art/storage/releases/rhcos-4.18-ppc64le/<release>/ppc64le/rhcos-<release>-live-rootfs.ppc64le.img"
"<url>/art/storage/releases/rhcos-4.18-s390x/<release>/s390x/rhcos-<release>-live-kernel-s390x"
"<url>/art/storage/releases/rhcos-4.18-s390x/<release>/s390x/rhcos-<release>-live-initramfs.s390x.img"
"<url>/art/storage/releases/rhcos-4.18-s390x/<release>/s390x/rhcos-<release>-live-rootfs.s390x.img"
"<url>/art/storage/releases/rhcos-4.18/x86_64/rhcos-<release>-live-kernel-x86_64"
"<url>/art/storage/releases/rhcos-4.18/<release>/x86_64/rhcos-<release>-live-initramfs.x86_64.img"
"<url>/art/storage/releases/rhcos-4.18/<release>/x86_64/rhcos-<release>-live-rootfs.x86_64.img"
```



### IMPORTANT

The RHCOS artifacts might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Only use the appropriate **kernel**, **initramfs**, and **rootfs** artifacts described below for this procedure. RHCOS QCOW2 images are not supported for this installation type.

The file names contain the OpenShift Container Platform version number. They resemble the following examples:

- **kernel: rhcos-<version>-live-kernel-<architecture>**
- **initramfs: rhcos-<version>-live-initramfs.<architecture>.img**

- **rootfs: rhcos-<version>-live-rootfs.<architecture>.img**

4. Upload the **rootfs**, **kernel**, and **initramfs** files to your HTTP server.



### IMPORTANT

If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

5. Configure the network boot infrastructure so that the machines boot from their local disks after RHCOS is installed on them.
6. Configure PXE or iPXE installation for the RHCOS images and begin the installation. Modify one of the following example menu entries for your environment and verify that the image and Ignition files are properly accessible:

- For PXE (**x86\_64**):

```
DEFAULT pxeboot
TIMEOUT 20
PROMPT 0
LABEL pxeboot
KERNEL http://<HTTP_server>/rhcos-<version>-live-kernel-<architecture> ①
APPEND initrd=http://<HTTP_server>/rhcos-<version>-live-initramfs.
<architecture>.img coreos.live.rootfs_url=http://<HTTP_server>/rhcos-<version>-live-
rootfs.<architecture>.img coreos.inst.install_dev=/dev/sda
coreos.inst.ignition_url=http://<HTTP_server>/bootstrap.ign ② ③
```

**①** ① Specify the location of the live **kernel** file that you uploaded to your HTTP server. The URL must be HTTP, TFTP, or FTP; HTTPS and NFS are not supported.

**②** ② If you use multiple NICs, specify a single interface in the **ip** option. For example, to use DHCP on a NIC that is named **eno1**, set **ip=eno1:dhcp**.

**③** ③ Specify the locations of the RHCOS files that you uploaded to your HTTP server. The **initrd** parameter value is the location of the **initramfs** file, the **coreos.live.rootfs\_url** parameter value is the location of the **rootfs** file, and the **coreos.inst.ignition\_url** parameter value is the location of the bootstrap Ignition config file. You can also add more kernel arguments to the **APPEND** line to configure networking or other boot options.



### NOTE

This configuration does not enable serial console access on machines with a graphical console. To configure a different console, add one or more **console=** arguments to the **APPEND** line. For example, add **console=tty0** **console=ttyS0** to set the first PC serial port as the primary console and the graphical console as a secondary console. For more information, see [How does one set up a serial terminal and/or console in Red Hat Enterprise Linux?](#) and "Enabling the serial console for PXE and ISO installation" in the "Advanced RHCOS installation configuration" section.

- For iPXE (**x86\_64 + aarch64**):

```
kernel http://<HTTP_server>/rhcos-<version>-live-kernel-<architecture> initrd=main
coreos.live.rootfs_url=http://<HTTP_server>/rhcos-<version>-live-rootfs.
<architecture>.img coreos.inst.install_dev=/dev/sda
coreos.inst.ignition_url=http://<HTTP_server>/bootstrap.ign ① ②
initrd --name main http://<HTTP_server>/rhcos-<version>-live-initramfs.
<architecture>.img ③
boot
```

- ① Specify the locations of the RHCOS files that you uploaded to your HTTP server. The **kernel** parameter value is the location of the **kernel** file, the **initrd=main** argument is needed for booting on UEFI systems, the **coreos.live.rootfs\_url** parameter value is the location of the **rootfs** file, and the **coreos.inst.ignition\_url** parameter value is the location of the bootstrap Ignition config file.
- ② If you use multiple NICs, specify a single interface in the **ip** option. For example, to use DHCP on a NIC that is named **eno1**, set **ip=eno1:dhcp**.
- ③ Specify the location of the **initramfs** file that you uploaded to your HTTP server.



#### NOTE

This configuration does not enable serial console access on machines with a graphical console. To configure a different console, add one or more **console=** arguments to the **kernel** line. For example, add **console=tty0** **console=ttyS0** to set the first PC serial port as the primary console and the graphical console as a secondary console. For more information, see [How does one set up a serial terminal and/or console in Red Hat Enterprise Linux?](#) and "Enabling the serial console for PXE and ISO installation" in the "Advanced RHCOS installation configuration" section.



#### NOTE

To network boot the CoreOS **kernel** on **aarch64** architecture, you need to use a version of iPXE build with the **IMAGE\_GZIP** option enabled. See [IMAGE\\_GZIP option in iPXE](#).

- For PXE (with UEFI and Grub as second stage) on **aarch64**:

```
menuentry 'Install CoreOS' {
    linux rhcos-<version>-live-kernel-<architecture>
    coreos.live.rootfs_url=http://<HTTP_server>/rhcos-<version>-live-rootfs.
    <architecture>.img coreos.inst.install_dev=/dev/sda
    coreos.inst.ignition_url=http://<HTTP_server>/bootstrap.ign ① ②
    initrd rhcos-<version>-live-initramfs.<architecture>.img ③
}
```

- ① Specify the locations of the RHCOS files that you uploaded to your HTTP/TFTP server. The **kernel** parameter value is the location of the **kernel** file on your TFTP server. The **coreos.live.rootfs\_url** parameter value is the location of the **rootfs** file, and the **coreos.inst.ignition\_url** parameter value is the location of the bootstrap Ignition config file on your HTTP Server.
- ② If you use multiple NICs, specify a single interface in the **ip** option. For example, to use

- ③ Specify the location of the **initramfs** file that you uploaded to your TFTP server.

7. Monitor the progress of the RHCOS installation on the console of the machine.



### IMPORTANT

Be sure that the installation is successful on each node before commencing with the OpenShift Container Platform installation. Observing the installation process can also help to determine the cause of RHCOS installation issues that might arise.

8. After RHCOS installs, the system reboots. During reboot, the system applies the Ignition config file that you specified.
9. Check the console output to verify that Ignition ran.

#### Example command

```
Ignition: ran on 2022/03/14 14:48:33 UTC (this boot)  
Ignition: user-provided config was applied
```

10. Continue to create the machines for your cluster.



### IMPORTANT

You must create the bootstrap and control plane machines at this time. If the control plane machines are not made schedulable, also create at least two compute machines before you install the cluster.

If the required network, DNS, and load balancer infrastructure are in place, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS nodes have rebooted.



### NOTE

RHCOS nodes do not include a default password for the **core** user. You can access the nodes by running **ssh core@<node>. <cluster\_name> <base\_domain>** as a user with access to the SSH private key that is paired to the public key that you specified in your **install\_config.yaml** file. OpenShift Container Platform 4 cluster nodes running RHCOS are immutable and rely on Operators to apply cluster changes. Accessing cluster nodes by using SSH is not recommended. However, when investigating installation issues, if the OpenShift Container Platform API is not available, or the kubelet is not properly functioning on a target node, SSH access might be required for debugging or disaster recovery.

#### 2.2.15.3. Advanced RHCOS installation configuration

A key benefit for manually provisioning the Red Hat Enterprise Linux CoreOS (RHCOS) nodes for OpenShift Container Platform is to be able to do configuration that is not available through default OpenShift Container Platform installation methods. This section describes some of the configurations that you can do using techniques that include:

- Passing kernel arguments to the live installer
- Running **coreos-installer** manually from the live system
- Customizing a live ISO or PXE boot image

The advanced configuration topics for manual Red Hat Enterprise Linux CoreOS (RHCOS) installations detailed in this section relate to disk partitioning, networking, and using Ignition configs in different ways.

### 2.2.15.3.1. Using advanced networking options for PXE and ISO installations

Networking for OpenShift Container Platform nodes uses DHCP by default to gather all necessary configuration settings. To set up static IP addresses or configure special settings, such as bonding, you can do one of the following:

- Pass special kernel parameters when you boot the live installer.
- Use a machine config to copy networking files to the installed system.
- Configure networking from a live installer shell prompt, then copy those settings to the installed system so that they take effect when the installed system first boots.

To configure a PXE or iPXE installation, use one of the following options:

- See the "Advanced RHCOS installation reference" tables.
- Use a machine config to copy networking files to the installed system.

To configure an ISO installation, use the following procedure.

#### Procedure

1. Boot the ISO installer.
2. From the live system shell prompt, configure networking for the live system using available RHEL tools, such as **nmcli** or **nmtui**.
3. Run the **coreos-installer** command to install the system, adding the **--copy-network** option to copy networking configuration. For example:

```
$ sudo coreos-installer install --copy-network \
--ignition-url=http://host/worker.ign /dev/disk/by-id/scsi-<serial_number>
```



#### IMPORTANT

The **--copy-network** option only copies networking configuration found under **/etc/NetworkManager/system-connections**. In particular, it does not copy the system hostname.

4. Reboot into the installed system.

#### Additional resources

- See [Getting started with nmcli](#) and [Getting started with nmtui](#) in the RHEL 8 documentation for more information about the **nmcli** and **nmtui** tools.

### 2.2.15.3.2. Disk partitioning

Disk partitions are created on OpenShift Container Platform cluster nodes during the Red Hat Enterprise Linux CoreOS (RHCOS) installation. Each RHCOS node of a particular architecture uses the same partition layout, unless you override the default partitioning configuration. During the RHCOS installation, the size of the root file system is increased to use any remaining available space on the target device.



#### IMPORTANT

The use of a custom partition scheme on your node might result in OpenShift Container Platform not monitoring or alerting on some node partitions. If you override the default partitioning, see [Understanding OpenShift File System Monitoring \(eviction conditions\)](#) for more information about how OpenShift Container Platform monitors your host file systems.

OpenShift Container Platform monitors the following two filesystem identifiers:

- **nodefs**, which is the filesystem that contains **/var/lib/kubelet**
- **imagefs**, which is the filesystem that contains **/var/lib/containers**

For the default partition scheme, **nodefs** and **imagefs** monitor the same root filesystem, **/**.

To override the default partitioning when installing RHCOS on an OpenShift Container Platform cluster node, you must create separate partitions. Consider a situation where you want to add a separate storage partition for your containers and container images. For example, by mounting **/var/lib/containers** in a separate partition, the kubelet separately monitors **/var/lib/containers** as the **imagefs** directory and the root file system as the **nodefs** directory.



#### IMPORTANT

If you have resized your disk size to host a larger file system, consider creating a separate **/var/lib/containers** partition. Consider resizing a disk that has an **xfs** format to reduce CPU time issues caused by a high number of allocation groups.

#### 2.2.15.3.2.1. Creating a separate **/var** partition

In general, you should use the default disk partitioning that is created during the RHCOS installation. However, there are cases where you might want to create a separate partition for a directory that you expect to grow.

OpenShift Container Platform supports the addition of a single partition to attach storage to either the **/var** directory or a subdirectory of **/var**. For example:

- **/var/lib/containers**: Holds container-related content that can grow as more images and containers are added to a system.
- **/var/lib/etcd**: Holds data that you might want to keep separate for purposes such as performance optimization of etcd storage.
- **/var**: Holds data that you might want to keep separate for purposes such as auditing.



## IMPORTANT

For disk sizes larger than 100GB, and especially larger than 1TB, create a separate `/var` partition.

Storing the contents of a `/var` directory separately makes it easier to grow storage for those areas as needed and reinstall OpenShift Container Platform at a later date and keep that data intact. With this method, you will not have to pull all your containers again, nor will you have to copy massive log files when you update systems.

The use of a separate partition for the `/var` directory or a subdirectory of `/var` also prevents data growth in the partitioned directory from filling up the root file system.

The following procedure sets up a separate `/var` partition by adding a machine config manifest that is wrapped into the Ignition config file for a node type during the preparation phase of an installation.

### Procedure

- 1 On your installation host, change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

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

- 2 Create a Butane config that configures the additional partition. For example, name the file `$HOME/clusterconfig/98-var-partition.bu`, change the disk device name to the name of the storage device on the `worker` systems, and set the storage size as appropriate. This example places the `/var` directory on a separate partition:

```
variant: openshift
version: 4.18.0
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 98-var-partition
storage:
  disks:
    - device: /dev/disk/by-id/<device_name> ①
      partitions:
        - label: var
          start_mib: <partition_start_offset> ②
          size_mib: <partition_size> ③
          number: 5
  filesystems:
    - device: /dev/disk/by-partlabel/var
      path: /var
      format: xfs
      mount_options: [defaults, prjquota] ④
      with_mount_unit: true
```

- 1 The storage device name of the disk that you want to partition.
- 2 When adding a data partition to the boot disk, a minimum offset value of 25000 mebibytes is recommended. The root file system is automatically resized to fill all available space up to the specified offset. If no offset value is specified, or if the specified value is smaller than the recommended minimum, the resulting root file system will be too small, and future

reinstalls of RHCOS might overwrite the beginning of the data partition.

- 3 The size of the data partition in mebibytes.
- 4 The **prjquota** mount option must be enabled for filesystems used for container storage.



### NOTE

When creating a separate **/var** partition, you cannot use different instance types for compute nodes, if the different instance types do not have the same device name.

- 3 Create a manifest from the Butane config and save it to the **clusterconfig/openshift** directory. For example, run the following command:

```
$ butane $HOME/clusterconfig/98-var-partition.bu -o $HOME/clusterconfig/openshift/98-var-partition.yaml
```

- 4 Create the Ignition config files:

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

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

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory:

```

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

```

The files in the **<installation\_directory>/manifest** and **<installation\_directory>/openshift** directories are wrapped into the Ignition config files, including the file that contains the **98-var-partition** custom **MachineConfig** object.

## Next steps

- You can apply the custom disk partitioning by referencing the Ignition config files during the RHCOS installations.

### 2.2.15.3.2.2. Retaining existing partitions

For an ISO installation, you can add options to the **coreos-installer** command that cause the installer to maintain one or more existing partitions. For a PXE installation, you can add **coreos.inst.\*** options to the **APPEND** parameter to preserve partitions.

Saved partitions might be data partitions from an existing OpenShift Container Platform system. You can identify the disk partitions you want to keep either by partition label or by number.



### NOTE

If you save existing partitions, and those partitions do not leave enough space for RHCOS, the installation will fail without damaging the saved partitions.

#### Retaining existing partitions during an ISO installation

This example preserves any partition in which the partition label begins with **data (data\*)**:

```
# coreos-installer install --ignition-url http://10.0.2.2:8080/user.ign \
--save-partlabel 'data*' \
/dev/disk/by-id/scsi-<serial_number>
```

The following example illustrates running the **coreos-installer** in a way that preserves the sixth (6) partition on the disk:

```
# coreos-installer install --ignition-url http://10.0.2.2:8080/user.ign \
--save-partindex 6 /dev/disk/by-id/scsi-<serial_number>
```

This example preserves partitions 5 and higher:

```
# coreos-installer install --ignition-url http://10.0.2.2:8080/user.ign \
--save-partindex 5- /dev/disk/by-id/scsi-<serial_number>
```

In the previous examples where partition saving is used, **coreos-installer** recreates the partition immediately.

#### Retaining existing partitions during a PXE installation

This **APPEND** option preserves any partition in which the partition label begins with 'data' ('data\*'):

```
coreos.inst.save_partlabel=data*
```

This **APPEND** option preserves partitions 5 and higher:

```
coreos.inst.save_partindex=5-
```

This **APPEND** option preserves partition 6:

```
coreos.inst.save_partindex=6
```

#### 2.2.15.3.3. Identifying Ignition configs

When doing an RHCOS manual installation, there are two types of Ignition configs that you can provide, with different reasons for providing each one:

- **Permanent install Ignition config:** Every manual RHCOS installation needs to pass one of the Ignition config files generated by **openshift-installer**, such as **bootstrap.ign**, **master.ign** and **worker.ign**, to carry out the installation.



## IMPORTANT

It is not recommended to modify these Ignition config files directly. You can update the manifest files that are wrapped into the Ignition config files, as outlined in examples in the preceding sections.

For PXE installations, you pass the Ignition configs on the **APPEND** line using the **coreos.inst.ignition\_url=** option. For ISO installations, after the ISO boots to the shell prompt, you identify the Ignition config on the **coreos-installer** command line with the **--ignition-url=** option. In both cases, only HTTP and HTTPS protocols are supported.

- **Live install Ignition config:** This type can be created by using the **coreos-installer customize** subcommand and its various options. With this method, the Ignition config passes to the live install medium, runs immediately upon booting, and performs setup tasks before or after the RHCOS system installs to disk. This method should only be used for performing tasks that must be done once and not applied again later, such as with advanced partitioning that cannot be done using a machine config.

For PXE or ISO boots, you can create the Ignition config and **APPEND** the **ignition.config.url=** option to identify the location of the Ignition config. You also need to append **ignition.firstboot** **ignition.platform.id=metal** or the **ignition.config.url** option will be ignored.

### 2.2.15.3.4. Default console configuration

Red Hat Enterprise Linux CoreOS (RHCOS) nodes installed from an OpenShift Container Platform 4.18 boot image use a default console that is meant to accommodate most virtualized and bare metal setups. Different cloud and virtualization platforms may use different default settings depending on the chosen architecture. Bare metal installations use the kernel default settings which typically means the graphical console is the primary console and the serial console is disabled.

The default consoles may not match your specific hardware configuration or you might have specific needs that require you to adjust the default console. For example:

- You want to access the emergency shell on the console for debugging purposes.
- Your cloud platform does not provide interactive access to the graphical console, but provides a serial console.
- You want to enable multiple consoles.

Console configuration is inherited from the boot image. This means that new nodes in existing clusters are unaffected by changes to the default console.

You can configure the console for bare metal installations in the following ways:

- Using **coreos-installer** manually on the command line.
- Using the **coreos-installer iso customize** or **coreos-installer pxe customize** subcommands with the **--dest-console** option to create a custom image that automates the process.



## NOTE

For advanced customization, perform console configuration using the **coreos-installer iso** or **coreos-installer pxe** subcommands, and not kernel arguments.

### 2.2.15.3.5. Enabling the serial console for PXE and ISO installations

By default, the Red Hat Enterprise Linux CoreOS (RHCOS) serial console is disabled and all output is written to the graphical console. You can enable the serial console for an ISO installation and reconfigure the bootloader so that output is sent to both the serial console and the graphical console.

## Procedure

- 1 Boot the ISO installer.
- 2 Run the **coreos-installer** command to install the system, adding the **--console** option once to specify the graphical console, and a second time to specify the serial console:

```
$ coreos-installer install \
--console=tty0 \ ①
--console=ttyS0,<options> \ ②
--ignition-url=http://host/worker.ign /dev/disk/by-id/scsi-<serial_number>
```

- ① The desired secondary console. In this case, the graphical console. Omitting this option will disable the graphical console.
- ② The desired primary console. In this case the serial console. The **options** field defines the baud rate and other settings. A common value for this field is **11520n8**. If no options are provided, the default kernel value of **9600n8** is used. For more information on the format of this option, see [Linux kernel serial console](#) documentation.

- 3 Reboot into the installed system.



### NOTE

A similar outcome can be obtained by using the **coreos-installer install --append-karg** option, and specifying the console with **console=**. However, this will only set the console for the kernel and not the bootloader.

To configure a PXE installation, make sure the **coreos.inst.install\_dev** kernel command-line option is omitted, and use the shell prompt to run **coreos-installer** manually using the above ISO installation procedure.

#### 2.2.15.3.6. Customizing a live RHCOS ISO or PXE install

You can use the live ISO image or PXE environment to install RHCOS by injecting an Ignition config file directly into the image. This creates a customized image that you can use to provision your system.

For an ISO image, the mechanism to do this is the **coreos-installer iso customize** subcommand, which modifies the **.iso** file with your configuration. Similarly, the mechanism for a PXE environment is the **coreos-installer pxe customize** subcommand, which creates a new **initramfs** file that includes your customizations.

The **customize** subcommand is a general purpose tool that can embed other types of customizations as well. The following tasks are examples of some of the more common customizations:

- Inject custom CA certificates for when corporate security policy requires their use.
- Configure network settings without the need for kernel arguments.
- Embed arbitrary preinstall and post-install scripts or binaries.

### 2.2.15.3.7. Customizing a live RHCOS ISO image

You can customize a live RHCOS ISO image directly with the **coreos-installer iso customize** subcommand. When you boot the ISO image, the customizations are applied automatically.

You can use this feature to configure the ISO image to automatically install RHCOS.

#### Procedure

- 1 Download the **coreos-installer** binary from the [coreos-installer image mirror](#) page.
- 2 Retrieve the RHCOS ISO image from the [RHCOS image mirror](#) page and the Ignition config file, and then run the following command to inject the Ignition config directly into the ISO image:

```
$ coreos-installer iso customize rhcos-<version>-live.x86_64.iso \
--dest-ignition bootstrap.ign \ ①
--dest-device /dev/disk/by-id/scsi-<serial_number> ②
```

- ① The Ignition config file that is generated from the **openshift-installer** installation program.
- ② When you specify this option, the ISO image automatically runs an installation. Otherwise, the image remains configured for installation, but does not install automatically unless you specify the **coreos.inst.install\_dev** kernel argument.

- 3 Optional: To remove the ISO image customizations and return the image to its pristine state, run:

```
$ coreos-installer iso reset rhcos-<version>-live.x86_64.iso
```

You can now re-customize the live ISO image or use it in its pristine state.

Applying your customizations affects every subsequent boot of RHCOS.

### 2.2.15.3.7.1. Modifying a live install ISO image to enable the serial console

On clusters installed with OpenShift Container Platform 4.12 and above, the serial console is disabled by default and all output is written to the graphical console. You can enable the serial console with the following procedure.

#### Procedure

- 1 Download the **coreos-installer** binary from the [coreos-installer image mirror](#) page.
- 2 Retrieve the RHCOS ISO image from the [RHCOS image mirror](#) page and run the following command to customize the ISO image to enable the serial console to receive output:

```
$ coreos-installer iso customize rhcos-<version>-live.x86_64.iso \
--dest-ignition <path> \ ①
--dest-console tty0 \ ②
--dest-console ttyS0,<options> \ ③
--dest-device /dev/disk/by-id/scsi-<serial_number> ④
```

- ① The location of the Ignition config to install.

- 2 The desired secondary console. In this case, the graphical console. Omitting this option will disable the graphical console.
- 3 The desired primary console. In this case, the serial console. The **options** field defines the baud rate and other settings. A common value for this field is **115200n8**. If no options are provided, the default kernel value of **9600n8** is used. For more information on the format of this option, see the [Linux kernel serial console](#) documentation.
- 4 The specified disk to install to. If you omit this option, the ISO image automatically runs the installation program which will fail unless you also specify the **coreos.inst.install\_dev** kernel argument.



#### NOTE

The **--dest-console** option affects the installed system and not the live ISO system. To modify the console for a live ISO system, use the **--live-karg-append** option and specify the console with **console=**.

Your customizations are applied and affect every subsequent boot of the ISO image.

3. Optional: To remove the ISO image customizations and return the image to its original state, run the following command:

```
$ coreos-installer iso reset rhcos-<version>-live.x86_64.iso
```

You can now recustomize the live ISO image or use it in its original state.

#### 2.2.15.3.7.2. Modifying a live install ISO image to use a custom certificate authority

You can provide certificate authority (CA) certificates to Ignition with the **--ignition-ca** flag of the **customize** subcommand. You can use the CA certificates during both the installation boot and when provisioning the installed system.



#### NOTE

Custom CA certificates affect how Ignition fetches remote resources but they do not affect the certificates installed onto the system.

#### Procedure

1. Download the **coreos-installer** binary from the [coreos-installer](#) image mirror page.
2. Retrieve the RHCOS ISO image from the [RHCOS image mirror](#) page and run the following command to customize the ISO image for use with a custom CA:

```
$ coreos-installer iso customize rhcos-<version>-live.x86_64.iso --ignition-ca cert.pem
```



#### IMPORTANT

The **coreos.inst.ignition\_url** kernel parameter does not work with the **--ignition-ca** flag. You must use the **--dest-ignition** flag to create a customized image for each cluster.

Applying your custom CA certificate affects every subsequent boot of RHCOS.

### 2.2.15.3.7.3. Modifying a live install ISO image with customized network settings

You can embed a NetworkManager keyfile into the live ISO image and pass it through to the installed system with the **--network-keyfile** flag of the **customize** subcommand.



#### WARNING

When creating a connection profile, you must use a **.nmconnection** filename extension in the filename of the connection profile. If you do not use a **.nmconnection** filename extension, the cluster will apply the connection profile to the live environment, but it will not apply the configuration when the cluster first boots up the nodes, resulting in a setup that does not work.

#### Procedure

1. Download the **coreos-installer** binary from the [coreos-installer image mirror](#) page.
2. Create a connection profile for a bonded interface. For example, create the **bond0.nmconnection** file in your local directory with the following content:

```
[connection]
id=bond0
type=bond
interface-name=bond0
multi-connect=1

[bond]
miimon=100
mode=active-backup

[ipv4]
method=auto

[ipv6]
method=auto
```

3. Create a connection profile for a secondary interface to add to the bond. For example, create the **bond0-proxy-em1.nmconnection** file in your local directory with the following content:

```
[connection]
id=em1
type=ethernet
interface-name=em1
master=bond0
multi-connect=1
slave-type=bond
```

- Create a connection profile for a secondary interface to add to the bond. For example, create the **bond0-proxy-em2.nmconnection** file in your local directory with the following content:

```
[connection]
id=em2
type=ethernet
interface-name=em2
master=bond0
multi-connect=1
slave-type=bond
```

- Retrieve the RHCOS ISO image from the [RHCOS image mirror](#) page and run the following command to customize the ISO image with your configured networking:

```
$ coreos-installer iso customize rhcos-<version>-live.x86_64.iso \
--network-keyfile bond0.nmconnection \
--network-keyfile bond0-proxy-em1.nmconnection \
--network-keyfile bond0-proxy-em2.nmconnection
```

Network settings are applied to the live system and are carried over to the destination system.

#### 2.2.15.3.7.4. Customizing a live install ISO image for an iSCSI boot device

You can set the iSCSI target and initiator values for automatic mounting, booting and configuration using a customized version of the live RHCOS image.

##### Prerequisites

- You have an iSCSI target you want to install RHCOS on.

##### Procedure

- Download the **coreos-installer** binary from the [coreos-installer](#) image mirror page.
- Retrieve the RHCOS ISO image from the [RHCOS image mirror](#) page and run the following command to customize the ISO image with the following information:

```
$ coreos-installer iso customize \
--pre-install mount-iscsi.sh \ ①
--post-install umount-iscsi.sh \ ②
--dest-device /dev/disk/by-path/<IP_address>:<port>-iscsi-<target_iqn>-lun-<lun> \ ③
--dest-ignition config.ign \ ④
--dest-karg-append rd.iscsi.initiator=<initiator_iqn> \ ⑤
--dest-karg-append netroot=<target_iqn> \ ⑥
-o custom.iso rhcos-<version>-live.x86_64.iso
```

- The script that gets run before installation. It should contain the **iscsiadm** commands for mounting the iSCSI target and any commands enabling multipathing.
- The script that gets run after installation. It should contain the command **iscsiadm --mode node --logout=all**.
-

The location of the destination system. You must provide the IP address of the target portal, the associated port number, the target iSCSI node in IQN format, and the iSCSI

- 4 The Ignition configuration for the destination system.
- 5 The iSCSI initiator, or client, name in IQN format. The initiator forms a session to connect to the iSCSI target.
- 6 The the iSCSI target, or server, name in IQN format.

For more information about the iSCSI options supported by **dracut**, see the [dracut.cmdline manual page](#).

#### 2.2.15.3.7.5. Customizing a live install ISO image for an iSCSI boot device with iBFT

You can set the iSCSI target and initiator values for automatic mounting, booting and configuration using a customized version of the live RHCOS image.

##### Prerequisites

1. You have an iSCSI target you want to install RHCOS on.
2. Optional: you have multipathed your iSCSI target.

##### Procedure

1. Download the **coreos-installer** binary from the [coreos-installer image mirror](#) page.
2. Retrieve the RHCOS ISO image from the [RHCOS image mirror](#) page and run the following command to customize the ISO image with the following information:

```
$ coreos-installer iso customize \
--pre-install mount-iscsi.sh \ ①
--post-install unmount-iscsi.sh \ ②
--dest-device /dev/mapper/mpatha \ ③
--dest-ignition config.ign \ ④
--dest-karg-append rd.iscsi.firmware=1 \ ⑤
--dest-karg-append rd.multipath=default \ ⑥
-o custom.iso rhcos-<version>-live.x86_64.iso
```

- 1 The script that gets run before installation. It should contain the **iscsiadm** commands for mounting the iSCSI target and any commands enabling multipathing.
- 2 The script that gets run after installation. It should contain the command **iscsiadm --mode node --logout=all**.
- 3 The path to the device. If you are using multipath, the multipath device, **/dev/mapper/mpatha**. If there are multiple multipath devices connected, or to be explicit, you can use the World Wide Name (WWN) symlink available in **/dev/disk/by-path**.
- 4 The Ignition configuration for the destination system.
- 5 The iSCSI parameter is read from the BIOS firmware.

- 6 Optional: include this parameter if you are enabling multipathing.

For more information about the iSCSI options supported by **dracut**, see the [dracut.cmdline manual page](#).

#### 2.2.15.3.8. Customizing a live RHCOS PXE environment

You can customize a live RHCOS PXE environment directly with the **coreos-installer pxe customize** subcommand. When you boot the PXE environment, the customizations are applied automatically.

You can use this feature to configure the PXE environment to automatically install RHCOS.

#### Procedure

- 1 Download the **coreos-installer** binary from the [coreos-installer image mirror](#) page.
- 2 Retrieve the RHCOS **kernel**, **initramfs** and **rootfs** files from the [RHCOS image mirror](#) page and the Ignition config file, and then run the following command to create a new **initramfs** file that contains the customizations from your Ignition config:

```
$ coreos-installer pxe customize rhcos-<version>-live-initramfs.x86_64.img \
--dest-ignition bootstrap.ign \ ①
--dest-device /dev/disk/by-id/scsi-<serial_number> \ ②
-o rhcos-<version>-custom-initramfs.x86_64.img ③
```

- 1 The Ignition config file that is generated from **openshift-installer**.
- 2 When you specify this option, the PXE environment automatically runs an install. Otherwise, the image remains configured for installing, but does not do so automatically unless you specify the **coreos.inst.install\_dev** kernel argument.
- 3 Use the customized **initramfs** file in your PXE configuration. Add the **ignition.firstboot** and **ignition.platform.id=metal** kernel arguments if they are not already present.

Applying your customizations affects every subsequent boot of RHCOS.

#### 2.2.15.3.8.1. Modifying a live install PXE environment to enable the serial console

On clusters installed with OpenShift Container Platform 4.12 and above, the serial console is disabled by default and all output is written to the graphical console. You can enable the serial console with the following procedure.

#### Procedure

- 1 Download the **coreos-installer** binary from the [coreos-installer image mirror](#) page.
- 2 Retrieve the RHCOS **kernel**, **initramfs** and **rootfs** files from the [RHCOS image mirror](#) page and the Ignition config file, and then run the following command to create a new customized **initramfs** file that enables the serial console to receive output:

```
$ coreos-installer pxe customize rhcos-<version>-live-initramfs.x86_64.img \
--dest-ignition <path> \ ①
--dest-console tty0 \ ②
```

```
--dest-console ttyS0,<options> \ ③
--dest-device /dev/disk/by-id/scsi-<serial_number> \ ④
-o rhcos-<version>-custom-initramfs.x86_64.img ⑤
```

- 1 The location of the Ignition config to install.
- 2 The desired secondary console. In this case, the graphical console. Omitting this option will disable the graphical console.
- 3 The desired primary console. In this case, the serial console. The **options** field defines the baud rate and other settings. A common value for this field is **115200n8**. If no options are provided, the default kernel value of **9600n8** is used. For more information on the format of this option, see the [Linux kernel serial console](#) documentation.
- 4 The specified disk to install to. If you omit this option, the PXE environment automatically runs the installer which will fail unless you also specify the **coreos.inst.install\_dev** kernel argument.
- 5 Use the customized **initramfs** file in your PXE configuration. Add the **ignition.firstboot** and **ignition.platform.id=metal** kernel arguments if they are not already present.

Your customizations are applied and affect every subsequent boot of the PXE environment.

#### 2.2.15.3.8.2. Modifying a live install PXE environment to use a custom certificate authority

You can provide certificate authority (CA) certificates to Ignition with the **--ignition-ca** flag of the **customize** subcommand. You can use the CA certificates during both the installation boot and when provisioning the installed system.



#### NOTE

Custom CA certificates affect how Ignition fetches remote resources but they do not affect the certificates installed onto the system.

#### Procedure

1. Download the **coreos-installer** binary from the [coreos-installer](#) image mirror page.
2. Retrieve the RHCOS **kernel**, **initramfs** and **rootfs** files from the [RHCOS image mirror](#) page and run the following command to create a new customized **initramfs** file for use with a custom CA:

```
$ coreos-installer pxe customize rhcos-<version>-live-initramfs.x86_64.img \
--ignition-ca cert.pem \
-o rhcos-<version>-custom-initramfs.x86_64.img
```

3. Use the customized **initramfs** file in your PXE configuration. Add the **ignition.firstboot** and **ignition.platform.id=metal** kernel arguments if they are not already present.



#### IMPORTANT

The **coreos.inst.ignition\_url** kernel parameter does not work with the **--ignition-ca** flag. You must use the **--dest-ignition** flag to create a customized image for each cluster.

Applying your custom CA certificate affects every subsequent boot of RHCOS.

### 2.2.15.3.8.3. Modifying a live install PXE environment with customized network settings

You can embed a NetworkManager keyfile into the live PXE environment and pass it through to the installed system with the **--network-keyfile** flag of the **customize** subcommand.



#### WARNING

When creating a connection profile, you must use a **.nmconnection** filename extension in the filename of the connection profile. If you do not use a **.nmconnection** filename extension, the cluster will apply the connection profile to the live environment, but it will not apply the configuration when the cluster first boots up the nodes, resulting in a setup that does not work.

#### Procedure

1. Download the **coreos-installer** binary from the [coreos-installer image mirror](#) page.
2. Create a connection profile for a bonded interface. For example, create the **bond0.nmconnection** file in your local directory with the following content:

```
[connection]
id=bond0
type=bond
interface-name=bond0
multi-connect=1

[bond]
miimon=100
mode=active-backup

[ipv4]
method=auto

[ipv6]
method=auto
```

3. Create a connection profile for a secondary interface to add to the bond. For example, create the **bond0-proxy-em1.nmconnection** file in your local directory with the following content:

```
[connection]
id=em1
type=etherent
interface-name=em1
master=bond0
multi-connect=1
slave-type=bond
```

- Create a connection profile for a secondary interface to add to the bond. For example, create the **bond0-proxy-em2.nmconnection** file in your local directory with the following content:

```
[connection]
id=em2
type=ethernet
interface-name=em2
master=bond0
multi-connect=1
slave-type=bond
```

- Retrieve the RHCOS **kernel**, **initramfs** and **rootfs** files from the [RHCOS image mirror](#) page and run the following command to create a new customized **initramfs** file that contains your configured networking:

```
$ coreos-installer pxe customize rhcos-<version>-live-initramfs.x86_64.img \
--network-keyfile bond0.nmconnection \
--network-keyfile bond0-proxy-em1.nmconnection \
--network-keyfile bond0-proxy-em2.nmconnection \
-o rhcos-<version>-custom-initramfs.x86_64.img
```

- Use the customized **initramfs** file in your PXE configuration. Add the **ignition.firstboot** and **ignition.platform.id=metal** kernel arguments if they are not already present. Network settings are applied to the live system and are carried over to the destination system.

#### 2.2.15.3.8.4. Customizing a live install PXE environment for an iSCSI boot device

You can set the iSCSI target and initiator values for automatic mounting, booting and configuration using a customized version of the live RHCOS image.

##### Prerequisites

- You have an iSCSI target you want to install RHCOS on.

##### Procedure

- Download the **coreos-installer** binary from the [coreos-installer image mirror](#) page.
- Retrieve the RHCOS **kernel**, **initramfs** and **rootfs** files from the [RHCOS image mirror](#) page and run the following command to create a new customized **initramfs** file with the following information:

```
$ coreos-installer pxe customize \
--pre-install mount-iscsi.sh \ ①
--post-install umount-iscsi.sh \ ②
--dest-device /dev/disk/by-path/<IP_address>:<port>-iscsi-<target_iqn>-lun-<lun> \ ③
--dest-ignition config.ign \ ④
--dest-karg-append rd.iscsi.initiator=<initiator_iqn> \ ⑤
--dest-karg-append netroot=<target_iqn> \ ⑥
-o custom.img rhcos-<version>-live-initramfs.x86_64.img
```

① The script that gets run before installation. It should contain the **iscsiadm** commands for mounting the iSCSI target and any commands enabling multipathing.

- 2 The script that gets run after installation. It should contain the command **iscsiadm --mode node --logout=all**.
- 3 The location of the destination system. You must provide the IP address of the target portal, the associated port number, the target iSCSI node in IQN format, and the iSCSI logical unit number (LUN).
- 4 The Ignition configuration for the destination system.
- 5 The iSCSI initiator, or client, name in IQN format. The initiator forms a session to connect to the iSCSI target.
- 6 The the iSCSI target, or server, name in IQN format.

For more information about the iSCSI options supported by **dracut**, see the [dracut.cmdline manual page](#).

#### 2.2.15.3.8.5. Customizing a live install PXE environment for an iSCSI boot device with iBFT

You can set the iSCSI target and initiator values for automatic mounting, booting and configuration using a customized version of the live RHCOS image.

##### Prerequisites

1. You have an iSCSI target you want to install RHCOS on.
2. Optional: you have multipathed your iSCSI target.

##### Procedure

1. Download the **coreos-installer** binary from the [coreos-installer image mirror](#) page.
2. Retrieve the RHCOS **kernel**, **initramfs** and **rootfs** files from the [RHCOS image mirror](#) page and run the following command to create a new customized **initramfs** file with the following information:

```
$ coreos-installer pxe customize \
--pre-install mount-iscsi.sh \ 1
--post-install unmount-iscsi.sh \ 2
--dest-device /dev/mapper/mpatha \ 3
--dest-ignition config.ign \ 4
--dest-karg-append rd.iscsi.firmware=1 \ 5
--dest-karg-append rd.multipath=default \ 6
-o custom.img rhcos-<version>-live-initramfs.x86_64.img
```

- 1 The script that gets run before installation. It should contain the **iscsiadm** commands for mounting the iSCSI target.
- 2 The script that gets run after installation. It should contain the command **iscsiadm --mode node --logout=all**.
- 3 The path to the device. If you are using multipath, the multipath device, **/dev/mapper/mpatha**. If there are multiple multipath devices connected, or to be explicit, you can use the World Wide Name (WWN) symlink available in **/dev/disk/by-path**.

- 4 The Ignition configuration for the destination system.
- 5 The iSCSI parameter is read from the BIOS firmware.
- 6 Optional: include this parameter if you are enabling multipathing.

For more information about the iSCSI options supported by **dracut**, see the [dracut.cmdline manual page](#).

### 2.2.15.3.9. Advanced RHCOS installation reference

This section illustrates the networking configuration and other advanced options that allow you to modify the Red Hat Enterprise Linux CoreOS (RHCOS) manual installation process. The following tables describe the kernel arguments and command-line options you can use with the RHCOS live installer and the **coreos-installer** command.

#### 2.2.15.3.9.1. Networking and bonding options for ISO installations

If you install RHCOS from an ISO image, you can add kernel arguments manually when you boot the image to configure networking for a node. If no networking arguments are specified, DHCP is activated in the initramfs when RHCOS detects that networking is required to fetch the Ignition config file.



#### IMPORTANT

When adding networking arguments manually, you must also add the **rd.neednet=1** kernel argument to bring the network up in the initramfs.

The following information provides examples for configuring networking and bonding on your RHCOS nodes for ISO installations. The examples describe how to use the **ip=**, **nameserver=**, and **bond=** kernel arguments.



#### NOTE

Ordering is important when adding the kernel arguments: **ip=**, **nameserver=**, and then **bond=**.

The networking options are passed to the **dracut** tool during system boot. For more information about the networking options supported by **dracut**, see the [dracut.cmdline manual page](#).

The following examples are the networking options for ISO installation.

Configuring DHCP or static IP addresses

To configure an IP address, either use DHCP (**ip=dhcp**) or set an individual static IP address (**ip=<host\_ip>**). If setting a static IP, you must then identify the DNS server IP address (**nameserver=<dns\_ip>**) on each node. The following example sets:

- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The hostname to **core0.example.com**

- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
nameserver=4.4.4.41
```



### NOTE

When you use DHCP to configure IP addressing for the RHCOS machines, the machines also obtain the DNS server information through DHCP. For DHCP-based deployments, you can define the DNS server address that is used by the RHCOS nodes through your DHCP server configuration.

#### Configuring an IP address without a static hostname

You can configure an IP address without assigning a static hostname. If a static hostname is not set by the user, it will be picked up and automatically set by a reverse DNS lookup. To configure an IP address without a static hostname refer to the following example:

- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0::enp1s0:none
nameserver=4.4.4.41
```

#### Specifying multiple network interfaces

You can specify multiple network interfaces by setting multiple **ip=** entries.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=10.10.10.3::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

#### Configuring default gateway and route

Optional: You can configure routes to additional networks by setting an **rd.route=** value.



### NOTE

When you configure one or multiple networks, one default gateway is required. If the additional network gateway is different from the primary network gateway, the default gateway must be the primary network gateway.

- Run the following command to configure the default gateway:

```
ip=:10.10.10.254:::
```

- Enter the following command to configure the route for the additional network:

```
rd.route=20.20.20.0/24:20.20.20.254:enp2s0
```

#### Disabling DHCP on a single interface

You can disable DHCP on a single interface, such as when there are two or more network interfaces and only one interface is being used. In the example, the **enp1s0** interface has a static networking configuration and DHCP is disabled for **enp2s0**, which is not used:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=::::core0.example.com:enp2s0:none
```

#### Combining DHCP and static IP configurations

You can combine DHCP and static IP configurations on systems with multiple network interfaces, for example:

```
ip=enp1s0:dhcp
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

#### Configuring VLANs on individual interfaces

Optional: You can configure VLANs on individual interfaces by using the **vlan=** parameter.

- To configure a VLAN on a network interface and use a static IP address, run the following command:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0.100:none
vlan=enp2s0.100:enp2s0
```

- To configure a VLAN on a network interface and to use DHCP, run the following command:

```
ip=enp2s0.100:dhcp
vlan=enp2s0.100:enp2s0
```

#### Providing multiple DNS servers

You can provide multiple DNS servers by adding a **nameserver=** entry for each server, for example:

```
nameserver=1.1.1.1
nameserver=8.8.8.8
```

#### Bonding multiple network interfaces to a single interface

Optional: You can bond multiple network interfaces to a single interface by using the **bond=** option. Refer to the following examples:

- The syntax for configuring a bonded interface is: **bond=<name>[:<network\_interfaces>] [:options]**

**<name>** is the bonding device name (**bond0**), **<network\_interfaces>** represents a comma-separated list of physical (ethernet) interfaces (**em1,em2**), and **options** is a comma-separated list of bonding options. Enter **modinfo bonding** to see available options.

- When you create a bonded interface using **bond=**, you must specify how the IP address is assigned and other information for the bonded interface.
  - To configure the bonded interface to use DHCP, set the bond's IP address to **dhcp**. For example:

```
bond=bond0:em1,em2:mode=active-backup
ip=bond0:dhcp
```

- To configure the bonded interface to use a static IP address, enter the specific IP address you want and related information. For example:

```
bond=bond0:em1,em2:mode=active-backup
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0:none
```

Bonding multiple SR-IOV network interfaces to a dual port NIC interface

Optional: You can bond multiple SR-IOV network interfaces to a dual port NIC interface by using the **bond=** option.

On each node, you must perform the following tasks:

1. Create the SR-IOV virtual functions (VFs) following the guidance in [Managing SR-IOV devices](#). Follow the procedure in the "Attaching SR-IOV networking devices to virtual machines" section.
2. Create the bond, attach the desired VFs to the bond and set the bond link state up following the guidance in [Configuring network bonding](#). Follow any of the described procedures to create the bond.

The following examples illustrate the syntax you must use:

- The syntax for configuring a bonded interface is **bond=<name>[:<network\_interfaces>] [:options]**.  
**<name>** is the bonding device name (**bond0**), **<network\_interfaces>** represents the virtual functions (VFs) by their known name in the kernel and shown in the output of the **ip link** command(**eno1f0, eno2f0**), and **options** is a comma-separated list of bonding options. Enter **modinfo bonding** to see available options.

- When you create a bonded interface using **bond=**, you must specify how the IP address is assigned and other information for the bonded interface.
  - To configure the bonded interface to use DHCP, set the bond's IP address to **dhcp**. For example:

```
bond=bond0:eno1f0,eno2f0:mode=active-backup
ip=bond0:dhcp
```

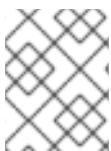
- To configure the bonded interface to use a static IP address, enter the specific IP address you want and related information. For example:

```
bond=bond0:eno1f0,eno2f0:mode=active-backup
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0:none
```

Using network teaming

Optional: You can use a network teaming as an alternative to bonding by using the **team=** parameter:

- The syntax for configuring a team interface is: **team=name[:network\_interfaces]**  
**name** is the team device name (**team0**) and **network\_interfaces** represents a comma-separated list of physical (ethernet) interfaces (**em1, em2**).



## NOTE

Teaming is planned to be deprecated when RHCOS switches to an upcoming version of RHEL. For more information, see this [Red Hat Knowledgebase Article](#).

Use the following example to configure a network team:

```
team=team0:em1,em2
ip=team0:dhcp
```

### 2.2.15.3.9.2. coreos-installer options for ISO and PXE installations

You can install RHCOS by running **coreos-installer install <options> <device>** at the command prompt, after booting into the RHCOS live environment from an ISO image.

The following table shows the subcommands, options, and arguments you can pass to the **coreos-installer** command.

**Table 2.29. coreos-installer subcommands, command-line options, and arguments**

coreos-installer install subcommand	
<i>Subcommand</i>	<i>Description</i>
<b>\$ coreos-installer install &lt;options&gt; &lt;device&gt;</b>	Embed an Ignition config in an ISO image.
coreos-installer install subcommand options	
<i>Option</i>	<i>Description</i>
<b>-u, --image-url &lt;url&gt;</b>	Specify the image URL manually.
<b>-f, --image-file &lt;path&gt;</b>	Specify a local image file manually. Used for debugging.
<b>-i, --ignition-file &lt;path&gt;</b>	Embed an Ignition config from a file.
<b>-l, --ignition-url &lt;URL&gt;</b>	Embed an Ignition config from a URL.
<b>--ignition-hash &lt;digest&gt;</b>	Digest <b>type-value</b> of the Ignition config.
<b>-p, --platform &lt;name&gt;</b>	Override the Ignition platform ID for the installed system.
<b>--console &lt;spec&gt;</b>	Set the kernel and bootloader console for the installed system. For more information about the format of <b>&lt;spec&gt;</b> , see the <a href="#">Linux kernel serial console</a> documentation.

<b>--append-karg &lt;arg&gt;...</b>	Append a default kernel argument to the installed system.
<b>--delete-karg &lt;arg&gt;...</b>	Delete a default kernel argument from the installed system.
<b>-n, --copy-network</b>	Copy the network configuration from the install environment.
	<p><b>IMPORTANT</b></p> <p>The <b>--copy-network</b> option only copies networking configuration found under <b>/etc/NetworkManager/system-connections</b>. In particular, it does not copy the system hostname.</p>
<b>--network-dir &lt;path&gt;</b>	For use with <b>-n</b> . Default is <b>/etc/NetworkManager/system-connections/</b> .
<b>--save-partlabel &lt;lx&gt;..</b>	Save partitions with this label glob.
<b>--save-partindex &lt;id&gt;...</b>	Save partitions with this number or range.
<b>--insecure</b>	Skip RHCOS image signature verification.
<b>--insecure-ignition</b>	Allow Ignition URL without HTTPS or hash.
<b>--architecture &lt;name&gt;</b>	Target CPU architecture. Valid values are <b>x86_64</b> and <b>aarch64</b> .
<b>--preserve-on-error</b>	Do not clear partition table on error.
<b>-h, --help</b>	Print help information.

**coreos-installer install subcommand argument**

<i>Argument</i>	<i>Description</i>
<b>&lt;device&gt;</b>	The destination device.

**coreos-installer ISO subcommands**

<i>Subcommand</i>	<i>Description</i>
<b>\$ coreos-installer iso customize &lt;options&gt; &lt;ISO_image&gt;</b>	Customize a RHCOS live ISO image.

<b>coreos-installer iso reset &lt;options&gt; &lt;ISO_image&gt;</b>	Restore a RHCOS live ISO image to default settings.
<b>coreos-installer iso ignition remove &lt;options&gt; &lt;ISO_image&gt;</b>	Remove the embedded Ignition config from an ISO image.
<b>coreos-installer ISO customize subcommand options</b>	
<i>Option</i>	<i>Description</i>
<b>--dest-ignition &lt;path&gt;</b>	Merge the specified Ignition config file into a new configuration fragment for the destination system.
<b>--dest-console &lt;spec&gt;</b>	Specify the kernel and bootloader console for the destination system.
<b>--dest-device &lt;path&gt;</b>	Install and overwrite the specified destination device.
<b>--dest-karg-append &lt;arg&gt;</b>	Add a kernel argument to each boot of the destination system.
<b>--dest-karg-delete &lt;arg&gt;</b>	Delete a kernel argument from each boot of the destination system.
<b>--network-keyfile &lt;path&gt;</b>	Configure networking by using the specified NetworkManager keyfile for live and destination systems.
<b>--ignition-ca &lt;path&gt;</b>	Specify an additional TLS certificate authority to be trusted by Ignition.
<b>--pre-install &lt;path&gt;</b>	Run the specified script before installation.
<b>--post-install &lt;path&gt;</b>	Run the specified script after installation.
<b>--installer-config &lt;path&gt;</b>	Apply the specified installer configuration file.
<b>--live-ignition &lt;path&gt;</b>	Merge the specified Ignition config file into a new configuration fragment for the live environment.
<b>--live-karg-append &lt;arg&gt;</b>	Add a kernel argument to each boot of the live environment.
<b>--live-karg-delete &lt;arg&gt;</b>	Delete a kernel argument from each boot of the live environment.
<b>--live-karg-replace &lt;k=o=n&gt;</b>	Replace a kernel argument in each boot of the live environment, in the form <b>key=old=new</b> .

<b>-f, --force</b>	Overwrite an existing Ignition config.
<b>-o, --output &lt;path&gt;</b>	Write the ISO to a new output file.
<b>-h, --help</b>	Print help information.

**coreos-installer PXE subcommands**

<i>Subcommand</i>	<i>Description</i>
Note that not all of these options are accepted by all subcommands.	
<b>coreos-installer pxe customize &lt;options&gt; &lt;path&gt;</b>	Customize a RHCOS live PXE boot config.
<b>coreos-installer pxe ignition wrap &lt;options&gt;</b>	Wrap an Ignition config in an image.
<b>coreos-installer pxe ignition unwrap &lt;options&gt; &lt;image_name&gt;</b>	Show the wrapped Ignition config in an image.

**coreos-installer PXE customize subcommand options**

<i>Option</i>	<i>Description</i>
Note that not all of these options are accepted by all subcommands.	
<b>--dest-ignition &lt;path&gt;</b>	Merge the specified Ignition config file into a new configuration fragment for the destination system.
<b>--dest-console &lt;spec&gt;</b>	Specify the kernel and bootloader console for the destination system.
<b>--dest-device &lt;path&gt;</b>	Install and overwrite the specified destination device.
<b>--network-keyfile &lt;path&gt;</b>	Configure networking by using the specified NetworkManager keyfile for live and destination systems.
<b>--ignition-ca &lt;path&gt;</b>	Specify an additional TLS certificate authority to be trusted by Ignition.
<b>--pre-install &lt;path&gt;</b>	Run the specified script before installation.
<b>post-install &lt;path&gt;</b>	Run the specified script after installation.
<b>--installer-config &lt;path&gt;</b>	Apply the specified installer configuration file.

<b>--live-ignition &lt;path&gt;</b>	Merge the specified Ignition config file into a new configuration fragment for the live environment.
<b>-O, --output &lt;path&gt;</b>	<p>Write the initramfs to a new output file.</p>  <p><b>NOTE</b></p> <p>This option is required for PXE environments.</p>
<b>-h, --help</b>	Print help information.

#### 2.2.15.3.9.3. **coreos.inst** boot options for ISO or PXE installations

You can automatically invoke **coreos-installer** options at boot time by passing **coreos.inst** boot arguments to the RHCOS live installer. These are provided in addition to the standard boot arguments.

- For ISO installations, the **coreos.inst** options can be added by interrupting the automatic boot at the bootloader menu. You can interrupt the automatic boot by pressing **TAB** while the **RHEL CoreOS (Live)** menu option is highlighted.
- For PXE or iPXE installations, the **coreos.inst** options must be added to the **APPEND** line before the RHCOS live installer is booted.

The following table shows the RHCOS live installer **coreos.inst** boot options for ISO and PXE installations.

Table 2.30. **coreos.inst** boot options

Argument	Description
<b>coreos.inst.install_dev</b>	<p>Required. The block device on the system to install to.</p>  <p><b>NOTE</b></p> <p>It is recommended to use the full path, such as <b>/dev/sda</b>, although <b>sda</b> is allowed.</p>
<b>coreos.inst.ignition_url</b>	<p>Optional: The URL of the Ignition config to embed into the installed system. If no URL is specified, no Ignition config is embedded. Only HTTP and HTTPS protocols are supported.</p>

Argument	Description
<b>coreos.inst.save_partlabel</b>	Optional: Comma-separated labels of partitions to preserve during the install. Glob-style wildcards are permitted. The specified partitions do not need to exist.
<b>coreos.inst.save_partindex</b>	Optional: Comma-separated indexes of partitions to preserve during the install. Ranges <b>m-n</b> are permitted, and either <b>m</b> or <b>n</b> can be omitted. The specified partitions do not need to exist.
<b>coreos.inst.insecure</b>	Optional: Permits the OS image that is specified by <b>coreos.inst.image_url</b> to be unsigned.
<b>coreos.inst.image_url</b>	<p>Optional: Download and install the specified RHCOS image.</p> <ul style="list-style-type: none"> <li>• This argument should not be used in production environments and is intended for debugging purposes only.</li> <li>• While this argument can be used to install a version of RHCOS that does not match the live media, it is recommended that you instead use the media that matches the version you want to install.</li> <li>• If you are using <b>coreos.inst.image_url</b>, you must also use <b>coreos.inst.insecure</b>. This is because the bare-metal media are not GPG-signed for OpenShift Container Platform.</li> <li>• Only HTTP and HTTPS protocols are supported.</li> </ul>
<b>coreos.inst.skip_reboot</b>	Optional: The system will not reboot after installing. After the install finishes, you will receive a prompt that allows you to inspect what is happening during installation. This argument should not be used in production environments and is intended for debugging purposes only.
<b>coreos.inst.platform_id</b>	Optional: The Ignition platform ID of the platform the RHCOS image is being installed on. Default is <b>metal</b> . This option determines whether or not to request an Ignition config from the cloud provider, such as VMware. For example: <b>coreos.inst.platform_id=vmware</b> .

Argument	Description
<b>ignition.config.url</b>	Optional: The URL of the Ignition config for the live boot. For example, this can be used to customize how <b>coreos-installer</b> is invoked, or to run code before or after the installation. This is different from <b>coreos.inst.ignition_url</b> , which is the Ignition config for the installed system.

#### 2.2.15.4. Enabling multipathing with kernel arguments on RHCOS

RHCOS supports multipathing on the primary disk, allowing stronger resilience to hardware failure to achieve higher host availability.

You can enable multipathing at installation time for nodes that were provisioned in OpenShift Container Platform 4.8 or later. While postinstallation support is available by activating multipathing via the machine config, enabling multipathing during installation is recommended.

In setups where any I/O to non-optimized paths results in I/O system errors, you must enable multipathing at installation time.



#### IMPORTANT

On IBM Z® and IBM® LinuxONE, you can enable multipathing only if you configured your cluster for it during installation. For more information, see "Installing RHCOS and starting the OpenShift Container Platform bootstrap process" in *Installing a cluster with z/VM on IBM Z® and IBM® LinuxONE*.

The following procedure enables multipath at installation time and appends kernel arguments to the **coreos-installer install** command so that the installed system itself will use multipath beginning from the first boot.



#### NOTE

OpenShift Container Platform does not support enabling multipathing as a day-2 activity on nodes that have been upgraded from 4.6 or earlier.

#### Prerequisites

- You have created the Ignition config files for your cluster.
- You have reviewed *Installing RHCOS and starting the OpenShift Container Platform bootstrap process*.

#### Procedure

1. To enable multipath and start the **multipathd** daemon, run the following command on the installation host:

```
$ mpathconf --enable && systemctl start multipathd.service
```

- Optional: If booting the PXE or ISO, you can instead enable multipath by adding **rd.multipath=default** from the kernel command line.
2. Append the kernel arguments by invoking the **coreos-installer** program:
    - If there is only one multipath device connected to the machine, it should be available at path **/dev/mapper/mpatha**. For example:

```
$ coreos-installer install /dev/mapper/mpatha \①
--ignition-url=http://host/worker.ign \
--append-karg rd.multipath=default \
--append-karg root=/dev/disk/by-label/dm-mpath-root \
--append-karg rw
```

① Indicates the path of the single multipathed device.

- If there are multiple multipath devices connected to the machine, or to be more explicit, instead of using **/dev/mapper/mpatha**, it is recommended to use the World Wide Name (WWN) symlink available in **/dev/disk/by-id**. For example:

```
$ coreos-installer install /dev/disk/by-id/wwn-<wwn_ID> \①
--ignition-url=http://host/worker.ign \
--append-karg rd.multipath=default \
--append-karg root=/dev/disk/by-label/dm-mpath-root \
--append-karg rw
```

① Indicates the WWN ID of the target multipathed device. For example, **0xx194e957fcedb4841**.

This symlink can also be used as the **coreos.inst.install\_dev** kernel argument when using special **coreos.inst.\*** arguments to direct the live installer. For more information, see "Installing RHCOS and starting the OpenShift Container Platform bootstrap process".

3. Reboot into the installed system.
4. Check that the kernel arguments worked by going to one of the worker nodes and listing the kernel command-line arguments (in **/proc/cmdline** on the host):

```
$ oc debug node/ip-10-0-141-105.ec2.internal
```

### Example output

```
Starting pod/ip-10-0-141-105ec2internal-debug ...
To use host binaries, run `chroot /host`

sh-4.2# cat /host/proc/cmdline
...
rd.multipath=default root=/dev/disk/by-label/dm-mpath-root
...
sh-4.2# exit
```

You should see the added kernel arguments.

### 2.2.15.4.1. Enabling multipathing on secondary disks

RHCOS also supports multipathing on a secondary disk. Instead of kernel arguments, you use Ignition to enable multipathing for the secondary disk at installation time.

#### Prerequisites

- You have read the section *Disk partitioning*.
- You have read *Enabling multipathing with kernel arguments on RHCOS*.
- You have installed the Butane utility.

#### Procedure

1. Create a Butane config with information similar to the following:

##### Example multipath-config.bu

```
variant: openshift
version: 4.18.0
systemd:
units:
- name: mpath-configure.service
  enabled: true
  contents: |
    [Unit]
    Description=Configure Multipath on Secondary Disk
    ConditionFirstBoot=true
    ConditionPathExists=!/etc/multipath.conf
    Before=multipathd.service ①
    DefaultDependencies=no

    [Service]
    Type=oneshot
    ExecStart=/usr/sbin/mpathconf --enable ②

    [Install]
    WantedBy=multi-user.target
- name: mpath-var-lib-container.service
  enabled: true
  contents: |
    [Unit]
    Description=Set Up Multipath On /var/lib/containers
    ConditionFirstBoot=true ③
    Requires=dev-mapper-mpatha.device
    After=dev-mapper-mpatha.device
    After=ostree-remount.service
    Before=kubelet.service
    DefaultDependencies=no

    [Service] ④
    Type=oneshot
    ExecStart=/usr/sbin/mkfs.xfs -L containers -m reflink=1 /dev/mapper/mpatha
    ExecStart=/usr/bin/mkdir -p /var/lib/containers
```

```
[Install]
WantedBy=multi-user.target
- name: var-lib-containers.mount
  enabled: true
  contents: |
    [Unit]
    Description=Mount /var/lib/containers
    After=mpath-var-lib-containers.service
    Before=kubelet.service ⑤

    [Mount] ⑥
    What=/dev/disk/by-label/dm-mpath-containers
    Where=/var/lib/containers
    Type=xfs

[Install]
WantedBy=multi-user.target
```

- 1 The configuration must be set before launching the multipath daemon.
- 2 Starts the **mpathconf** utility.
- 3 This field must be set to the value **true**.
- 4 Creates the filesystem and directory **/var/lib/containers**.
- 5 The device must be mounted before starting any nodes.
- 6 Mounts the device to the **/var/lib/containers** mount point. This location cannot be a symlink.

2. Create the Ignition configuration by running the following command:

```
$ butane --pretty --strict multipath-config.bu > multipath-config.ign
```

3. Continue with the rest of the first boot RHCOS installation process.



### IMPORTANT

Do not add the **rd.multipath** or **root** kernel arguments on the command-line during installation unless the primary disk is also multipathed.

#### 2.2.15.5. Installing RHCOS manually on an iSCSI boot device

You can manually install RHCOS on an iSCSI target.

##### Prerequisites

1. You are in the RHCOS live environment.
2. You have an iSCSI target that you want to install RHCOS on.

##### Procedure

1. Mount the iSCSI target from the live environment by running the following command:

```
$ iscsiadm \
--mode discovery \
--type sendtargets \
--portal <IP_address> \ ①
--login
```

- ① The IP address of the target portal.

2. Install RHCOS onto the iSCSI target by running the following command and using the necessary kernel arguments, for example:

```
$ coreos-installer install \
/dev/disk/by-path/ip-<IP_address>:<port>-iscsi-<target_iqn>-lun-<lun> \ ①
--append-karg rd.iscsi.initiator=<initiator_iqn> \ ②
--append.karg netroot=<target_iqn> \ ③
--console ttyS0,115200n8
--ignition-file <path_to_file>
```

- ① The location you are installing to. You must provide the IP address of the target portal, the associated port number, the target iSCSI node in IQN format, and the iSCSI logical unit number (LUN).
- ② The iSCSI initiator, or client, name in IQN format. The initiator forms a session to connect to the iSCSI target.
- ③ The the iSCSI target, or server, name in IQN format.

For more information about the iSCSI options supported by **dracut**, see the [dracut.cmdline manual page](#).

3. Unmount the iSCSI disk with the following command:

```
$ iscsiadm --mode node --logoutall=all
```

This procedure can also be performed using the **coreos-installer iso customize** or **coreos-installer pxe customize** subcommands.

### 2.2.15.6. Installing RHCOS on an iSCSI boot device using iBFT

On a completely diskless machine, the iSCSI target and initiator values can be passed through iBFT. iSCSI multipathing is also supported.

#### Prerequisites

1. You are in the RHCOS live environment.
2. You have an iSCSI target you want to install RHCOS on.
3. Optional: you have multipathed your iSCSI target.

## Procedure

1. Mount the iSCSI target from the live environment by running the following command:

```
$ iscsiadm \
--mode discovery \
--type sendtargets \
--portal <IP_address> \ ①
--login
```

- ① The IP address of the target portal.

2. Optional: enable multipathing and start the daemon with the following command:

```
$ mpathconf --enable && systemctl start multipathd.service
```

3. Install RHCOS onto the iSCSI target by running the following command and using the necessary kernel arguments, for example:

```
$ coreos-installer install \
/dev/mapper/mpatha \ ①
--append-karg rd.iscsi.firmware=1 \ ②
--append-karg rd.multipath=default \ ③
--console ttyS0 \
--ignition-file <path_to_file>
```

- ① The path of a single multipathed device. If there are multiple multipath devices connected, or to be explicit, you can use the World Wide Name (WWN) symlink available in **/dev/disk/by-path**.
- ② The iSCSI parameter is read from the BIOS firmware.
- ③ Optional: include this parameter if you are enabling multipathing.

For more information about the iSCSI options supported by **dracut**, see the [dracut.cmdline manual page](#).

4. Unmount the iSCSI disk:

```
$ iscsiadm --mode node --logout=all
```

This procedure can also be performed using the **coreos-installer iso customize** or **coreos-installer pxe customize** subcommands.

### 2.2.16. Waiting for the bootstrap process to complete

The OpenShift Container Platform bootstrap process begins after the cluster nodes first boot into the persistent RHCOS environment that has been installed to disk. The configuration information provided through the Ignition config files is used to initialize the bootstrap process and install OpenShift Container Platform on the machines. You must wait for the bootstrap process to complete.

#### Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have obtained the installation program and generated the Ignition config files for your cluster.
- You installed RHCOS on your cluster machines and provided the Ignition config files that the OpenShift Container Platform installation program generated.
- Your machines have direct internet access or have an HTTP or HTTPS proxy available.

## Procedure

1. Monitor the bootstrap process:

```
$ ./openshift-install --dir <installation_directory> wait-for bootstrap-complete \ ①
--log-level=info ②
```

- 1 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.
- 2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

## Example output

```
INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...
INFO API v1.31.3 up
INFO Waiting up to 30m0s for bootstrapping to complete...
INFO It is now safe to remove the bootstrap resources
```

The command succeeds when the Kubernetes API server signals that it has been bootstrapped on the control plane machines.

2. After the bootstrap process is complete, remove the bootstrap machine from the load balancer.



### IMPORTANT

You must remove the bootstrap machine from the load balancer at this point.  
You can also remove or reformat the bootstrap machine itself.

## Additional resources

- See [Monitoring installation progress](#) for more information about monitoring the installation logs and retrieving diagnostic data if installation issues arise.

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

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

## Prerequisites

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

## Procedure

1. Export the **kubeadmin** credentials:

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

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

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

```
$ oc whoami
```

### Example output

```
system:admin
```

## 2.2.18. Approving the certificate signing requests for your machines

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

## Prerequisites

- You added machines to your cluster.

## Procedure

1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

### Example output

NAME	STATUS	ROLES	AGE	VERSION
master-0	Ready	master	63m	v1.31.3
master-1	Ready	master	63m	v1.31.3
master-2	Ready	master	64m	v1.31.3

The output lists all of the machines that you created.



### NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

- Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

```
$ oc get csr
```

### Example output

NAME	AGE	REQUESTOR	CONDITION
csr-8b2br	15m	system:serviceaccount:openshift-machine-config-operator:node-bootstrapper	Pending
csr-8vnps	15m	system:serviceaccount:openshift-machine-config-operator:node-bootstrapper	Pending
...			

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

- If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:



### NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approvers** if the Kubelet requests a new certificate with identical parameters.



### NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

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

```
$ oc adm certificate approve <csr_name> ①
```

① **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}\n{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```



### NOTE

Some Operators might not become available until some CSRs are approved.

- Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

### Example output

NAME	AGE	REQUESTOR	CONDITION
csr-bfd72	5m26s	system:node:ip-10-0-50-126.us-east-2.compute.internal	Pending
csr-c57lv	5m26s	system:node:ip-10-0-95-157.us-east-2.compute.internal	Pending
	...		

- If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

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

```
$ oc adm certificate approve <csr_name> ①
```

① **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}\n{{end}}{{end}}' | xargs oc adm certificate approve
```

- After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

### Example output

NAME	STATUS	ROLES	AGE	VERSION
master-0	Ready	master	73m	v1.31.3
master-1	Ready	master	73m	v1.31.3
master-2	Ready	master	74m	v1.31.3
worker-0	Ready	worker	11m	v1.31.3
worker-1	Ready	worker	11m	v1.31.3

**NOTE**

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

**Additional information**

- [Certificate Signing Requests](#)

**2.2.19. Initial Operator configuration**

After the control plane initializes, you must immediately configure some Operators so that they all become available.

**Prerequisites**

- Your control plane has initialized.

**Procedure**

1. Watch the cluster components come online:

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

**Example output**

NAME SINCE	VERSION	AVAILABLE	PROGRESSING	DEGRADED
authentication	4.18.0	True	False	False 19m
baremetal	4.18.0	True	False	False 37m
cloud-credential	4.18.0	True	False	False 40m
cluster-autoscaler	4.18.0	True	False	False 37m
config-operator	4.18.0	True	False	False 38m
console	4.18.0	True	False	False 26m
csi-snapshot-controller	4.18.0	True	False	False 37m
dns	4.18.0	True	False	False 37m
etcd	4.18.0	True	False	False 36m
image-registry	4.18.0	True	False	False 31m
ingress	4.18.0	True	False	False 30m
insights	4.18.0	True	False	False 31m
kube-apiserver	4.18.0	True	False	False 26m
kube-controller-manager	4.18.0	True	False	False 36m
kube-scheduler	4.18.0	True	False	False 36m
kube-storage-version-migrator	4.18.0	True	False	False 37m
machine-api	4.18.0	True	False	False 29m
machine approver	4.18.0	True	False	False 37m
machine-config	4.18.0	True	False	False 36m
marketplace	4.18.0	True	False	False 37m
monitoring	4.18.0	True	False	False 29m
network	4.18.0	True	False	False 38m
node-tuning	4.18.0	True	False	False 37m
openshift-apiserver	4.18.0	True	False	False 32m
openshift-controller-manager	4.18.0	True	False	False 30m
openshift-samples	4.18.0	True	False	False 32m

operator-lifecycle-manager	4.18.0	True	False	False	37m
operator-lifecycle-manager-catalog	4.18.0	True	False	False	37m
operator-lifecycle-manager-packageserver	4.18.0	True	False	False	32m
service-ca	4.18.0	True	False	False	38m
storage	4.18.0	True	False	False	37m

- Configure the Operators that are not available.

## Additional resources

- See [Gathering logs from a failed installation](#) for details about gathering data in the event of a failed OpenShift Container Platform installation.
- See [Troubleshooting Operator issues](#) for steps to check Operator pod health across the cluster and gather Operator logs for diagnosis.

### 2.2.19.1. Image registry removed during installation

On platforms that do not provide shareable object storage, the OpenShift Image Registry Operator bootstraps itself as **Removed**. This allows **openshift-installer** to complete installations on these platform types.

After installation, you must edit the Image Registry Operator configuration to switch the **managementState** from **Removed** to **Managed**. When this has completed, you must configure storage.

### 2.2.19.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

### 2.2.19.3. Configuring block registry storage for bare metal

To allow the image registry to use block storage types during upgrades as a cluster administrator, you can use the **Recreate** rollout strategy.



#### IMPORTANT

Block storage volumes, or block persistent volumes, are supported but not recommended for use with the image registry on production clusters. An installation where the registry is configured on block storage is not highly available because the registry cannot have more than one replica.

If you choose to use a block storage volume with the image registry, you must use a filesystem persistent volume claim (PVC).

## Procedure

- Enter the following command to set the image registry storage as a block storage type, patch the registry so that it uses the **Recreate** rollout strategy, and runs with only one (1) replica:

```
$ oc patch config.imageregistry.operator.openshift.io/cluster --type=merge -p '{"spec": {"rolloutStrategy":"Recreate","replicas":1}}'
```

- Provision the PV for the block storage device, and create a PVC for that volume. The requested block volume uses the ReadWriteOnce (RWO) access mode.
  - Create a **pvc.yaml** file with the following contents to define a VMware vSphere **PersistentVolumeClaim** object:

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: image-registry-storage ①
  namespace: openshift-image-registry ②
spec:
  accessModes:
    - ReadWriteOnce ③
  resources:
    requests:
      storage: 100Gi ④
```

- ① A unique name that represents the **PersistentVolumeClaim** object.
- ② The namespace for the **PersistentVolumeClaim** object, which is **openshift-image-registry**.
- ③ The access mode of the persistent volume claim. With **ReadWriteOnce**, the volume can be mounted with read and write permissions by a single node.
- ④ The size of the persistent volume claim.

- Enter the following command to create the **PersistentVolumeClaim** object from the file:

```
$ oc create -f pvc.yaml -n openshift-image-registry
```

- Enter the following command to edit the registry configuration so that it references the correct PVC:

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

### Example output

```
storage:
pvc:
claim: ①
```

- ① By creating a custom PVC, you can leave the **claim** field blank for the default automatic creation of an **image-registry-storage** PVC.

## 2.2.20. Completing installation on user-provisioned infrastructure

After you complete the Operator configuration, you can finish installing the cluster on infrastructure that you provide.

### Prerequisites

- Your control plane has initialized.
- You have completed the initial Operator configuration.

### Procedure

1. Confirm that all the cluster components are online with the following command:

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

### Example output

NAME SINCE	VERSION	AVAILABLE	PROGRESSING	DEGRADED
authentication	4.18.0	True	False	False 19m
baremetal	4.18.0	True	False	False 37m
cloud-credential	4.18.0	True	False	False 40m
cluster-autoscaler	4.18.0	True	False	False 37m
config-operator	4.18.0	True	False	False 38m
console	4.18.0	True	False	False 26m
csi-snapshot-controller	4.18.0	True	False	False 37m
dns	4.18.0	True	False	False 37m
etcd	4.18.0	True	False	False 36m
image-registry	4.18.0	True	False	False 31m
ingress	4.18.0	True	False	False 30m
insights	4.18.0	True	False	False 31m
kube-apiserver	4.18.0	True	False	False 26m
kube-controller-manager	4.18.0	True	False	False 36m
kube-scheduler	4.18.0	True	False	False 36m
kube-storage-version-migrator	4.18.0	True	False	False 37m
machine-api	4.18.0	True	False	False 29m
machine-approver	4.18.0	True	False	False 37m
machine-config	4.18.0	True	False	False 36m
marketplace	4.18.0	True	False	False 37m
monitoring	4.18.0	True	False	False 29m
network	4.18.0	True	False	False 38m
node-tuning	4.18.0	True	False	False 37m
openshift-apiserver	4.18.0	True	False	False 32m
openshift-controller-manager	4.18.0	True	False	False 30m
openshift-samples	4.18.0	True	False	False 32m
operator-lifecycle-manager	4.18.0	True	False	False 37m
operator-lifecycle-manager-catalog	4.18.0	True	False	False 37m
operator-lifecycle-manager-packageserver	4.18.0	True	False	False 32m
service-ca	4.18.0	True	False	False 38m
storage	4.18.0	True	False	False 37m

Alternatively, the following command notifies you when all of the clusters are available. It also retrieves and displays credentials:

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

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

### Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

The command succeeds when the Cluster Version Operator finishes deploying the OpenShift Container Platform cluster from Kubernetes API server.



### IMPORTANT

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

- Confirm that the Kubernetes API server is communicating with the pods.

- To view a list of all pods, use the following command:

```
$ oc get pods --all-namespaces
```

### Example output

NAMESPACE	NAME	READY	STATUS
RESTARTS	AGE		
openshift-apiserver-operator	openshift-apiserver-operator-85cb746d55-zqhs8	1/1	
Running 1 9m			
openshift-apiserver	apiserver-67b9g	1/1	Running 0
3m			
openshift-apiserver	apiserver-ljcmx	1/1	Running 0
1m			
openshift-apiserver	apiserver-z25h4	1/1	Running 0
2m			
openshift-authentication-operator	authentication-operator-69d5d8bf84-vh2n8	1/1	
Running 0 5m			
...			

- b. View the logs for a pod that is listed in the output of the previous command by using the following command:

```
$ oc logs <pod_name> -n <namespace> ①
```

- ① Specify the pod name and namespace, as shown in the output of the previous command.

If the pod logs display, the Kubernetes API server can communicate with the cluster machines.

3. For an installation with Fibre Channel Protocol (FCP), additional steps are required to enable multipathing. Do not enable multipathing during installation.

See "Enabling multipathing with kernel arguments on RHCOS" in the *Postinstallation machine configuration tasks* documentation for more information.

### 2.2.21. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.18, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

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

#### Additional resources

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

### 2.2.22. Next steps

- [Validating an installation](#).
- [Customize your cluster](#).
- If necessary, you can [opt out of remote health reporting](#).
- [Set up your registry and configure registry storage](#).

## 2.3. INSTALLING A USER-PROVISIONED BARE METAL CLUSTER ON A DISCONNECTED ENVIRONMENT

In OpenShift Container Platform 4.18, you can install a cluster on bare metal infrastructure that you provision in a restricted network.



#### IMPORTANT

While you might be able to follow this procedure to deploy a cluster on virtualized or cloud environments, you must be aware of additional considerations for non-bare metal platforms. Review the information in the [guidelines for deploying OpenShift Container Platform on non-tested platforms](#) before you attempt to install an OpenShift Container Platform cluster in such an environment.

### 2.3.1. Prerequisites

- You reviewed details about the [OpenShift Container Platform installation and update processes](#).
- You read the documentation on [selecting a cluster installation method and preparing it for users](#).
- You [created a registry on your mirror host](#) and obtained the **imageContentSources** data for your version of OpenShift Container Platform.



#### IMPORTANT

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

- You provisioned [persistent storage](#) for your cluster. To deploy a private image registry, your storage must provide ReadWriteMany access modes.
- If you use a firewall and plan to use the Telemetry service, you [configured the firewall to allow the sites](#) that your cluster requires access to.



#### NOTE

Be sure to also review this site list if you are configuring a proxy.

### 2.3.2. About installations in restricted networks

In OpenShift Container Platform 4.18, you can perform an installation that does not require an active connection to the internet to obtain software components. Restricted network installations can be completed using installer-provisioned infrastructure or user-provisioned infrastructure, depending on the cloud platform to which you are installing the cluster.

If you choose to perform a restricted network installation on a cloud platform, you still require access to its cloud APIs. Some cloud functions, like Amazon Web Service’s Route 53 DNS and IAM services, require internet access. Depending on your network, you might require less internet access for an installation on bare metal hardware, Nutanix, or on VMware vSphere.

To complete a restricted network installation, you must create a registry that mirrors the contents of the OpenShift image registry and contains the installation media. You can create this registry on a mirror host, which can access both the internet and your closed network, or by using other methods that meet your restrictions.



#### IMPORTANT

Because of the complexity of the configuration for user-provisioned installations, consider completing a standard user-provisioned infrastructure installation before you attempt a restricted network installation using user-provisioned infrastructure. Completing this test installation might make it easier to isolate and troubleshoot any issues that might arise during your installation in a restricted network.

#### 2.3.2.1. Additional limits

Clusters in restricted networks have the following additional limitations and restrictions:

- The **ClusterVersion** status includes an **Unable to retrieve available updates** error.
- By default, you cannot use the contents of the Developer Catalog because you cannot access the required image stream tags.

### 2.3.3. Internet access for OpenShift Container Platform

In OpenShift Container Platform 4.18, you require access to the internet to obtain the images that are necessary to install your cluster.

You must have internet access to:

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

### 2.3.4. Requirements for a cluster with user-provisioned infrastructure

For a cluster that contains user-provisioned infrastructure, you must deploy all of the required machines.

This section describes the requirements for deploying OpenShift Container Platform on user-provisioned infrastructure.

#### 2.3.4.1. Required machines for cluster installation

The smallest OpenShift Container Platform clusters require the following hosts:

**Table 2.31. Minimum required hosts**

Hosts	Description
One temporary bootstrap machine	The cluster requires the bootstrap machine to deploy the OpenShift Container Platform cluster on the three control plane machines. You can remove the bootstrap machine after you install the cluster.
Three control plane machines	The control plane machines run the Kubernetes and OpenShift Container Platform services that form the control plane.
At least two compute machines, which are also known as worker machines.	The workloads requested by OpenShift Container Platform users run on the compute machines.



#### NOTE

As an exception, you can run zero compute machines in a bare metal cluster that consists of three control plane machines only. This provides smaller, more resource efficient clusters for cluster administrators and developers to use for testing, development, and production. Running one compute machine is not supported.



## IMPORTANT

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

The bootstrap and control plane machines must use Red Hat Enterprise Linux CoreOS (RHCOS) as the operating system. However, the compute machines can choose between Red Hat Enterprise Linux CoreOS (RHCOS), Red Hat Enterprise Linux (RHEL) 8.6 and later.

Note that RHCOS is based on Red Hat Enterprise Linux (RHEL) 9.2 and inherits all of its hardware certifications and requirements. See [Red Hat Enterprise Linux technology capabilities and limits](#).

### 2.3.4.2. Minimum resource requirements for cluster installation

Each cluster machine must meet the following minimum requirements:

**Table 2.32. Minimum resource requirements**

Machine	Operating System	CPU[1]	RAM	Storage	Input/Output Per Second (IOPS)[2]
Bootstrap	RHCOS	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS, RHEL 8.6 and later [3]	2	8 GB	100 GB	300

1. One CPU is equivalent to one physical core when simultaneous multithreading (SMT), or Hyper-Threading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = CPUs.
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes which require a 10 ms p99 fsync duration. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.
3. As with all user-provisioned installations, if you choose to use RHEL compute machines in your cluster, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Use of RHEL 7 compute machines is deprecated and has been removed in OpenShift Container Platform 4.10 and later.



## NOTE

For OpenShift Container Platform version 4.18, RHCOS is based on RHEL version 9.4, which updates the micro-architecture requirements. The following list contains the minimum instruction set architectures (ISA) that each architecture requires:

- x86-64 architecture requires x86-64-v2 ISA
- ARM64 architecture requires ARMv8.0-A ISA
- IBM Power architecture requires Power 9 ISA
- s390x architecture requires z14 ISA

For more information, see [Architectures](#) (RHEL documentation).

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

### Additional resources

- [Optimizing storage](#)

#### 2.3.4.3. Certificate signing requests management

Because your cluster has limited access to automatic machine management when you use infrastructure that you provision, you must provide a mechanism for approving cluster certificate signing requests (CSRs) after installation. The **kube-controller-manager** only approves the kubelet client CSRs. The **machine approver** cannot guarantee the validity of a serving certificate that is requested by using kubelet credentials because it cannot confirm that the correct machine issued the request. You must determine and implement a method of verifying the validity of the kubelet serving certificate requests and approving them.

### Additional resources

- See [Configuring a three-node cluster](#) for details about deploying three-node clusters in bare metal environments.
- See [Approving the certificate signing requests for your machines](#) for more information about approving cluster certificate signing requests after installation.

#### 2.3.4.4. Networking requirements for user-provisioned infrastructure

All the Red Hat Enterprise Linux CoreOS (RHCOS) machines require networking to be configured in **initramfs** during boot to fetch their Ignition config files.

During the initial boot, the machines require an IP address configuration that is set either through a DHCP server or statically by providing the required boot options. After a network connection is established, the machines download their Ignition config files from an HTTP or HTTPS server. The Ignition config files are then used to set the exact state of each machine. The Machine Config Operator completes more changes to the machines, such as the application of new certificates or keys, after installation.



## NOTE

- It is recommended to use a DHCP server for long-term management of the cluster machines. Ensure that the DHCP server is configured to provide persistent IP addresses, DNS server information, and hostnames to the cluster machines.
- If a DHCP service is not available for your user-provisioned infrastructure, you can instead provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

The Kubernetes API server must be able to resolve the node names of the cluster machines. If the API servers and worker nodes are in different zones, you can configure a default DNS search zone to allow the API server to resolve the node names. Another supported approach is to always refer to hosts by their fully-qualified domain names in both the node objects and all DNS requests.

### 2.3.4.4.1. Setting the cluster node hostnames through DHCP

On Red Hat Enterprise Linux CoreOS (RHCOS) machines, the hostname is set through NetworkManager. By default, the machines obtain their hostname through DHCP. If the hostname is not provided by DHCP, set statically through kernel arguments, or another method, it is obtained through a reverse DNS lookup. Reverse DNS lookup occurs after the network has been initialized on a node and can take time to resolve. Other system services can start prior to this and detect the hostname as **localhost** or similar. You can avoid this by using DHCP to provide the hostname for each cluster node.

Additionally, setting the hostnames through DHCP can bypass any manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

### 2.3.4.4.2. Network connectivity requirements

You must configure the network connectivity between machines to allow OpenShift Container Platform cluster components to communicate. Each machine must be able to resolve the hostnames of all other machines in the cluster.

This section provides details about the ports that are required.

**Table 2.33. Ports used for all-machine to all-machine communications**

Protocol	Port	Description
ICMP	N/A	Network reachability tests
TCP	<b>1936</b>	Metrics
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> and the Cluster Version Operator on port <b>9099</b> .
	<b>10250-10259</b>	The default ports that Kubernetes reserves
UDP	<b>4789</b>	VXLAN

Protocol	Port	Description
	<b>6081</b>	Geneve
	<b>9000-9999</b>	Host level services, including the node exporter on ports <b>9100-9101</b> .
	<b>500</b>	IPsec IKE packets
	<b>4500</b>	IPsec NAT-T packets
	<b>123</b>	Network Time Protocol (NTP) on UDP port <b>123</b>  If an external NTP time server is configured, you must open UDP port <b>123</b> .
TCP/UDP	<b>30000-32767</b>	Kubernetes node port
ESP	N/A	IPsec Encapsulating Security Payload (ESP)

Table 2.34. Ports used for all-machine to control plane communications

Protocol	Port	Description
TCP	<b>6443</b>	Kubernetes API

Table 2.35. Ports used for control plane machine to control plane machine communications

Protocol	Port	Description
TCP	<b>2379-2380</b>	etcd server and peer ports

### NTP configuration for user-provisioned infrastructure

OpenShift Container Platform clusters are configured to use a public Network Time Protocol (NTP) server by default. If you want to use a local enterprise NTP server, or if your cluster is being deployed in a disconnected network, you can configure the cluster to use a specific time server. For more information, see the documentation for [Configuring chrony time service](#).

If a DHCP server provides NTP server information, the chrony time service on the Red Hat Enterprise Linux CoreOS (RHCOS) machines read the information and can sync the clock with the NTP servers.

### Additional resources

- [Configuring chrony time service](#)

#### 2.3.4.5. User-provisioned DNS requirements

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API
- The OpenShift Container Platform application wildcard
- The bootstrap, control plane, and compute machines

Reverse DNS resolution is also required for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

DNS A/AAAA or CNAME records are used for name resolution and PTR records are used for reverse name resolution. The reverse records are important because Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records to set the hostnames for all the nodes, unless the hostnames are provided by DHCP. Additionally, the reverse records are used to generate the certificate signing requests (CSR) that OpenShift Container Platform needs to operate.



### NOTE

It is recommended to use a DHCP server to provide the hostnames to each cluster node. See the *DHCP recommendations for user-provisioned infrastructure* section for more information.

The following DNS records are required for a user-provisioned OpenShift Container Platform cluster and they must be in place before installation. In each record, `<cluster_name>` is the cluster name and `<base_domain>` is the base domain that you specify in the `install-config.yaml` file. A complete DNS record takes the form: `<component>.<cluster_name>.<base_domain>..`

**Table 2.36. Required DNS records**

Component	Record	Description
Kubernetes API	<code>api.&lt;cluster_name&gt;.&lt;base_domain&gt;.</code>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
	<code>api-int.&lt;cluster_name&gt;.&lt;base_domain&gt;.</code>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to internally identify the API load balancer. These records must be resolvable from all the nodes within the cluster.



### IMPORTANT

The API server must be able to resolve the worker nodes by the hostnames that are recorded in Kubernetes. If the API server cannot resolve the node names, then proxied API calls can fail, and you cannot retrieve logs from pods.

Component	Record	Description
Routes	<code>*.apps.&lt;cluster_name&gt;. &lt;base_domain&gt;.</code>	A wildcard DNS A/AAAA or CNAME record that refers to the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.  For example, <code>console-openshift-console.apps.&lt;cluster_name&gt;. &lt;base_domain&gt;</code> is used as a wildcard route to the OpenShift Container Platform console.
Bootstrap machine	<code>bootstrap.&lt;cluster_name&gt;. &lt;base_domain&gt;.</code>	A DNS A/AAAA or CNAME record, and a DNS PTR record, to identify the bootstrap machine. These records must be resolvable by the nodes within the cluster.
Control plane machines	<code>&lt;control_plane&gt;&lt;n&gt;. &lt;cluster_name&gt;. &lt;base_domain&gt;.</code>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the control plane nodes. These records must be resolvable by the nodes within the cluster.
Compute machines	<code>&lt;compute&gt;&lt;n&gt;. &lt;cluster_name&gt;. &lt;base_domain&gt;.</code>	DNS A/AAAA or CNAME records and DNS PTR records to identify each machine for the worker nodes. These records must be resolvable by the nodes within the cluster.



## NOTE

In OpenShift Container Platform 4.4 and later, you do not need to specify etcd host and SRV records in your DNS configuration.

## TIP

You can use the `dig` command to verify name and reverse name resolution. See the section on [Validating DNS resolution for user-provisioned infrastructure](#) for detailed validation steps.

### 2.3.4.5.1. Example DNS configuration for user-provisioned clusters

This section provides A and PTR record configuration samples that meet the DNS requirements for deploying OpenShift Container Platform on user-provisioned infrastructure. The samples are not meant to provide advice for choosing one DNS solution over another.

In the examples, the cluster name is `ocp4` and the base domain is `example.com`.

#### Example DNS A record configuration for a user-provisioned cluster

The following example is a BIND zone file that shows sample A records for name resolution in a user-provisioned cluster.

### Example 2.7. Sample DNS zone database

```
$TTL 1W
@ IN SOA ns1.example.com. root (
    2019070700 ; serial
    3H ; refresh (3 hours)
    30M ; retry (30 minutes)
    2W ; expiry (2 weeks)
    1W ) ; minimum (1 week)
IN NS ns1.example.com.
IN MX 10 smtp.example.com.
;
;
ns1.example.com. IN A 192.168.1.5
smtp.example.com. IN A 192.168.1.5
;
helper.example.com. IN A 192.168.1.5
helper.ocp4.example.com. IN A 192.168.1.5
;
api.ocp4.example.com. IN A 192.168.1.5 ①
api-int.ocp4.example.com. IN A 192.168.1.5 ②
;
*.apps.ocp4.example.com. IN A 192.168.1.5 ③
;
bootstrap.ocp4.example.com. IN A 192.168.1.96 ④
;
control-plane0.ocp4.example.com. IN A 192.168.1.97 ⑤
control-plane1.ocp4.example.com. IN A 192.168.1.98 ⑥
control-plane2.ocp4.example.com. IN A 192.168.1.99 ⑦
;
compute0.ocp4.example.com. IN A 192.168.1.11 ⑧
compute1.ocp4.example.com. IN A 192.168.1.7 ⑨
;
;EOF
```

- ① Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer.
- ② Provides name resolution for the Kubernetes API. The record refers to the IP address of the API load balancer and is used for internal cluster communications.
- ③ Provides name resolution for the wildcard routes. The record refers to the IP address of the application ingress load balancer. The application ingress load balancer targets the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



#### NOTE

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

- ④ Provides name resolution for the bootstrap machine.
- ⑤ ⑥ ⑦ Provides name resolution for the control plane machines.
- ⑧ ⑨ Provides name resolution for the compute machines.

### Example DNS PTR record configuration for a user-provisioned cluster

The following example BIND zone file shows sample PTR records for reverse name resolution in a user-provisioned cluster.

#### Example 2.8. Sample DNS zone database for reverse records

```
$TTL 1W
@ IN SOA ns1.example.com. root (
    2019070700 ; serial
    3H ; refresh (3 hours)
    30M ; retry (30 minutes)
    2W ; expiry (2 weeks)
    1W ) ; minimum (1 week)
IN NS ns1.example.com.
;
5.1.168.192.in-addr.arpa. IN PTR api.ocp4.example.com. ①
5.1.168.192.in-addr.arpa. IN PTR api-int.ocp4.example.com. ②
;
96.1.168.192.in-addr.arpa. IN PTR bootstrap.ocp4.example.com. ③
;
97.1.168.192.in-addr.arpa. IN PTR control-plane0.ocp4.example.com. ④
98.1.168.192.in-addr.arpa. IN PTR control-plane1.ocp4.example.com. ⑤
99.1.168.192.in-addr.arpa. IN PTR control-plane2.ocp4.example.com. ⑥
;
11.1.168.192.in-addr.arpa. IN PTR compute0.ocp4.example.com. ⑦
7.1.168.192.in-addr.arpa. IN PTR compute1.ocp4.example.com. ⑧
;
:EOF
```

- ① Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer.
- ② Provides reverse DNS resolution for the Kubernetes API. The PTR record refers to the record name of the API load balancer and is used for internal cluster communications.
- ③ Provides reverse DNS resolution for the bootstrap machine.
- ④ ⑤ ⑥ Provides reverse DNS resolution for the control plane machines.
- ⑦ ⑧ Provides reverse DNS resolution for the compute machines.

**NOTE**

A PTR record is not required for the OpenShift Container Platform application wildcard.

**Additional resources**

- [Validating DNS resolution for user-provisioned infrastructure](#)

**2.3.4.6. Load balancing requirements for user-provisioned infrastructure**

Before you install OpenShift Container Platform, you must provision the API and application Ingress load balancing infrastructure. In production scenarios, you can deploy the API and application Ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

**NOTE**

If you want to deploy the API and application Ingress load balancers with a Red Hat Enterprise Linux (RHEL) instance, you must purchase the RHEL subscription separately.

The load balancing infrastructure must meet the following requirements:

1. **API load balancer:** Provides a common endpoint for users, both human and machine, to interact with and configure the platform. Configure the following conditions:
  - Layer 4 load balancing only. This can be referred to as Raw TCP or SSL Passthrough mode.
  - A stateless load balancing algorithm. The options vary based on the load balancer implementation.

**IMPORTANT**

Do not configure session persistence for an API load balancer. Configuring session persistence for a Kubernetes API server might cause performance issues from excess application traffic for your OpenShift Container Platform cluster and the Kubernetes API that runs inside the cluster.

Configure the following ports on both the front and back of the load balancers:

**Table 2.37. API load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
<b>6443</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane. You must configure the <b>/readyz</b> endpoint for the API server health check probe.	X	X	Kubernetes API server

Port	Back-end machines (pool members)	Internal	External	Description
<b>22623</b>	Bootstrap and control plane. You remove the bootstrap machine from the load balancer after the bootstrap machine initializes the cluster control plane.	X		Machine config server



### NOTE

The load balancer must be configured to take a maximum of 30 seconds from the time the API server turns off the `/readyz` endpoint to the removal of the API server instance from the pool. Within the time frame after `/readyz` returns an error or becomes healthy, the endpoint must have been removed or added. Probing every 5 or 10 seconds, with two successful requests to become healthy and three to become unhealthy, are well-tested values.

2. **Application Ingress load balancer:** Provides an ingress point for application traffic flowing in from outside the cluster. A working configuration for the Ingress router is required for an OpenShift Container Platform cluster.

Configure the following conditions:

- Layer 4 load balancing only. This can be referred to as Raw TCP or SSL Passthrough mode.
- A connection-based or session-based persistence is recommended, based on the options available and types of applications that will be hosted on the platform.

### TIP

If the true IP address of the client can be seen by the application Ingress load balancer, enabling source IP-based session persistence can improve performance for applications that use end-to-end TLS encryption.

Configure the following ports on both the front and back of the load balancers:

**Table 2.38. Application Ingress load balancer**

Port	Back-end machines (pool members)	Internal	External	Description
<b>443</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTPS traffic
<b>80</b>	The machines that run the Ingress Controller pods, compute, or worker, by default.	X	X	HTTP traffic

**NOTE**

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

#### 2.3.4.6.1. Example load balancer configuration for user-provisioned clusters

This section provides an example API and application Ingress load balancer configuration that meets the load balancing requirements for user-provisioned clusters. The sample is an `/etc/haproxy/haproxy.cfg` configuration for an HAProxy load balancer. The example is not meant to provide advice for choosing one load balancing solution over another.

In the example, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

**NOTE**

If you are using HAProxy as a load balancer and SELinux is set to **enforcing**, you must ensure that the HAProxy service can bind to the configured TCP port by running `setsebool -P haproxy_connect_any=1`.

#### Example 2.9. Sample API and application Ingress load balancer configuration

```

global
log    127.0.0.1 local2
pidfile /var/run/haproxy.pid
maxconn 4000
daemon
defaults
mode      http
log       global
option    dontlognull
option http-server-close
option    redispatch
retries   3
timeout http-request 10s
timeout queue     1m
timeout connect   10s
timeout client    1m
timeout server    1m
timeout http-keep-alive 10s
timeout check     10s
maxconn   3000
listen api-server-6443 1
bind *:6443
mode tcp
option httpchk GET /readyz HTTP/1.0
option log-health-checks
balance roundrobin
server bootstrap bootstrap.ocp4.example.com:6443 verify none check check-ssl inter 10s fall 2
rise 3 backup 2
server master0 master0.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s

```

```

fall 2 rise 3
  server master1 master1.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
  server master2 master2.ocp4.example.com:6443 weight 1 verify none check check-ssl inter 10s
fall 2 rise 3
listen machine-config-server-22623 3
  bind *:22623
  mode tcp
  server bootstrap bootstrap.ocp4.example.com:22623 check inter 1s backup 4
  server master0 master0.ocp4.example.com:22623 check inter 1s
  server master1 master1.ocp4.example.com:22623 check inter 1s
  server master2 master2.ocp4.example.com:22623 check inter 1s
listen ingress-router-443 5
  bind *:443
  mode tcp
  balance source
  server compute0 compute0.ocp4.example.com:443 check inter 1s
  server compute1 compute1.ocp4.example.com:443 check inter 1s
listen ingress-router-80 6
  bind *:80
  mode tcp
  balance source
  server compute0 compute0.ocp4.example.com:80 check inter 1s
  server compute1 compute1.ocp4.example.com:80 check inter 1s

```

- 1** Port **6443** handles the Kubernetes API traffic and points to the control plane machines.
- 2** **4** The bootstrap entries must be in place before the OpenShift Container Platform cluster installation and they must be removed after the bootstrap process is complete.
- 3** Port **22623** handles the machine config server traffic and points to the control plane machines.
- 5** Port **443** handles the HTTPS traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.
- 6** Port **80** handles the HTTP traffic and points to the machines that run the Ingress Controller pods. The Ingress Controller pods run on the compute machines by default.



#### NOTE

If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application Ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes.

#### TIP

If you are using HAProxy as a load balancer, you can check that the **haproxy** process is listening on ports **6443**, **22623**, **443**, and **80** by running **netstat -nltpu** on the HAProxy node.

### 2.3.5. Creating a manifest object that includes a customized br-ex bridge

As an alternative to using the **configure-ovs.sh** shell script to set a **br-ex** bridge on a bare-metal platform, you can create a **MachineConfig** object that includes an NMState configuration file. The NMState configuration file creates a customized **br-ex** bridge network configuration on each node in your cluster.

Consider the following use cases for creating a manifest object that includes a customized **br-ex** bridge:

- You want to make postinstallation changes to the bridge, such as changing the Open vSwitch (OVS) or OVN-Kubernetes **br-ex** bridge network. The **configure-ovs.sh** shell script does not support making postinstallation changes to the bridge.
- You want to deploy the bridge on a different interface than the interface available on a host or server IP address.
- You want to make advanced configurations to the bridge that are not possible with the **configure-ovs.sh** shell script. Using the script for these configurations might result in the bridge failing to connect multiple network interfaces and facilitating data forwarding between the interfaces.



### NOTE

If you require an environment with a single network interface controller (NIC) and default network settings, use the **configure-ovs.sh** shell script.

After you install Red Hat Enterprise Linux CoreOS (RHCOS) and the system reboots, the Machine Config Operator injects Ignition configuration files into each node in your cluster, so that each node received the **br-ex** bridge network configuration. To prevent configuration conflicts, the **configure-ovs.sh** shell script receives a signal to not configure the **br-ex** bridge.

## Prerequisites

- Optional: You have installed the **nmstate** API so that you can validate the NMState configuration.

## Procedure

- 1 Create a NMState configuration file that has decoded base64 information for your customized **br-ex** bridge network:

### Example of an NMState configuration for a customized **br-ex** bridge network

```
interfaces:
- name: enp2s0 1
  type: ethernet 2
  state: up 3
  ipv4:
    enabled: false 4
  ipv6:
    enabled: false
- name: br-ex
  type: ovs-bridge
  state: up
  ipv4:
    enabled: false
```

```

    dhcp: false
  ipv6:
    enabled: false
    dhcp: false
  bridge:
    options:
      mcast-snooping-enable: true
  port:
    - name: enp2s0 ⑤
    - name: br-ex
  - name: br-ex
  type: ovs-interface
  state: up
  copy-mac-from: enp2s0
  ipv4:
    enabled: true
    dhcp: true
  ipv6:
    enabled: false
    dhcp: false
# ...

```

- ① Name of the interface.
- ② The type of ethernet.
- ③ The requested state for the interface after creation.
- ④ Disables IPv4 and IPv6 in this example.
- ⑤ The node NIC to which the bridge attaches.

2. Use the **cat** command to base64-encode the contents of the NMState configuration:

```
$ cat <nmstate_configuration>.yaml | base64 ①
```

- ① Replace **<nmstate\_configuration>** with the name of your NMState resource YAML file.

3. Create a **MachineConfig** manifest file and define a customized **br-ex** bridge network configuration analogous to the following example:

```

apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker ①
  name: 10-br-ex-worker ②
spec:
  config:
    ignition:
      version: 3.2.0
  storage:
    files:

```

```

- contents:
  source: data:text/plain;charset=utf-8;base64,
<base64_encoded_nmstate_configuration> ③
  mode: 0644
  overwrite: true
  path: /etc/nmstate/openshift/cluster.yml
# ...

```

- ① For each node in your cluster, specify the hostname path to your node and the base-64 encoded Ignition configuration file data for the machine type. If you have a single global configuration specified in an **/etc/nmstate/openshift/cluster.yml** configuration file that you want to apply to all nodes in your cluster, you do not need to specify the hostname path for each node. The **worker** role is the default role for nodes in your cluster. The **.yaml** extension does not work when specifying the hostname path for each node or all nodes in the **MachineConfig** manifest file.
- ② The name of the policy.
- ③ Writes the encoded base64 information to the specified path.

### 2.3.5.1. Scaling each machine set to compute nodes

To apply a customized **br-ex** bridge configuration to all compute nodes in your OpenShift Container Platform cluster, you must edit your **MachineConfig** custom resource (CR) and modify its roles. Additionally, you must create a **BareMetalHost** CR that defines information for your bare-metal machine, such as hostname, credentials, and so on.

After you configure these resources, you must scale machine sets, so that the machine sets can apply the resource configuration to each compute node and reboot the nodes.

#### Prerequisites

- You created a **MachineConfig** manifest object that includes a customized **br-ex** bridge configuration.

#### Procedure

1. Edit the **MachineConfig** CR by entering the following command:

```
$ oc edit mc <machineconfig_custom_resource_name>
```

2. Add each compute node configuration to the CR, so that the CR can manage roles for each defined compute node in your cluster.
3. Create a **Secret** object named **extraworker-secret** that has a minimal static IP configuration.
4. Apply the **extraworker-secret** secret to each node in your cluster by entering the following command. This step provides each compute node access to the Ignition config file.

```
$ oc apply -f ./extraworker-secret.yaml
```

5. Create a **BareMetalHost** resource and specify the network secret in the **preprovisioningNetworkDataName** parameter:

## Example BareMetalHost resource with an attached network secret

```
apiVersion: metal3.io/v1alpha1
kind: BareMetalHost
spec:
# ...
  preprovisioningNetworkDataName: otest-extraworker-0-network-config-secret
# ...
```

6. To manage the **BareMetalHost** object within the **openshift-machine-api** namespace of your cluster, change to the namespace by entering the following command:

```
$ oc project openshift-machine-api
```

7. Get the machine sets:

```
$ oc get machinesets
```

8. Scale each machine set by entering the following command. You must run this command for each machine set.

```
$ oc scale machineset <machineset_name> --replicas=<n> ①
```

- ① Where **<machineset\_name>** is the name of the machine set and **<n>** is the number of compute nodes.

### 2.3.6. Preparing the user-provisioned infrastructure

Before you install OpenShift Container Platform on user-provisioned infrastructure, you must prepare the underlying infrastructure.

This section provides details about the high-level steps required to set up your cluster infrastructure in preparation for an OpenShift Container Platform installation. This includes configuring IP networking and network connectivity for your cluster nodes, enabling the required ports through your firewall, and setting up the required DNS and load balancing infrastructure.

After preparation, your cluster infrastructure must meet the requirements outlined in the *Requirements for a cluster with user-provisioned infrastructure* section.

#### Prerequisites

- You have reviewed the [OpenShift Container Platform 4.x Tested Integrations](#) page.
- You have reviewed the infrastructure requirements detailed in the *Requirements for a cluster with user-provisioned infrastructure* section.

#### Procedure

1. If you are using DHCP to provide the IP networking configuration to your cluster nodes, configure your DHCP service.

- a. Add persistent IP addresses for the nodes to your DHCP server configuration. In your configuration, match the MAC address of the relevant network interface to the intended IP address for each node.
- b. When you use DHCP to configure IP addressing for the cluster machines, the machines also obtain the DNS server information through DHCP. Define the persistent DNS server address that is used by the cluster nodes through your DHCP server configuration.



#### NOTE

If you are not using a DHCP service, you must provide the IP networking configuration and the address of the DNS server to the nodes at RHCOS install time. These can be passed as boot arguments if you are installing from an ISO image. See the *Installing RHCOS and starting the OpenShift Container Platform bootstrap process* section for more information about static IP provisioning and advanced networking options.

- c. Define the hostnames of your cluster nodes in your DHCP server configuration. See the *Setting the cluster node hostnames through DHCP* section for details about hostname considerations.



#### NOTE

If you are not using a DHCP service, the cluster nodes obtain their hostname through a reverse DNS lookup.

2. Ensure that your network infrastructure provides the required network connectivity between the cluster components. See the *Networking requirements for user-provisioned infrastructure* section for details about the requirements.
3. Configure your firewall to enable the ports required for the OpenShift Container Platform cluster components to communicate. See *Networking requirements for user-provisioned infrastructure* section for details about the ports that are required.



#### IMPORTANT

By default, port **1936** is accessible for an OpenShift Container Platform cluster, because each control plane node needs access to this port.

Avoid using the Ingress load balancer to expose this port, because doing so might result in the exposure of sensitive information, such as statistics and metrics, related to Ingress Controllers.

4. Setup the required DNS infrastructure for your cluster.
  - a. Configure DNS name resolution for the Kubernetes API, the application wildcard, the bootstrap machine, the control plane machines, and the compute machines.
  - b. Configure reverse DNS resolution for the Kubernetes API, the bootstrap machine, the control plane machines, and the compute machines.

See the *User-provisioned DNS requirements* section for more information about the OpenShift Container Platform DNS requirements.
5. Validate your DNS configuration.

- a. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses in the responses correspond to the correct components.
  - b. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names in the responses correspond to the correct components.  
See the *Validating DNS resolution for user-provisioned infrastructure* section for detailed DNS validation steps.
6. Provision the required API and application ingress load balancing infrastructure. See the *Load balancing requirements for user-provisioned infrastructure* section for more information about the requirements.



#### NOTE

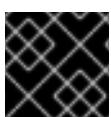
Some load balancing solutions require the DNS name resolution for the cluster nodes to be in place before the load balancing is initialized.

#### Additional resources

- Requirements for a cluster with user-provisioned infrastructure
- Installing RHCOS and starting the OpenShift Container Platform bootstrap process
- Setting the cluster node hostnames through DHCP
- Advanced RHCOS installation configuration
- Networking requirements for user-provisioned infrastructure
- User-provisioned DNS requirements
- Validating DNS resolution for user-provisioned infrastructure
- Load balancing requirements for user-provisioned infrastructure

### 2.3.7. Validating DNS resolution for user-provisioned infrastructure

You can validate your DNS configuration before installing OpenShift Container Platform on user-provisioned infrastructure.



#### IMPORTANT

The validation steps detailed in this section must succeed before you install your cluster.

#### Prerequisites

- You have configured the required DNS records for your user-provisioned infrastructure.

#### Procedure

1. From your installation node, run DNS lookups against the record names of the Kubernetes API, the wildcard routes, and the cluster nodes. Validate that the IP addresses contained in the responses correspond to the correct components.

- Perform a lookup against the Kubernetes API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api.<cluster_name>.<base_domain> 1
```

- 1** Replace **<nameserver\_ip>** with the IP address of the nameserver, **<cluster\_name>** with your cluster name, and **<base\_domain>** with your base domain name.

### Example output

```
api.ocp4.example.com. 604800 IN A 192.168.1.5
```

- Perform a lookup against the Kubernetes internal API record name. Check that the result points to the IP address of the API load balancer:

```
$ dig +noall +answer @<nameserver_ip> api-int.<cluster_name>.<base_domain>
```

### Example output

```
api-int.ocp4.example.com. 604800 IN A 192.168.1.5
```

- Test an example **\*.apps.<cluster\_name>.<base\_domain>** DNS wildcard lookup. All of the application wildcard lookups must resolve to the IP address of the application ingress load balancer:

```
$ dig +noall +answer @<nameserver_ip> random.apps.<cluster_name>.<base_domain>
```

### Example output

```
random.apps.ocp4.example.com. 604800 IN A 192.168.1.5
```



### NOTE

In the example outputs, the same load balancer is used for the Kubernetes API and application ingress traffic. In production scenarios, you can deploy the API and application ingress load balancers separately so that you can scale the load balancer infrastructure for each in isolation.

You can replace **random** with another wildcard value. For example, you can query the route to the OpenShift Container Platform console:

```
$ dig +noall +answer @<nameserver_ip> console-openshift-console.apps.<cluster_name>.<base_domain>
```

### Example output

```
console-openshift-console.apps.ocp4.example.com. 604800 IN A 192.168.1.5
```

- Run a lookup against the bootstrap DNS record name. Check that the result points to the IP address of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> bootstrap.<cluster_name>.<base_domain>
```

### Example output

```
bootstrap.ocp4.example.com. 604800 IN A 192.168.1.96
```

- e. Use this method to perform lookups against the DNS record names for the control plane and compute nodes. Check that the results correspond to the IP addresses of each node.
2. From your installation node, run reverse DNS lookups against the IP addresses of the load balancer and the cluster nodes. Validate that the record names contained in the responses correspond to the correct components.
  - a. Perform a reverse lookup against the IP address of the API load balancer. Check that the response includes the record names for the Kubernetes API and the Kubernetes internal API:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.5
```

### Example output

```
5.1.168.192.in-addr.arpa. 604800 IN PTR api-int.ocp4.example.com. ①
5.1.168.192.in-addr.arpa. 604800 IN PTR api.ocp4.example.com. ②
```

- ① Provides the record name for the Kubernetes internal API.
- ② Provides the record name for the Kubernetes API.



### NOTE

A PTR record is not required for the OpenShift Container Platform application wildcard. No validation step is needed for reverse DNS resolution against the IP address of the application ingress load balancer.

- b. Perform a reverse lookup against the IP address of the bootstrap node. Check that the result points to the DNS record name of the bootstrap node:

```
$ dig +noall +answer @<nameserver_ip> -x 192.168.1.96
```

### Example output

```
96.1.168.192.in-addr.arpa. 604800 IN PTR bootstrap.ocp4.example.com.
```

- c. Use this method to perform reverse lookups against the IP addresses for the control plane and compute nodes. Check that the results correspond to the DNS record names of each node.

## Additional resources

- [User-provisioned DNS requirements](#)

- Load balancing requirements for user-provisioned infrastructure

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

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

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

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



#### IMPORTANT

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



#### NOTE

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

#### Procedure

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

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

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



#### NOTE

If you plan to install an OpenShift Container Platform cluster that uses the RHEL cryptographic libraries that have been submitted to NIST for FIPS 140-2/140-3 Validation on only the `x86_64`, `ppc64le`, and `s390x` architectures, do not create a key that uses the `ed25519` algorithm. Instead, create a key that uses the `rsa` or `ecdsa` algorithm.

2. View the public SSH key:

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

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

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

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



#### NOTE

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

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

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

#### Example output

```
Agent pid 31874
```



#### NOTE

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

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

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

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

#### Example output

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

#### Next steps

- When you install OpenShift Container Platform, provide the SSH public key to the installation program. If you install a cluster on infrastructure that you provision, you must provide the key to the installation program.

#### Additional resources

- [Verifying node health](#)

### 2.3.9. Manually creating the installation configuration file

Installing the cluster requires that you manually create the installation configuration file.

#### Prerequisites

- You have an SSH public key on your local machine to provide to the installation program. The key will be used for SSH authentication onto your cluster nodes for debugging and disaster recovery.
- You have obtained the OpenShift Container Platform installation program and the pull secret for your cluster.
- Obtain the **imageContentSources** section from the output of the command to mirror the repository.
- Obtain the contents of the certificate for your mirror registry.

## Procedure

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

```
$ mkdir <installation_directory>
```



### IMPORTANT

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

2. Customize the sample **install-config.yaml** file template that is provided and save it in the **<installation\_directory>**.



### NOTE

You must name this configuration file **install-config.yaml**.

- Unless you use a registry that RHCOS trusts by default, such as **docker.io**, you must provide the contents of the certificate for your mirror repository in the **additionalTrustBundle** section. In most cases, you must provide the certificate for your mirror.
- You must include the **imageContentSources** section from the output of the command to mirror the repository.

**IMPORTANT**

- The **ImageContentSourcePolicy** file is generated as an output of **oc mirror** after the mirroring process is finished.
- The **oc mirror** command generates an **ImageContentSourcePolicy** file which contains the YAML needed to define **ImageContentSourcePolicy**. Copy the text from this file and paste it into your **install-config.yaml** file.
- You must run the 'oc mirror' command twice. The first time you run the **oc mirror** command, you get a full **ImageContentSourcePolicy** file. The second time you run the **oc mirror** command, you only get the difference between the first and second run. Because of this behavior, you must always keep a backup of these files in case you need to merge them into one complete **ImageContentSourcePolicy** file. Keeping a backup of these two output files ensures that you have a complete **ImageContentSourcePolicy** file.

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.

**Additional resources**

- [Installation configuration parameters for bare metal](#)

**2.3.9.1. Sample install-config.yaml file for bare metal**

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

```
apiVersion: v1
baseDomain: example.com 1
compute: 2
- hyperthreading: Enabled 3
  name: worker
  replicas: 0 4
controlPlane: 5
  hyperthreading: Enabled 6
  name: master
  replicas: 3 7
metadata:
  name: test 8
networking:
  clusterNetwork:
    - cidr: 10.128.0.0/14 9
      hostPrefix: 23 10
  networkType: OVNKubernetes 11
  serviceNetwork:
    - 172.30.0.0/16
platform:
```

- 1 The base domain of the cluster. All DNS records must be sub-domains of this base and include the cluster name.
  - 2 5 The **controlPlane** section is a single mapping, but the **compute** section is a sequence of mappings. To meet the requirements of the different data structures, the first line of the **compute** section must begin with a hyphen, -, and the first line of the **controlPlane** section must not. Only one control plane pool is used.
  - 3 6 Specifies whether to enable or disable simultaneous multithreading (SMT), or hyperthreading. By default, SMT is enabled to increase the performance of the cores in your machines. You can disable it by setting the parameter value to **Disabled**. If you disable SMT, you must disable it in all cluster machines; this includes both control plane and compute machines.



## NOTE

Simultaneous multithreading (SMT) is enabled by default. If SMT is not enabled in your BIOS settings, the **hyperthreading** parameter has no effect.



## **IMPORTANT**

If you disable **hyperthreading**, whether in the BIOS or in the **install-config.yaml** file, ensure that your capacity planning accounts for the dramatically decreased machine performance.

- 4 You must set this value to **0** when you install OpenShift Container Platform on user-provisioned infrastructure. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. In user-provisioned installations, you must manually deploy the compute machines before you finish installing the cluster.



## NOTE

If you are installing a three-node cluster, do not deploy any compute machines when you install the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

- 7 The number of control plane machines that you add to the cluster. Because the cluster uses these values as the number of etcd endpoints in the cluster, the value must match the number of control plane machines that you deploy.

- 8 The cluster name that you specified in your DNS records.
- 9 A block of IP addresses from which pod IP addresses are allocated. This block must not overlap with existing physical networks. These IP addresses are used for the pod network. If you need to access the pods from an external network, you must configure load balancers and routers to manage the traffic.



### NOTE

Class E CIDR range is reserved for a future use. To use the Class E CIDR range, you must ensure your networking environment accepts the IP addresses within the Class E CIDR range.

- 10 The subnet prefix length to assign to each individual node. For example, if **hostPrefix** is set to **23**, then each node is assigned a /23 subnet out of the given **cidr**, which allows for 510 ( $2^{(32 - 23)} - 2$ ) pod IP addresses. If you are required to provide access to nodes from an external network, configure load balancers and routers to manage the traffic.
- 11 The cluster network plugin to install. The default value **OVNKubernetes** is the only supported value.
- 12 The IP address pool to use for service IP addresses. You can enter only one IP address pool. This block must not overlap with existing physical networks. If you need to access the services from an external network, configure load balancers and routers to manage the traffic.
- 13 You must set the platform to **none**. You cannot provide additional platform configuration variables for your platform.



### IMPORTANT

Clusters that are installed with the platform type **none** are unable to use some features, such as managing compute machines with the Machine API. This limitation applies even if the compute machines that are attached to the cluster are installed on a platform that would normally support the feature. This parameter cannot be changed after installation.

- 14 Whether to enable or disable FIPS mode. By default, FIPS mode is not enabled. If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.



### IMPORTANT

To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see [Switching RHEL to FIPS mode](#).

When running Red Hat Enterprise Linux (RHEL) or Red Hat Enterprise Linux CoreOS (RHCOS) booted in FIPS mode, OpenShift Container Platform core components use the RHEL cryptographic libraries that have been submitted to NIST for FIPS 140-2/140-3 Validation on only the x86\_64, ppc64le, and s390x architectures.

- 15 For <**local\_registry**>, specify the registry domain name, and optionally the port, that your mirror registry uses to serve content. For example, **registry.example.com** or
- 16 The SSH public key for the **core** user in Red Hat Enterprise Linux CoreOS (RHCOS).



#### NOTE

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

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



#### IMPORTANT

- When using the **oc adm release mirror** command, use the output from the **imageContentSources** section.
- When using **oc mirror** command, use the **repositoryDigestMirrors** section of the **ImageContentSourcePolicy** file that results from running the command.
- **ImageContentSourcePolicy** is deprecated. For more information see *Configuring image registry repository mirroring*.

### Additional resources

- See [Load balancing requirements for user-provisioned infrastructure](#) for more information on the API and application ingress load balancing requirements.

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

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



#### NOTE

For bare metal installations, if you do not assign node IP addresses from the range that is specified in the **networking.machineNetwork[].cidr** field in the **install-config.yaml** file, you must include them in the **proxy.noProxy** field.

### Prerequisites

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



## NOTE

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

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

## Procedure

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

```
apiVersion: v1
baseDomain: my.domain.com
proxy:
  httpProxy: http://<username>:<pswd>@<ip>:<port> ①
  httpsProxy: https://<username>:<pswd>@<ip>:<port> ②
  noProxy: example.com ③
  additionalTrustBundle: | ④
    -----BEGIN CERTIFICATE-----
    <MY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
additionalTrustBundlePolicy: <policy_to_add_additionalTrustBundle> ⑤
```

- 1 A proxy URL to use for creating HTTP connections outside the cluster. The URL scheme must be **http**.
- 2 A proxy URL to use for creating HTTPS connections outside the cluster.
- 3 A comma-separated list of destination domain names, IP addresses, or other network CIDRs to exclude from proxying. Preface a domain with `.` to match subdomains only. For example, **.y.com** matches **x.y.com**, but not **y.com**. Use `*` to bypass the proxy for all destinations.
- 4 If provided, the installation program generates a config map that is named **user-ca-bundle** in the **openshift-config** namespace 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** config map that merges these contents with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle, and this config map is referenced in the **trustedCA** field of the **Proxy** object. The **additionalTrustBundle** field is required unless the proxy's identity certificate is signed by an authority from the RHCOS trust bundle.
- 5 Optional: The policy to determine the configuration of the **Proxy** object to reference the **user-ca-bundle** config map in the **trustedCA** field. The allowed values are **Proxyonly** and **Always**. Use **Proxyonly** to reference the **user-ca-bundle** config map only when **http/https** proxy is configured. Use **Always** to always reference the **user-ca-bundle** config map. The default value is **Proxyonly**.



## NOTE

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

**NOTE**

If the installer times out, restart and then complete the deployment by using the **wait-for** command of the installer. For example:

```
$ ./openshift-install wait-for install-complete --log-level debug
```

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.

### 2.3.9.3. Configuring a three-node cluster

Optionally, you can deploy zero compute machines in a bare metal cluster that consists of three control plane machines only. This provides smaller, more resource efficient clusters for cluster administrators and developers to use for testing, development, and production.

In three-node OpenShift Container Platform environments, the three control plane machines are schedulable, which means that your application workloads are scheduled to run on them.

#### Prerequisites

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

#### Procedure

- Ensure that the number of compute replicas is set to **0** in your **install-config.yaml** file, as shown in the following **compute** stanza:

```
compute:
- name: worker
  platform: {}
  replicas: 0
```

**NOTE**

You must set the value of the **replicas** parameter for the compute machines to **0** when you install OpenShift Container Platform on user-provisioned infrastructure, regardless of the number of compute machines you are deploying. In installer-provisioned installations, the parameter controls the number of compute machines that the cluster creates and manages for you. This does not apply to user-provisioned installations, where the compute machines are deployed manually.

For three-node cluster installations, follow these next steps:

- If you are deploying a three-node cluster with zero compute nodes, the Ingress Controller pods run on the control plane nodes. In three-node cluster deployments, you must configure your application ingress load balancer to route HTTP and HTTPS traffic to the control plane nodes. See the *Load balancing requirements for user-provisioned infrastructure* section for more information.
- When you create the Kubernetes manifest files in the following procedure, ensure that the **mastersSchedulable** parameter in the **<installation\_directory>/manifests/cluster-scheduler-02-config.yaml** file is set to **true**. This enables your application workloads to run on the control plane nodes.
- Do not deploy any compute nodes when you create the Red Hat Enterprise Linux CoreOS (RHCOS) machines.

### 2.3.10. Creating the Kubernetes manifest and Ignition config files

Because you must modify some cluster definition files and manually start the cluster machines, you must generate the Kubernetes manifest and Ignition config files that the cluster needs to configure the machines.

The installation configuration file transforms into the Kubernetes manifests. The manifests wrap into the Ignition configuration files, which are later used to configure the cluster machines.



#### IMPORTANT

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

#### Prerequisites

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

#### Procedure

1. Change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

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

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

**WARNING**

If you are installing a three-node cluster, skip the following step to allow the control plane nodes to be schedulable.

**IMPORTANT**

When you configure control plane nodes from the default unschedulable to schedulable, additional subscriptions are required. This is because control plane nodes then become compute nodes.

2. Check that the **mastersSchedulable** parameter in the `<installation_directory>/manifests/cluster-scheduler-02-config.yml` Kubernetes manifest file is set to **false**. This setting prevents pods from being scheduled on the control plane machines:
  - a. Open the `<installation_directory>/manifests/cluster-scheduler-02-config.yml` file.
  - b. Locate the **mastersSchedulable** parameter and ensure that it is set to **false**.
  - c. Save and exit the file.
3. To create the Ignition configuration files, run the following command from the directory that contains the installation program:

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

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

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory. The **kubeadmin-password** and **kubeconfig** files are created in the `./<installation_directory>/auth` directory:

**Additional resources**

- See [Recovering from expired control plane certificates](#) for more information about recovering kubelet certificates.

**2.3.11. Configuring chrony time service**

You must set the time server and related settings used by the chrony time service (**chronyd**) by modifying the contents of the **chrony.conf** file and passing those contents to your nodes as a machine config.

## Procedure

- 1 Create a Butane config including the contents of the **chrony.conf** file. For example, to configure chrony on worker nodes, create a **99-worker-chrony.bu** file.



### NOTE

The [Butane version](#) you specify in the config file should match the OpenShift Container Platform version and always ends in **0**. For example, **4.18.0**. See "Creating machine configs with Butane" for information about Butane.

```
variant: openshift
version: 4.18.0
metadata:
  name: 99-worker-chrony ①
  labels:
    machineconfiguration.openshift.io/role: worker ②
storage:
  files:
    - path: /etc/chrony.conf
      mode: 0644 ③
      overwrite: true
      contents:
        inline: |
          pool 0.rhel.pool.ntp.org iburst ④
          driftfile /var/lib/chrony/drift
          makestep 1.0 3
          rtcsync
          logdir /var/log/chrony
```

**① ②** On control plane nodes, substitute **master** for **worker** in both of these locations.

- ③** Specify an octal value mode for the **mode** field in the machine config file. After creating the file and applying the changes, the **mode** is converted to a decimal value. You can check the YAML file with the command **oc get mc <mc-name> -o yaml**.
- ④** Specify any valid, reachable time source, such as the one provided by your DHCP server.



### NOTE

For all-machine to all-machine communication, the Network Time Protocol (NTP) on UDP is port **123**. If an external NTP time server is configured, you must open UDP port **123**.

- 2 Use Butane to generate a **MachineConfig** object file, **99-worker-chrony.yaml**, containing the configuration to be delivered to the nodes:

```
$ butane 99-worker-chrony.bu -o 99-worker-chrony.yaml
```

3. Apply the configurations in one of two ways:

- If the cluster is not running yet, after you generate manifest files, add the **MachineConfig** object file to the `<installation_directory>/openshift` directory, and then continue to create the cluster.
- If the cluster is already running, apply the file:

```
$ oc apply -f ./99-worker-chrony.yaml
```

### 2.3.12. Installing RHCOS and starting the OpenShift Container Platform bootstrap process

To install OpenShift Container Platform on bare metal infrastructure that you provision, you must install Red Hat Enterprise Linux CoreOS (RHCOS) on the machines. When you install RHCOS, you must provide the Ignition config file that was generated by the OpenShift Container Platform installation program for the type of machine you are installing. If you have configured suitable networking, DNS, and load balancing infrastructure, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS machines have rebooted.

To install RHCOS on the machines, follow either the steps to use an ISO image or network PXE booting.



#### NOTE

The compute node deployment steps included in this installation document are RHCOS-specific. If you choose instead to deploy RHEL-based compute nodes, you take responsibility for all operating system life cycle management and maintenance, including performing system updates, applying patches, and completing all other required tasks. Only RHEL 8 compute machines are supported.

You can configure RHCOS during ISO and PXE installations by using the following methods:

- Kernel arguments: You can use kernel arguments to provide installation-specific information. For example, you can specify the locations of the RHCOS installation files that you uploaded to your HTTP server and the location of the Ignition config file for the type of node you are installing. For a PXE installation, you can use the **APPEND** parameter to pass the arguments to the kernel of the live installer. For an ISO installation, you can interrupt the live installation boot process to add the kernel arguments. In both installation cases, you can use special **coreos.inst.\*** arguments to direct the live installer, as well as standard installation boot arguments for turning standard kernel services on or off.
- Ignition configs: OpenShift Container Platform Ignition config files (**\*.ign**) are specific to the type of node you are installing. You pass the location of a bootstrap, control plane, or compute node Ignition config file during the RHCOS installation so that it takes effect on first boot. In special cases, you can create a separate, limited Ignition config to pass to the live system. That Ignition config could do a certain set of tasks, such as reporting success to a provisioning system after completing installation. This special Ignition config is consumed by the **coreos-installer** to be applied on first boot of the installed system. Do not provide the standard control plane and compute node Ignition configs to the live ISO directly.
- **coreos-installer**: You can boot the live ISO installer to a shell prompt, which allows you to prepare the permanent system in a variety of ways before first boot. In particular, you can run the **coreos-installer** command to identify various artifacts to include, work with disk partitions, and set up networking. In some cases, you can configure features on the live system and copy them to the installed system.

Whether to use an ISO or PXE install depends on your situation. A PXE install requires an available DHCP service and more preparation, but can make the installation process more automated. An ISO install is a more manual process and can be inconvenient if you are setting up more than a few machines.

### 2.3.12.1. Installing RHCOS by using an ISO image

You can use an ISO image to install RHCOS on the machines.

#### Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have an HTTP server that can be accessed from your computer, and from the machines that you create.
- You have reviewed the *Advanced RHCOS installation configuration* section for different ways to configure features, such as networking and disk partitioning.

#### Procedure

1. Obtain the SHA512 digest for each of your Ignition config files. For example, you can use the following on a system running Linux to get the SHA512 digest for your **bootstrap.ign** Ignition config file:

```
$ sha512sum <installation_directory>/bootstrap.ign
```

The digests are provided to the **coreos-installer** in a later step to validate the authenticity of the Ignition config files on the cluster nodes.

2. Upload the bootstrap, control plane, and compute node Ignition config files that the installation program created to your HTTP server. Note the URLs of these files.



#### IMPORTANT

You can add or change configuration settings in your Ignition configs before saving them to your HTTP server. If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

3. From the installation host, validate that the Ignition config files are available on the URLs. The following example gets the Ignition config file for the bootstrap node:

```
$ curl -k http://<HTTP_server>/bootstrap.ign ①
```

#### Example output

```
% Total % Received % Xferd Average Speed Time Time Time Current
          Dload Upload Total Spent Left Speed
0 0 0 0 0 0 0 --:--:--:--:--:-- 0{"ignition": {"version": "3.2.0"}, "passwd": {"users": [{"name": "core", "sshAuthorizedKeys": ["ssh-rsa..."]}}]}
```

Replace **bootstrap.ign** with **master.ign** or **worker.ign** in the command to validate that the Ignition config files for the control plane and compute nodes are also available.

- Although it is possible to obtain the RHCOS images that are required for your preferred method of installing operating system instances from the [RHCOS image mirror](#) page, the recommended way to obtain the correct version of your RHCOS images are from the output of **openshift-install** command:

```
$ openshift-install coreos print-stream-json | grep '\.iso[^.]'
```

### Example output

```
"location": "<curl>/art/storage/releases/rhcos-4.18-aarch64/<release>/aarch64/rhcos-<release>-live.aarch64.iso",
"location": "<curl>/art/storage/releases/rhcos-4.18-ppc64le/<release>/ppc64le/rhcos-<release>-live.ppc64le.iso",
"location": "<curl>/art/storage/releases/rhcos-4.18-s390x/<release>/s390x/rhcos-<release>-live.s390x.iso",
"location": "<curl>/art/storage/releases/rhcos-4.18/<release>/x86_64/rhcos-<release>-live.x86_64.iso",
```



### IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Use the image versions that match your OpenShift Container Platform version if they are available. Use only ISO images for this procedure. RHCOS qcow2 images are not supported for this installation type.

ISO file names resemble the following example:

**rhcos-<version>-live.<architecture>.iso**

- Use the ISO to start the RHCOS installation. Use one of the following installation options:
  - Burn the ISO image to a disk and boot it directly.
  - Use ISO redirection by using a lights-out management (LOM) interface.
- Boot the RHCOS ISO image without specifying any options or interrupting the live boot sequence. Wait for the installer to boot into a shell prompt in the RHCOS live environment.



### NOTE

It is possible to interrupt the RHCOS installation boot process to add kernel arguments. However, for this ISO procedure you should use the **coreos-installer** command as outlined in the following steps, instead of adding kernel arguments.

- Run the **coreos-installer** command and specify the options that meet your installation requirements. At a minimum, you must specify the URL that points to the Ignition config file for the node type, and the device that you are installing to:

```
$ sudo coreos-installer install --ignition-url=http://<HTTP_server>/<node_type>.ign <device>
\ ①
--ignition-hash=sha512-<digest> --offline ②
```

① You must run the **coreos-installer** command by using **sudo**, because the **core** user does not have the required root privileges to perform the installation.

② The **--ignition-hash** option is required when the Ignition config file is obtained through an HTTP URL to validate the authenticity of the Ignition config file on the cluster node. **<digest>** is the Ignition config file SHA512 digest obtained in a preceding step.



### NOTE

If you want to provide your Ignition config files through an HTTPS server that uses TLS, you can add the internal certificate authority (CA) to the system trust store before running **coreos-installer**.

The following example initializes a bootstrap node installation to the **/dev/sda** device. The Ignition config file for the bootstrap node is obtained from an HTTP web server with the IP address 192.168.1.2:

```
$ sudo coreos-installer install --ignition-
url=http://192.168.1.2:80/installation_directory/bootstrap.ign /dev/sda \
--ignition-hash=sha512-
a5a2d43879223273c9b60af66b44202a1d1248fc01cf156c46d4a79f552b6bad47bc8cc78ddf011
6e80c59d2ea9e32ba53bc807afbca581aa059311def2c3e3b \
--offline
```

8. Monitor the progress of the RHCOS installation on the console of the machine.



### IMPORTANT

Be sure that the installation is successful on each node before commencing with the OpenShift Container Platform installation. Observing the installation process can also help to determine the cause of RHCOS installation issues that might arise.

9. After RHCOS installs, you must reboot the system. During the system reboot, it applies the Ignition config file that you specified.
10. Check the console output to verify that Ignition ran.

### Example command

```
Ignition: ran on 2022/03/14 14:48:33 UTC (this boot)
Ignition: user-provided config was applied
```

11. Continue to create the other machines for your cluster.



## IMPORTANT

You must create the bootstrap and control plane machines at this time. If the control plane machines are not made schedulable, also create at least two compute machines before you install OpenShift Container Platform.

If the required network, DNS, and load balancer infrastructure are in place, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS nodes have rebooted.



## NOTE

RHCOS nodes do not include a default password for the **core** user. You can access the nodes by running `ssh core@<node>.<cluster_name>`.

<**base\_domain**> as a user with access to the SSH private key that is paired to the public key that you specified in your **install\_config.yaml** file. OpenShift Container Platform 4 cluster nodes running RHCOS are immutable and rely on Operators to apply cluster changes. Accessing cluster nodes by using SSH is not recommended. However, when investigating installation issues, if the OpenShift Container Platform API is not available, or the kubelet is not properly functioning on a target node, SSH access might be required for debugging or disaster recovery.

### 2.3.12.2. Installing RHCOS by using PXE or iPXE booting

You can use PXE or iPXE booting to install RHCOS on the machines.

#### Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have configured suitable PXE or iPXE infrastructure.
- You have an HTTP server that can be accessed from your computer, and from the machines that you create.
- You have reviewed the *Advanced RHCOS installation configuration* section for different ways to configure features, such as networking and disk partitioning.

#### Procedure

1. Upload the bootstrap, control plane, and compute node Ignition config files that the installation program created to your HTTP server. Note the URLs of these files.



## IMPORTANT

You can add or change configuration settings in your Ignition configs before saving them to your HTTP server. If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

2. From the installation host, validate that the Ignition config files are available on the URLs. The following example gets the Ignition config file for the bootstrap node:

```
$ curl -k http://<HTTP_server>/bootstrap.ign ①
```

### Example output

```
% Total % Received % Xferd Average Speed Time Time Current
          Dload Upload Total Spent Left Speed
0 0 0 0 0 0 0 --:--:--:--:--:-- 0{"ignition": "version": "3.2.0"}, "passwd": {"users": [{"name": "core", "sshAuthorizedKeys": ["ssh-rsa..."]}}
```

Replace **bootstrap.ign** with **master.ign** or **worker.ign** in the command to validate that the Ignition config files for the control plane and compute nodes are also available.

3. Although it is possible to obtain the RHCOS **kernel**, **initramfs** and **rootfs** files that are required for your preferred method of installing operating system instances from the [RHCOS image mirror](#) page, the recommended way to obtain the correct version of your RHCOS files are from the output of **openshift-install** command:

```
$ openshift-install coreos print-stream-json | grep -Eo "'https:(kernel|initramfs|rootfs.)\w+(\.img)?'"
```

### Example output

```
"<url>/art/storage/releases/rhcos-4.18-aarch64/<release>/aarch64/rhcos-<release>-live-kernel-aarch64"
"<url>/art/storage/releases/rhcos-4.18-aarch64/<release>/aarch64/rhcos-<release>-live-initramfs.aarch64.img"
"<url>/art/storage/releases/rhcos-4.18-aarch64/<release>/aarch64/rhcos-<release>-live-rootfs.aarch64.img"
"<url>/art/storage/releases/rhcos-4.18-ppc64le/49.84.202110081256-0/ppc64le/rhcos-<release>-live-kernel-ppc64le"
"<url>/art/storage/releases/rhcos-4.18-ppc64le/<release>/ppc64le/rhcos-<release>-live-initramfs.ppc64le.img"
"<url>/art/storage/releases/rhcos-4.18-ppc64le/<release>/ppc64le/rhcos-<release>-live-rootfs.ppc64le.img"
"<url>/art/storage/releases/rhcos-4.18-s390x/<release>/s390x/rhcos-<release>-live-kernel-s390x"
"<url>/art/storage/releases/rhcos-4.18-s390x/<release>/s390x/rhcos-<release>-live-initramfs.s390x.img"
"<url>/art/storage/releases/rhcos-4.18-s390x/<release>/s390x/rhcos-<release>-live-rootfs.s390x.img"
"<url>/art/storage/releases/rhcos-4.18/<release>/x86_64/rhcos-<release>-live-kernel-x86_64"
"<url>/art/storage/releases/rhcos-4.18/<release>/x86_64/rhcos-<release>-live-initramfs.x86_64.img"
"<url>/art/storage/releases/rhcos-4.18/<release>/x86_64/rhcos-<release>-live-rootfs.x86_64.img"
```



## IMPORTANT

The RHCOS artifacts might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the OpenShift Container Platform version that you install. Only use the appropriate **kernel**, **initramfs**, and **rootfs** artifacts described below for this procedure. RHCOS QCOW2 images are not supported for this installation type.

The file names contain the OpenShift Container Platform version number. They resemble the following examples:

- **kernel: rhcos-<version>-live-kernel-<architecture>**
- **initramfs: rhcos-<version>-live-initramfs.<architecture>.img**
- **rootfs: rhcos-<version>-live-rootfs.<architecture>.img**

4. Upload the **rootfs**, **kernel**, and **initramfs** files to your HTTP server.



## IMPORTANT

If you plan to add more compute machines to your cluster after you finish installation, do not delete these files.

5. Configure the network boot infrastructure so that the machines boot from their local disks after RHCOS is installed on them.
6. Configure PXE or iPXE installation for the RHCOS images and begin the installation. Modify one of the following example menu entries for your environment and verify that the image and Ignition files are properly accessible:

- For PXE (**x86\_64**):

```
DEFAULT pxeboot
TIMEOUT 20
PROMPT 0
LABEL pxeboot
  KERNEL http://<HTTP_server>/rhcos-<version>-live-kernel-<architecture> ①
  APPEND initrd=http://<HTTP_server>/rhcos-<version>-live-initramfs.
<architecture>.img coreos.live.rootfs_url=http://<HTTP_server>/rhcos-<version>-live-
rootfs.<architecture>.img coreos.inst.install_dev=/dev/sda
  coreos.inst.ignition_url=http://<HTTP_server>/bootstrap.ign ② ③
```

**①** Specify the location of the live **kernel** file that you uploaded to your HTTP server. The URL must be HTTP, TFTP, or FTP; HTTPS and NFS are not supported.

**②** If you use multiple NICs, specify a single interface in the **ip** option. For example, to use DHCP on a NIC that is named **eno1**, set **ip=eno1:dhcp**.

**③** Specify the locations of the RHCOS files that you uploaded to your HTTP server. The **initrd** parameter value is the location of the **initramfs** file, the **coreos.live.rootfs\_url** parameter value is the location of the **rootfs** file, and the **coreos.inst.ignition\_url** parameter value is the location of the bootstrap Ignition config file. You can also add more kernel arguments to the **APPEND** line to configure networking or other boot

options.



## NOTE

This configuration does not enable serial console access on machines with a graphical console. To configure a different console, add one or more **console=** arguments to the **APPEND** line. For example, add **console=tty0** **console=ttyS0** to set the first PC serial port as the primary console and the graphical console as a secondary console. For more information, see [How does one set up a serial terminal and/or console in Red Hat Enterprise Linux?](#) and "Enabling the serial console for PXE and ISO installation" in the "Advanced RHCOS installation configuration" section.

- For iPXE (**x86\_64 + aarch64**):

```
kernel http://<HTTP_server>/rhcos-<version>-live-kernel-<architecture> initrd=main
coreos.live.rootfs_url=http://<HTTP_server>/rhcos-<version>-live-rootfs.
<architecture>.img coreos.inst.install_dev=/dev/sda
coreos.inst.ignition_url=http://<HTTP_server>/bootstrap.ign ① ②
initrd --name main http://<HTTP_server>/rhcos-<version>-live-initramfs.
<architecture>.img ③
boot
```

- ① Specify the locations of the RHCOS files that you uploaded to your HTTP server. The **kernel** parameter value is the location of the **kernel** file, the **initrd=main** argument is needed for booting on UEFI systems, the **coreos.live.rootfs\_url** parameter value is the location of the **rootfs** file, and the **coreos.inst.ignition\_url** parameter value is the location of the bootstrap Ignition config file.
- ② If you use multiple NICs, specify a single interface in the **ip** option. For example, to use DHCP on a NIC that is named **eno1**, set **ip=eno1:dhcp**.
- ③ Specify the location of the **initramfs** file that you uploaded to your HTTP server.



## NOTE

This configuration does not enable serial console access on machines with a graphical console. To configure a different console, add one or more **console=** arguments to the **kernel** line. For example, add **console=tty0** **console=ttyS0** to set the first PC serial port as the primary console and the graphical console as a secondary console. For more information, see [How does one set up a serial terminal and/or console in Red Hat Enterprise Linux?](#) and "Enabling the serial console for PXE and ISO installation" in the "Advanced RHCOS installation configuration" section.



## NOTE

To network boot the CoreOS **kernel** on **aarch64** architecture, you need to use a version of iPXE build with the **IMAGE\_GZIP** option enabled. See [IMAGE\\_GZIP option in iPXE](#).

- For PXE (with UEFI and Grub as second stage) on **aarch64**:

```

menuentry 'Install CoreOS' {
    linux rhcos-<version>-live-kernel-<architecture>
    coreos.live.rootfs_url=http://<HTTP_server>/rhcos-<version>-live-rootfs.
    <architecture>.img coreos.inst.install_dev=/dev/sda
    coreos.inst.ignition_url=http://<HTTP_server>/bootstrap.ign ① ②
    initrd rhcos-<version>-live-initramfs.<architecture>.img ③
}

```

- ① Specify the locations of the RHCOS files that you uploaded to your HTTP/TFTP server. The **kernel** parameter value is the location of the **kernel** file on your TFTP server. The **coreos.live.rootfs\_url** parameter value is the location of the **rootfs** file, and the **coreos.inst.ignition\_url** parameter value is the location of the bootstrap Ignition config file on your HTTP Server.
- ② If you use multiple NICs, specify a single interface in the **ip** option. For example, to use DHCP on a NIC that is named **eno1**, set **ip=eno1:dhcp**.
- ③ Specify the location of the **initramfs** file that you uploaded to your TFTP server.

7. Monitor the progress of the RHCOS installation on the console of the machine.



### IMPORTANT

Be sure that the installation is successful on each node before commencing with the OpenShift Container Platform installation. Observing the installation process can also help to determine the cause of RHCOS installation issues that might arise.

8. After RHCOS installs, the system reboots. During reboot, the system applies the Ignition config file that you specified.
9. Check the console output to verify that Ignition ran.

### Example command

```

Ignition: ran on 2022/03/14 14:48:33 UTC (this boot)
Ignition: user-provided config was applied

```

10. Continue to create the machines for your cluster.



### IMPORTANT

You must create the bootstrap and control plane machines at this time. If the control plane machines are not made schedulable, also create at least two compute machines before you install the cluster.

If the required network, DNS, and load balancer infrastructure are in place, the OpenShift Container Platform bootstrap process begins automatically after the RHCOS nodes have rebooted.



## NOTE

RHCOS nodes do not include a default password for the **core** user. You can access the nodes by running `ssh core@<node>.<cluster_name>`. **<base\_domain>** as a user with access to the SSH private key that is paired to the public key that you specified in your `install_config.yaml` file. OpenShift Container Platform 4 cluster nodes running RHCOS are immutable and rely on Operators to apply cluster changes. Accessing cluster nodes by using SSH is not recommended. However, when investigating installation issues, if the OpenShift Container Platform API is not available, or the kubelet is not properly functioning on a target node, SSH access might be required for debugging or disaster recovery.

### 2.3.12.3. Advanced RHCOS installation configuration

A key benefit for manually provisioning the Red Hat Enterprise Linux CoreOS (RHCOS) nodes for OpenShift Container Platform is to be able to do configuration that is not available through default OpenShift Container Platform installation methods. This section describes some of the configurations that you can do using techniques that include:

- Passing kernel arguments to the live installer
- Running **coreos-installer** manually from the live system
- Customizing a live ISO or PXE boot image

The advanced configuration topics for manual Red Hat Enterprise Linux CoreOS (RHCOS) installations detailed in this section relate to disk partitioning, networking, and using Ignition configs in different ways.

#### 2.3.12.3.1. Using advanced networking options for PXE and ISO installations

Networking for OpenShift Container Platform nodes uses DHCP by default to gather all necessary configuration settings. To set up static IP addresses or configure special settings, such as bonding, you can do one of the following:

- Pass special kernel parameters when you boot the live installer.
- Use a machine config to copy networking files to the installed system.
- Configure networking from a live installer shell prompt, then copy those settings to the installed system so that they take effect when the installed system first boots.

To configure a PXE or iPXE installation, use one of the following options:

- See the "Advanced RHCOS installation reference" tables.
- Use a machine config to copy networking files to the installed system.

To configure an ISO installation, use the following procedure.

#### Procedure

1. Boot the ISO installer.
2. From the live system shell prompt, configure networking for the live system using available RHEL tools, such as **nmcli** or **nmtui**.

- Run the **coreos-installer** command to install the system, adding the **--copy-network** option to copy networking configuration. For example:

```
$ sudo coreos-installer install --copy-network \
--ignition-url=http://host/worker.ign \
--offline \
/dev/disk/by-id/scsi-<serial_number>
```



### IMPORTANT

The **--copy-network** option only copies networking configuration found under **/etc/NetworkManager/system-connections**. In particular, it does not copy the system hostname.

- Reboot into the installed system.

## Additional resources

- See [Getting started with nmcli](#) and [Getting started with nmtui](#) in the RHEL 8 documentation for more information about the **nmcli** and **nmtui** tools.

### 2.3.12.3.2. Disk partitioning

Disk partitions are created on OpenShift Container Platform cluster nodes during the Red Hat Enterprise Linux CoreOS (RHCOS) installation. Each RHCOS node of a particular architecture uses the same partition layout, unless you override the default partitioning configuration. During the RHCOS installation, the size of the root file system is increased to use any remaining available space on the target device.



### IMPORTANT

The use of a custom partition scheme on your node might result in OpenShift Container Platform not monitoring or alerting on some node partitions. If you override the default partitioning, see [Understanding OpenShift File System Monitoring \(eviction conditions\)](#) for more information about how OpenShift Container Platform monitors your host file systems.

OpenShift Container Platform monitors the following two filesystem identifiers:

- nodefs**, which is the filesystem that contains **/var/lib/kubelet**
- imagefs**, which is the filesystem that contains **/var/lib/containers**

For the default partition scheme, **nodefs** and **imagefs** monitor the same root filesystem, **/**.

To override the default partitioning when installing RHCOS on an OpenShift Container Platform cluster node, you must create separate partitions. Consider a situation where you want to add a separate storage partition for your containers and container images. For example, by mounting **/var/lib/containers** in a separate partition, the kubelet separately monitors **/var/lib/containers** as the **imagefs** directory and the root file system as the **nodefs** directory.



## IMPORTANT

If you have resized your disk size to host a larger file system, consider creating a separate **/var/lib/containers** partition. Consider resizing a disk that has an **xfs** format to reduce CPU time issues caused by a high number of allocation groups.

### 2.3.12.3.2.1. Creating a separate **/var** partition

In general, you should use the default disk partitioning that is created during the RHCOS installation. However, there are cases where you might want to create a separate partition for a directory that you expect to grow.

OpenShift Container Platform supports the addition of a single partition to attach storage to either the **/var** directory or a subdirectory of **/var**. For example:

- **/var/lib/containers**: Holds container-related content that can grow as more images and containers are added to a system.
- **/var/lib/etcd**: Holds data that you might want to keep separate for purposes such as performance optimization of etcd storage.
- **/var**: Holds data that you might want to keep separate for purposes such as auditing.



## IMPORTANT

For disk sizes larger than 100GB, and especially larger than 1TB, create a separate **/var** partition.

Storing the contents of a **/var** directory separately makes it easier to grow storage for those areas as needed and reinstall OpenShift Container Platform at a later date and keep that data intact. With this method, you will not have to pull all your containers again, nor will you have to copy massive log files when you update systems.

The use of a separate partition for the **/var** directory or a subdirectory of **/var** also prevents data growth in the partitioned directory from filling up the root file system.

The following procedure sets up a separate **/var** partition by adding a machine config manifest that is wrapped into the Ignition config file for a node type during the preparation phase of an installation.

### Procedure

1. On your installation host, change to the directory that contains the OpenShift Container Platform installation program and generate the Kubernetes manifests for the cluster:

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

2. Create a Butane config that configures the additional partition. For example, name the file **\$HOME/clusterconfig/98-var-partition.bu**, change the disk device name to the name of the storage device on the **worker** systems, and set the storage size as appropriate. This example places the **/var** directory on a separate partition:

```
variant: openshift
version: 4.18.0
metadata:
  labels:
```

```

machineconfiguration.openshift.io/role: worker
name: 98-var-partition
storage:
disks:
- device: /dev/disk/by-id/<device_name> ①
partitions:
- label: var
  start_mib: <partition_start_offset> ②
  size_mib: <partition_size> ③
  number: 5
filesystems:
- device: /dev/disk/by-partlabel/var
  path: /var
  format: xfs
  mount_options: [defaults, prjquota] ④
  with_mount_unit: true

```

- ① The storage device name of the disk that you want to partition.
- ② When adding a data partition to the boot disk, a minimum offset value of 25000 mebibytes is recommended. The root file system is automatically resized to fill all available space up to the specified offset. If no offset value is specified, or if the specified value is smaller than the recommended minimum, the resulting root file system will be too small, and future reinstalls of RHCOS might overwrite the beginning of the data partition.
- ③ The size of the data partition in mebibytes.
- ④ The **prjquota** mount option must be enabled for filesystems used for container storage.



#### NOTE

When creating a separate **/var** partition, you cannot use different instance types for compute nodes, if the different instance types do not have the same device name.

3. Create a manifest from the Butane config and save it to the **clusterconfig/openshift** directory. For example, run the following command:

```
$ butane $HOME/clusterconfig/98-var-partition.bu -o $HOME/clusterconfig/openshift/98-var-partition.yaml
```

4. Create the Ignition config files:

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

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

Ignition config files are created for the bootstrap, control plane, and compute nodes in the installation directory:

```

.
└── auth

```



The files in the `<installation_directory>/manifest` and `<installation_directory>/openshift` directories are wrapped into the Ignition config files, including the file that contains the **98-var-partition** custom **MachineConfig** object.

## Next steps

- You can apply the custom disk partitioning by referencing the Ignition config files during the RHCOS installations.

### 2.3.12.3.2.2. Retaining existing partitions

For an ISO installation, you can add options to the **coreos-installer** command that cause the installer to maintain one or more existing partitions. For a PXE installation, you can add **coreos.inst.\*** options to the **APPEND** parameter to preserve partitions.

Saved partitions might be data partitions from an existing OpenShift Container Platform system. You can identify the disk partitions you want to keep either by partition label or by number.



#### NOTE

If you save existing partitions, and those partitions do not leave enough space for RHCOS, the installation will fail without damaging the saved partitions.

#### Retaining existing partitions during an ISO installation

This example preserves any partition in which the partition label begins with **data (data\*)**:

```
# coreos-installer install --ignition-url http://10.0.2.2:8080/user.ign \
--save-partlabel 'data*' \
--offline \
/dev/disk/by-id/scsi-<serial_number>
```

The following example illustrates running the **coreos-installer** in a way that preserves the sixth (6) partition on the disk:

```
# coreos-installer install --ignition-url http://10.0.2.2:8080/user.ign \
--save-partindex 6 \
--offline \
/dev/disk/by-id/scsi-<serial_number>
```

This example preserves partitions 5 and higher:

```
# coreos-installer install --ignition-url http://10.0.2.2:8080/user.ign \
--save-partindex 5- \
--offline \
/dev/disk/by-id/scsi-<serial_number>
```

In the previous examples where partition saving is used, **coreos-installer** recreates the partition immediately.

### Retaining existing partitions during a PXE installation

This **APPEND** option preserves any partition in which the partition label begins with 'data' ('data\*'):

```
coreos.inst.save_partlabel=data*
```

This **APPEND** option preserves partitions 5 and higher:

```
coreos.inst.save_partindex=5-
```

This **APPEND** option preserves partition 6:

```
coreos.inst.save_partindex=6
```

#### 2.3.12.3.3. Identifying Ignition configs

When doing an RHCOS manual installation, there are two types of Ignition configs that you can provide, with different reasons for providing each one:

- **Permanent install Ignition config:** Every manual RHCOS installation needs to pass one of the Ignition config files generated by **openshift-installer**, such as **bootstrap.ign**, **master.ign** and **worker.ign**, to carry out the installation.



#### IMPORTANT

It is not recommended to modify these Ignition config files directly. You can update the manifest files that are wrapped into the Ignition config files, as outlined in examples in the preceding sections.

For PXE installations, you pass the Ignition configs on the **APPEND** line using the **coreos.inst.ignition\_url=** option. For ISO installations, after the ISO boots to the shell prompt, you identify the Ignition config on the **coreos-installer** command line with the **--ignition-url=** option. In both cases, only HTTP and HTTPS protocols are supported.

- **Live install Ignition config:** This type can be created by using the **coreos-installer customize** subcommand and its various options. With this method, the Ignition config passes to the live install medium, runs immediately upon booting, and performs setup tasks before or after the RHCOS system installs to disk. This method should only be used for performing tasks that must be done once and not applied again later, such as with advanced partitioning that cannot be done using a machine config.

For PXE or ISO boots, you can create the Ignition config and **APPEND** the **ignition.config.url=** option to identify the location of the Ignition config. You also need to append **ignition.firstboot** **ignition.platform.id=metal** or the **ignition.config.url** option will be ignored.

#### 2.3.12.3.4. Default console configuration

Red Hat Enterprise Linux CoreOS (RHCOS) nodes installed from an OpenShift Container Platform 4.18 boot image use a default console that is meant to accommodate most virtualized and bare metal setups. Different cloud and virtualization platforms may use different default settings depending on the chosen architecture. Bare metal installations use the kernel default settings which typically means the graphical console is the primary console and the serial console is disabled.

The default consoles may not match your specific hardware configuration or you might have specific needs that require you to adjust the default console. For example:

- You want to access the emergency shell on the console for debugging purposes.
- Your cloud platform does not provide interactive access to the graphical console, but provides a serial console.
- You want to enable multiple consoles.

Console configuration is inherited from the boot image. This means that new nodes in existing clusters are unaffected by changes to the default console.

You can configure the console for bare metal installations in the following ways:

- Using **coreos-installer** manually on the command line.
- Using the **coreos-installer iso customize** or **coreos-installer pxe customize** subcommands with the **--dest-console** option to create a custom image that automates the process.



#### NOTE

For advanced customization, perform console configuration using the **coreos-installer iso** or **coreos-installer pxe** subcommands, and not kernel arguments.

##### 2.3.12.3.5. Enabling the serial console for PXE and ISO installations

By default, the Red Hat Enterprise Linux CoreOS (RHCOS) serial console is disabled and all output is written to the graphical console. You can enable the serial console for an ISO installation and reconfigure the bootloader so that output is sent to both the serial console and the graphical console.

#### Procedure

1. Boot the ISO installer.
2. Run the **coreos-installer** command to install the system, adding the **--console** option once to specify the graphical console, and a second time to specify the serial console:

```
$ coreos-installer install \
--console=tty0 \①
--console=ttyS0,<options> \②
--ignition-url=http://host/worker.ign \
--offline \
/dev/disk/by-id/scsi-<serial_number>
```

- 1 The desired secondary console. In this case, the graphical console. Omitting this option will disable the graphical console.
- 2 The desired primary console. In this case the serial console. The **options** field defines the baud rate and other settings. A common value for this field is **11520n8**. If no options are provided, the default kernel value of **9600n8** is used. For more information on the format of this option, see [Linux kernel serial console](#) documentation.

3. Reboot into the installed system.



## NOTE

A similar outcome can be obtained by using the **coreos-installer install --append-karg** option, and specifying the console with **console=**. However, this will only set the console for the kernel and not the bootloader.

To configure a PXE installation, make sure the **coreos.inst.install\_dev** kernel command-line option is omitted, and use the shell prompt to run **coreos-installer** manually using the above ISO installation procedure.

### 2.3.12.3.6. Customizing a live RHCOS ISO or PXE install

You can use the live ISO image or PXE environment to install RHCOS by injecting an Ignition config file directly into the image. This creates a customized image that you can use to provision your system.

For an ISO image, the mechanism to do this is the **coreos-installer iso customize** subcommand, which modifies the **.iso** file with your configuration. Similarly, the mechanism for a PXE environment is the **coreos-installer pxe customize** subcommand, which creates a new **initramfs** file that includes your customizations.

The **customize** subcommand is a general purpose tool that can embed other types of customizations as well. The following tasks are examples of some of the more common customizations:

- Inject custom CA certificates for when corporate security policy requires their use.
- Configure network settings without the need for kernel arguments.
- Embed arbitrary preinstall and post-install scripts or binaries.

### 2.3.12.3.7. Customizing a live RHCOS ISO image

You can customize a live RHCOS ISO image directly with the **coreos-installer iso customize** subcommand. When you boot the ISO image, the customizations are applied automatically.

You can use this feature to configure the ISO image to automatically install RHCOS.

#### Procedure

1. Download the **coreos-installer** binary from the [coreos-installer image mirror](#) page.
2. Retrieve the RHCOS ISO image from the [RHCOS image mirror](#) page and the Ignition config file, and then run the following command to inject the Ignition config directly into the ISO image:

```
$ coreos-installer iso customize rhcos-<version>-live.x86_64.iso \
--dest-ignition bootstrap.ign \ ①
--dest-device /dev/disk/by-id/scsi-<serial_number> ②
```

- ① The Ignition config file that is generated from the **openshift-installer** installation program.
- ② When you specify this option, the ISO image automatically runs an installation. Otherwise, the image remains configured for installation, but does not install automatically unless you specify the **coreos.inst.install\_dev** kernel argument.

3. Optional: To remove the ISO image customizations and return the image to its pristine state, run:

```
$ coreos-installer iso reset rhcos-<version>-live.x86_64.iso
```

You can now re-customize the live ISO image or use it in its pristine state.

Applying your customizations affects every subsequent boot of RHCOS.

### 2.3.12.3.7.1. Modifying a live install ISO image to enable the serial console

On clusters installed with OpenShift Container Platform 4.12 and above, the serial console is disabled by default and all output is written to the graphical console. You can enable the serial console with the following procedure.

#### Procedure

1. Download the **coreos-installer** binary from the [coreos-installer image mirror](#) page.
2. Retrieve the RHCOS ISO image from the [RHCOS image mirror](#) page and run the following command to customize the ISO image to enable the serial console to receive output:

```
$ coreos-installer iso customize rhcos-<version>-live.x86_64.iso \
--dest-ignition <path> \①
--dest-console tty0 \②
--dest-console ttyS0,<options> \③
--dest-device /dev/disk/by-id/scsi-<serial_number> \④
```

- ① The location of the Ignition config to install.
- ② The desired secondary console. In this case, the graphical console. Omitting this option will disable the graphical console.
- ③ The desired primary console. In this case, the serial console. The **options** field defines the baud rate and other settings. A common value for this field is **115200n8**. If no options are provided, the default kernel value of **9600n8** is used. For more information on the format of this option, see the [Linux kernel serial console](#) documentation.
- ④ The specified disk to install to. If you omit this option, the ISO image automatically runs the installation program which will fail unless you also specify the **coreos.inst.install\_dev** kernel argument.



#### NOTE

The **--dest-console** option affects the installed system and not the live ISO system. To modify the console for a live ISO system, use the **--live-karg-append** option and specify the console with **console=**.

Your customizations are applied and affect every subsequent boot of the ISO image.

3. Optional: To remove the ISO image customizations and return the image to its original state, run the following command:

```
$ coreos-installer iso reset rhcos-<version>-live.x86_64.iso
```

You can now recustomize the live ISO image or use it in its original state.

### 2.3.12.3.7.2. Modifying a live install ISO image to use a custom certificate authority

You can provide certificate authority (CA) certificates to Ignition with the **--ignition-ca** flag of the **customize** subcommand. You can use the CA certificates during both the installation boot and when provisioning the installed system.



#### NOTE

Custom CA certificates affect how Ignition fetches remote resources but they do not affect the certificates installed onto the system.

#### Procedure

1. Download the **coreos-installer** binary from the [coreos-installer image mirror](#) page.
2. Retrieve the RHCOS ISO image from the [RHCOS image mirror](#) page and run the following command to customize the ISO image for use with a custom CA:

```
$ coreos-installer iso customize rhcos-<version>-live.x86_64.iso --ignition-ca cert.pem
```



#### IMPORTANT

The **coreos.inst.ignition\_url** kernel parameter does not work with the **--ignition-ca** flag. You must use the **--dest-ignition** flag to create a customized image for each cluster.

Applying your custom CA certificate affects every subsequent boot of RHCOS.

### 2.3.12.3.7.3. Modifying a live install ISO image with customized network settings

You can embed a NetworkManager keyfile into the live ISO image and pass it through to the installed system with the **--network-keyfile** flag of the **customize** subcommand.



#### WARNING

When creating a connection profile, you must use a **.nmconnection** filename extension in the filename of the connection profile. If you do not use a **.nmconnection** filename extension, the cluster will apply the connection profile to the live environment, but it will not apply the configuration when the cluster first boots up the nodes, resulting in a setup that does not work.

#### Procedure

1. Download the **coreos-installer** binary from the [coreos-installer image mirror](#) page.

2. Create a connection profile for a bonded interface. For example, create the **bond0.nmconnection** file in your local directory with the following content:

```
[connection]
id=bond0
type=bond
interface-name=bond0
multi-connect=1

[bond]
miimon=100
mode=active-backup

[ipv4]
method=auto

[ipv6]
method=auto
```

3. Create a connection profile for a secondary interface to add to the bond. For example, create the **bond0-proxy-em1.nmconnection** file in your local directory with the following content:

```
[connection]
id=em1
type=ethernet
interface-name=em1
master=bond0
multi-connect=1
slave-type=bond
```

4. Create a connection profile for a secondary interface to add to the bond. For example, create the **bond0-proxy-em2.nmconnection** file in your local directory with the following content:

```
[connection]
id=em2
type=ethernet
interface-name=em2
master=bond0
multi-connect=1
slave-type=bond
```

5. Retrieve the RHCOS ISO image from the [RHCOS image mirror](#) page and run the following command to customize the ISO image with your configured networking:

```
$ coreos-installer iso customize rhcos-<version>-live.x86_64.iso \
--network-keyfile bond0.nmconnection \
--network-keyfile bond0-proxy-em1.nmconnection \
--network-keyfile bond0-proxy-em2.nmconnection
```

Network settings are applied to the live system and are carried over to the destination system.

#### 2.3.12.3.7.4. Customizing a live install ISO image for an iSCSI boot device

You can set the iSCSI target and initiator values for automatic mounting, booting and configuration using a customized version of the live RHCOS image.

## Prerequisites

1. You have an iSCSI target you want to install RHCOS on.

## Procedure

1. Download the **coreos-installer** binary from the [coreos-installer image mirror](#) page.
2. Retrieve the RHCOS ISO image from the [RHCOS image mirror](#) page and run the following command to customize the ISO image with the following information:

```
$ coreos-installer iso customize \
--pre-install mount-iscsi.sh \ ①
--post-install unmount-iscsi.sh \ ②
--dest-device /dev/disk/by-path/<IP_address>:<port>-iscsi-<target_iqn>-lun-<lun> \ ③
--dest-ignition config.ign \ ④
--dest-karg-append rd.iscsi.initiator=<initiator_iqn> \ ⑤
--dest-karg-append netroot=<target_iqn> \ ⑥
-o custom.iso rhcos-<version>-live.x86_64.iso
```

- 1 The script that gets run before installation. It should contain the **iscsiadm** commands for mounting the iSCSI target and any commands enabling multipathing.
- 2 The script that gets run after installation. It should contain the command **iscsiadm --mode node --logout=all**.
- 3 The location of the destination system. You must provide the IP address of the target portal, the associated port number, the target iSCSI node in IQN format, and the iSCSI logical unit number (LUN).
- 4 The Ignition configuration for the destination system.
- 5 The iSCSI initiator, or client, name in IQN format. The initiator forms a session to connect to the iSCSI target.
- 6 The the iSCSI target, or server, name in IQN format.

For more information about the iSCSI options supported by **dracut**, see the [dracut.cmdline manual page](#).

### 2.3.12.3.7.5. Customizing a live install ISO image for an iSCSI boot device with iBFT

You can set the iSCSI target and initiator values for automatic mounting, booting and configuration using a customized version of the live RHCOS image.

## Prerequisites

1. You have an iSCSI target you want to install RHCOS on.
2. Optional: you have multipathed your iSCSI target.

## Procedure

1. Download the **coreos-installer** binary from the [coreos-installer](#) image mirror page.
2. Retrieve the RHCOS ISO image from the [RHCOS image mirror](#) page and run the following command to customize the ISO image with the following information:

```
$ coreos-installer iso customize \
--pre-install mount-iscsi.sh \ ①
--post-install unmount-iscsi.sh \ ②
--dest-device /dev/mapper/mpatha \ ③
--dest-ignition config.ign \ ④
--dest-karg-append rd.iscsi.firmware=1 \ ⑤
--dest-karg-append rd.multipath=default \ ⑥
-o custom.iso rhcos-<version>-live.x86_64.iso
```

- 1 The script that gets run before installation. It should contain the **iscsiadm** commands for mounting the iSCSI target and any commands enabling multipathing.
- 2 The script that gets run after installation. It should contain the command **iscsiadm --mode node --logout=all**.
- 3 The path to the device. If you are using multipath, the multipath device, **/dev/mapper/mpatha**. If there are multiple multipath devices connected, or to be explicit, you can use the World Wide Name (WWN) symlink available in **/dev/disk/by-path**.
- 4 The Ignition configuration for the destination system.
- 5 The iSCSI parameter is read from the BIOS firmware.
- 6 Optional: include this parameter if you are enabling multipathing.

For more information about the iSCSI options supported by **dracut**, see the [dracut.cmdline](#) manual page.

### 2.3.12.3.8. Customizing a live RHCOS PXE environment

You can customize a live RHCOS PXE environment directly with the **coreos-installer pxe customize** subcommand. When you boot the PXE environment, the customizations are applied automatically.

You can use this feature to configure the PXE environment to automatically install RHCOS.

## Procedure

1. Download the **coreos-installer** binary from the [coreos-installer](#) image mirror page.
2. Retrieve the RHCOS **kernel**, **initramfs** and **rootfs** files from the [RHCOS image mirror](#) page and the Ignition config file, and then run the following command to create a new **initramfs** file that contains the customizations from your Ignition config:

```
$ coreos-installer pxe customize rhcos-<version>-live-initramfs.x86_64.img \
--dest-ignition bootstrap.ign \ ①
--dest-device /dev/disk/by-id/scsi-<serial_number> \ ②
-o rhcos-<version>-custom-initramfs.x86_64.img \ ③
```

- 1 The Ignition config file that is generated from **openshift-installer**.
- 2 When you specify this option, the PXE environment automatically runs an install. Otherwise, the image remains configured for installing, but does not do so automatically unless you specify the **coreos.inst.install\_dev** kernel argument.
- 3 Use the customized **initramfs** file in your PXE configuration. Add the **ignition.firstboot** and **ignition.platform.id=metal** kernel arguments if they are not already present.

Applying your customizations affects every subsequent boot of RHCOS.

#### 2.3.12.3.8.1. Modifying a live install PXE environment to enable the serial console

On clusters installed with OpenShift Container Platform 4.12 and above, the serial console is disabled by default and all output is written to the graphical console. You can enable the serial console with the following procedure.

#### Procedure

- 1 Download the **coreos-installer** binary from the [coreos-installer](#) image mirror page.
- 2 Retrieve the RHCOS **kernel**, **initramfs** and **rootfs** files from the [RHCOS image mirror](#) page and the Ignition config file, and then run the following command to create a new customized **initramfs** file that enables the serial console to receive output:

```
$ coreos-installer pxe customize rhcos-<version>-live-initramfs.x86_64.img \
--dest-ignition <path> \①
--dest-console tty0 \②
--dest-console ttyS0,<options> \③
--dest-device /dev/disk/by-id/scsi-<serial_number> \④
-o rhcos-<version>-custom-initramfs.x86_64.img \⑤
```

- 1 The location of the Ignition config to install.
- 2 The desired secondary console. In this case, the graphical console. Omitting this option will disable the graphical console.
- 3 The desired primary console. In this case, the serial console. The **options** field defines the baud rate and other settings. A common value for this field is **115200n8**. If no options are provided, the default kernel value of **9600n8** is used. For more information on the format of this option, see the [Linux kernel serial console](#) documentation.
- 4 The specified disk to install to. If you omit this option, the PXE environment automatically runs the installer which will fail unless you also specify the **coreos.inst.install\_dev** kernel argument.
- 5 Use the customized **initramfs** file in your PXE configuration. Add the **ignition.firstboot** and **ignition.platform.id=metal** kernel arguments if they are not already present.

Your customizations are applied and affect every subsequent boot of the PXE environment.

#### 2.3.12.3.8.2. Modifying a live install PXE environment to use a custom certificate authority

You can provide certificate authority (CA) certificates to Ignition with the **--ignition-ca** flag of the **customize** subcommand. You can use the CA certificates during both the installation boot and when provisioning the installed system.



### NOTE

Custom CA certificates affect how Ignition fetches remote resources but they do not affect the certificates installed onto the system.

### Procedure

1. Download the **coreos-installer** binary from the [coreos-installer](#) image mirror page.
2. Retrieve the RHCOS **kernel**, **initramfs** and **rootfs** files from the [RHCOS image mirror](#) page and run the following command to create a new customized **initramfs** file for use with a custom CA:

```
$ coreos-installer pxe customize rhcos-<version>-live-initramfs.x86_64.img \
--ignition-ca cert.pem \
-o rhcos-<version>-custom-initramfs.x86_64.img
```

3. Use the customized **initramfs** file in your PXE configuration. Add the **ignition.firstboot** and **ignition.platform.id=metal** kernel arguments if they are not already present.



### IMPORTANT

The **coreos.inst.ignition\_url** kernel parameter does not work with the **--ignition-ca** flag. You must use the **--dest-ignition** flag to create a customized image for each cluster.

Applying your custom CA certificate affects every subsequent boot of RHCOS.

#### 2.3.12.3.8.3. Modifying a live install PXE environment with customized network settings

You can embed a NetworkManager keyfile into the live PXE environment and pass it through to the installed system with the **--network-keyfile** flag of the **customize** subcommand.



### WARNING

When creating a connection profile, you must use a **.nmconnection** filename extension in the filename of the connection profile. If you do not use a **.nmconnection** filename extension, the cluster will apply the connection profile to the live environment, but it will not apply the configuration when the cluster first boots up the nodes, resulting in a setup that does not work.

### Procedure

1. Download the **coreos-installer** binary from the [coreos-installer](#) image mirror page.
2. Create a connection profile for a bonded interface. For example, create the **bond0.nmconnection** file in your local directory with the following content:

```
[connection]
id=bond0
type=bond
interface-name=bond0
multi-connect=1

[bond]
miimon=100
mode=active-backup

[ipv4]
method=auto

[ipv6]
method=auto
```

3. Create a connection profile for a secondary interface to add to the bond. For example, create the **bond0-proxy-em1.nmconnection** file in your local directory with the following content:

```
[connection]
id=em1
type=ethernet
interface-name=em1
master=bond0
multi-connect=1
slave-type=bond
```

4. Create a connection profile for a secondary interface to add to the bond. For example, create the **bond0-proxy-em2.nmconnection** file in your local directory with the following content:

```
[connection]
id=em2
type=ethernet
interface-name=em2
master=bond0
multi-connect=1
slave-type=bond
```

5. Retrieve the RHCOS **kernel**, **initramfs** and **rootfs** files from the [RHCOS image mirror](#) page and run the following command to create a new customized **initramfs** file that contains your configured networking:

```
$ coreos-installer pxe customize rhcos-<version>-live-initramfs.x86_64.img \
--network-keyfile bond0.nmconnection \
--network-keyfile bond0-proxy-em1.nmconnection \
--network-keyfile bond0-proxy-em2.nmconnection \
-o rhcos-<version>-custom-initramfs.x86_64.img
```

6. Use the customized **initramfs** file in your PXE configuration. Add the **ignition.firstboot** and **ignition.platform.id=metal** kernel arguments if they are not already present. Network settings are applied to the live system and are carried over to the destination system.

#### 2.3.12.3.8.4. Customizing a live install PXE environment for an iSCSI boot device

You can set the iSCSI target and initiator values for automatic mounting, booting and configuration using a customized version of the live RHCOS image.

## Prerequisites

1. You have an iSCSI target you want to install RHCOS on.

## Procedure

1. Download the **coreos-installer** binary from the [coreos-installer image mirror](#) page.
2. Retrieve the RHCOS **kernel**, **initramfs** and **rootfs** files from the [RHCOS image mirror](#) page and run the following command to create a new customized **initramfs** file with the following information:

```
$ coreos-installer pxe customize \
--pre-install mount-iscsi.sh \ ❶
--post-install umount-iscsi.sh \ ❷
--dest-device /dev/disk/by-path/<IP_address>:<port>-iscsi-<target_iqn>-lun-<lun> \ ❸
--dest-ignition config.ign \ ❹
--dest-karg-append rd.iscsi.initiator=<initiator_iqn> \ ❺
--dest-karg-append netroot=<target_iqn> \ ❻
-o custom.img rhcos-<version>-live-initramfs.x86_64.img
```

- ❶ The script that gets run before installation. It should contain the **iscsiadm** commands for mounting the iSCSI target and any commands enabling multipathing.
- ❷ The script that gets run after installation. It should contain the command **iscsiadm --mode node --logout=all**.
- ❸ The location of the destination system. You must provide the IP address of the target portal, the associated port number, the target iSCSI node in IQN format, and the iSCSI logical unit number (LUN).
- ❹ The Ignition configuration for the destination system.
- ❺ The iSCSI initiator, or client, name in IQN format. The initiator forms a session to connect to the iSCSI target.
- ❻ The the iSCSI target, or server, name in IQN format.

For more information about the iSCSI options supported by **dracut**, see the [dracut.cmdline manual page](#).

### 2.3.12.3.8.5. Customizing a live install PXE environment for an iSCSI boot device with iBFT

You can set the iSCSI target and initiator values for automatic mounting, booting and configuration using a customized version of the live RHCOS image.

## Prerequisites

1. You have an iSCSI target you want to install RHCOS on.
2. Optional: you have multipathed your iSCSI target.

## Procedure

1. Download the **coreos-installer** binary from the [coreos-installer image mirror](#) page.
2. Retrieve the RHCOS **kernel**, **initramfs** and **rootfs** files from the [RHCOS image mirror](#) page and run the following command to create a new customized **initramfs** file with the following information:

```
$ coreos-installer pxe customize \
--pre-install mount-iscsi.sh \ ①
--post-install unmount-iscsi.sh \ ②
--dest-device /dev/mapper/mpatha \ ③
--dest-ignition config.ign \ ④
--dest-karg-append rd.iscsi.firmware=1 \ ⑤
--dest-karg-append rd.multipath=default \ ⑥
-o custom.img rhcos-<version>-live-initramfs.x86_64.img
```

- ① The script that gets run before installation. It should contain the **iscsiadm** commands for mounting the iSCSI target.
- ② The script that gets run after installation. It should contain the command **iscsiadm --mode node --logout=all**.
- ③ The path to the device. If you are using multipath, the multipath device, **/dev/mapper/mpatha**. If there are multiple multipath devices connected, or to be explicit, you can use the World Wide Name (WWN) symlink available in **/dev/disk/by-path**.
- ④ The Ignition configuration for the destination system.
- ⑤ The iSCSI parameter is read from the BIOS firmware.
- ⑥ Optional: include this parameter if you are enabling multipathing.

For more information about the iSCSI options supported by **dracut**, see the [dracut.cmdline manual page](#).

### 2.3.12.3.9. Advanced RHCOS installation reference

This section illustrates the networking configuration and other advanced options that allow you to modify the Red Hat Enterprise Linux CoreOS (RHCOS) manual installation process. The following tables describe the kernel arguments and command-line options you can use with the RHCOS live installer and the **coreos-installer** command.

#### 2.3.12.3.9.1. Networking and bonding options for ISO installations

If you install RHCOS from an ISO image, you can add kernel arguments manually when you boot the image to configure networking for a node. If no networking arguments are specified, DHCP is activated in the initramfs when RHCOS detects that networking is required to fetch the Ignition config file.



#### IMPORTANT

When adding networking arguments manually, you must also add the **rd.neednet=1** kernel argument to bring the network up in the initramfs.

The following information provides examples for configuring networking and bonding on your RHCOS nodes for ISO installations. The examples describe how to use the **ip=**, **nameserver=**, and **bond=** kernel arguments.



### NOTE

Ordering is important when adding the kernel arguments: **ip=**, **nameserver=**, and then **bond=**.

The networking options are passed to the **dracut** tool during system boot. For more information about the networking options supported by **dracut**, see the [dracut cmdline manual page](#).

The following examples are the networking options for ISO installation.

Configuring DHCP or static IP addresses

To configure an IP address, either use DHCP (**ip=dhcp**) or set an individual static IP address (**ip=<host\_ip>**). If setting a static IP, you must then identify the DNS server IP address (**nameserver=<dns\_ip>**) on each node. The following example sets:

- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The hostname to **core0.example.com**
- The DNS server address to **4.4.4.41**
- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
nameserver=4.4.4.41
```



### NOTE

When you use DHCP to configure IP addressing for the RHCOS machines, the machines also obtain the DNS server information through DHCP. For DHCP-based deployments, you can define the DNS server address that is used by the RHCOS nodes through your DHCP server configuration.

Configuring an IP address without a static hostname

You can configure an IP address without assigning a static hostname. If a static hostname is not set by the user, it will be picked up and automatically set by a reverse DNS lookup. To configure an IP address without a static hostname refer to the following example:

- The node's IP address to **10.10.10.2**
- The gateway address to **10.10.10.254**
- The netmask to **255.255.255.0**
- The DNS server address to **4.4.4.41**

- The auto-configuration value to **none**. No auto-configuration is required when IP networking is configured statically.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0::enp1s0:none
nameserver=4.4.4.41
```

#### Specifying multiple network interfaces

You can specify multiple network interfaces by setting multiple **ip=** entries.

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=10.10.10.3::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

#### Configuring default gateway and route

Optional: You can configure routes to additional networks by setting an **rd.route=** value.



#### NOTE

When you configure one or multiple networks, one default gateway is required. If the additional network gateway is different from the primary network gateway, the default gateway must be the primary network gateway.

- Run the following command to configure the default gateway:

```
ip=:10.10.10.254:::
```

- Enter the following command to configure the route for the additional network:

```
rd.route=20.20.20.0/24:20.20.20.254:enp2s0
```

#### Disabling DHCP on a single interface

You can disable DHCP on a single interface, such as when there are two or more network interfaces and only one interface is being used. In the example, the **enp1s0** interface has a static networking configuration and DHCP is disabled for **enp2s0**, which is not used:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp1s0:none
ip=:::core0.example.com:enp2s0:none
```

#### Combining DHCP and static IP configurations

You can combine DHCP and static IP configurations on systems with multiple network interfaces, for example:

```
ip=enp1s0:dhcp
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0:none
```

#### Configuring VLANs on individual interfaces

Optional: You can configure VLANs on individual interfaces by using the **vlan=** parameter.

- To configure a VLAN on a network interface and use a static IP address, run the following command:

```
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:enp2s0.100:none
vlan=enp2s0.100:enp2s0
```

- To configure a VLAN on a network interface and to use DHCP, run the following command:

```
ip=enp2s0.100:dhcp
vlan=enp2s0.100:enp2s0
```

Bonding multiple DNS servers

You can provide multiple DNS servers by adding a **nameserver=** entry for each server, for example:

```
nameserver=1.1.1.1
nameserver=8.8.8.8
```

Bonding multiple network interfaces to a single interface

Optional: You can bond multiple network interfaces to a single interface by using the **bond=** option. Refer to the following examples:

- The syntax for configuring a bonded interface is: **bond=<name>[:<network\_interfaces>] [:options]**  
**<name>** is the bonding device name (**bond0**), **<network\_interfaces>** represents a comma-separated list of physical (ethernet) interfaces (**em1,em2**), and **options** is a comma-separated list of bonding options. Enter **modinfo bonding** to see available options.
- When you create a bonded interface using **bond=**, you must specify how the IP address is assigned and other information for the bonded interface.
  - To configure the bonded interface to use DHCP, set the bond's IP address to **dhcp**. For example:

```
bond=bond0:em1,em2:mode=active-backup
ip=bond0:dhcp
```

- To configure the bonded interface to use a static IP address, enter the specific IP address you want and related information. For example:

```
bond=bond0:em1,em2:mode=active-backup
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0:none
```

Bonding multiple SR-IOV network interfaces to a dual port NIC interface

Optional: You can bond multiple SR-IOV network interfaces to a dual port NIC interface by using the **bond=** option.

On each node, you must perform the following tasks:

1. Create the SR-IOV virtual functions (VFs) following the guidance in [Managing SR-IOV devices](#). Follow the procedure in the "Attaching SR-IOV networking devices to virtual machines" section.
2. Create the bond, attach the desired VFs to the bond and set the bond link state up following the guidance in [Configuring network bonding](#). Follow any of the described procedures to create the bond.

The following examples illustrate the syntax you must use:

- The syntax for configuring a bonded interface is **bond=<name>[:<network\_interfaces>] [:options]**.  
**<name>** is the bonding device name (**bond0**), **<network\_interfaces>** represents the virtual functions (VFs) by their known name in the kernel and shown in the output of the **ip link**

command(**eno1f0**, **eno2f0**), and *options* is a comma-separated list of bonding options. Enter **modinfo bonding** to see available options.

- When you create a bonded interface using **bond=**, you must specify how the IP address is assigned and other information for the bonded interface.

- To configure the bonded interface to use DHCP, set the bond's IP address to **dhcp**. For example:

```
bond=bond0:eno1f0,eno2f0:mode=active-backup
ip=bond0:dhcp
```

- To configure the bonded interface to use a static IP address, enter the specific IP address you want and related information. For example:

```
bond=bond0:eno1f0,eno2f0:mode=active-backup
ip=10.10.10.2::10.10.10.254:255.255.255.0:core0.example.com:bond0:none
```

## Using network teaming

Optional: You can use a network teaming as an alternative to bonding by using the **team=** parameter:

- The syntax for configuring a team interface is: **team=name[:network\_interfaces]**  
*name* is the team device name (**team0**) and *network\_interfaces* represents a comma-separated list of physical (ethernet) interfaces (**em1**, **em2**).



### NOTE

Teaming is planned to be deprecated when RHCOS switches to an upcoming version of RHEL. For more information, see this [Red Hat Knowledgebase Article](#).

Use the following example to configure a network team:

```
team=team0:em1,em2
ip=team0:dhcp
```

### 2.3.12.3.9.2. coreos-installer options for ISO and PXE installations

You can install RHCOS by running **coreos-installer install <options> <device>** at the command prompt, after booting into the RHCOS live environment from an ISO image.

The following table shows the subcommands, options, and arguments you can pass to the **coreos-installer** command.

Table 2.39. **coreos-installer** subcommands, command-line options, and arguments

coreos-installer install subcommand	
Subcommand	Description
<b>\$ coreos-installer install &lt;options&gt; &lt;device&gt;</b>	Embed an Ignition config in an ISO image.
coreos-installer install subcommand options	

<i>Option</i>	<i>Description</i>
<b>-u, --image-url &lt;url&gt;</b>	Specify the image URL manually.
<b>-f, --image-file &lt;path&gt;</b>	Specify a local image file manually. Used for debugging.
<b>-i, --ignition-file &lt;path&gt;</b>	Embed an Ignition config from a file.
<b>-I, --ignition-url &lt;URL&gt;</b>	Embed an Ignition config from a URL.
<b>--ignition-hash &lt;digest&gt;</b>	Digest <b>type-value</b> of the Ignition config.
<b>-p, --platform &lt;name&gt;</b>	Override the Ignition platform ID for the installed system.
<b>--console &lt;spec&gt;</b>	Set the kernel and bootloader console for the installed system. For more information about the format of <b>&lt;spec&gt;</b> , see the <a href="#">Linux kernel serial console</a> documentation.
<b>--append-karg &lt;arg&gt;...</b>	Append a default kernel argument to the installed system.
<b>--delete-karg &lt;arg&gt;...</b>	Delete a default kernel argument from the installed system.
<b>-n, --copy-network</b>	Copy the network configuration from the install environment.
<b>--network-dir &lt;path&gt;</b>	For use with <b>-n</b> . Default is <b>/etc/NetworkManager/system-connections/</b> .
<b>--save-partlabel &lt;lx&gt;..</b>	Save partitions with this label glob.
<b>--save-partindex &lt;id&gt;...</b>	Save partitions with this number or range.
<b>--insecure</b>	Skip RHCOS image signature verification.
<b>--insecure-ignition</b>	Allow Ignition URL without HTTPS or hash.

**IMPORTANT**

The **--copy-network** option only copies networking configuration found under **/etc/NetworkManager/system-connections**. In particular, it does not copy the system hostname.

--architecture <name>	Target CPU architecture. Valid values are <b>x86_64</b> and <b>aarch64</b> .
--preserve-on-error	Do not clear partition table on error.
-h, --help	Print help information.

**coreos-installer install** subcommand argument

<i>Argument</i>	<i>Description</i>
<device>	The destination device.

**coreos-installer ISO** subcommands

<i>Subcommand</i>	<i>Description</i>
\$ coreos-installer iso customize <options> <ISO_image>	Customize a RHCOS live ISO image.
coreos-installer iso reset <options> <ISO_image>	Restore a RHCOS live ISO image to default settings.
coreos-installer iso ignition remove <options> <ISO_image>	Remove the embedded Ignition config from an ISO image.

**coreos-installer ISO customize** subcommand options

<i>Option</i>	<i>Description</i>
--dest-ignition <path>	Merge the specified Ignition config file into a new configuration fragment for the destination system.
--dest-console <spec>	Specify the kernel and bootloader console for the destination system.
--dest-device <path>	Install and overwrite the specified destination device.
--dest-karg-append <arg>	Add a kernel argument to each boot of the destination system.
--dest-karg-delete <arg>	Delete a kernel argument from each boot of the destination system.
--network-keyfile <path>	Configure networking by using the specified NetworkManager keyfile for live and destination systems.

<b>--ignition-ca &lt;path&gt;</b>	Specify an additional TLS certificate authority to be trusted by Ignition.
<b>--pre-install &lt;path&gt;</b>	Run the specified script before installation.
<b>--post-install &lt;path&gt;</b>	Run the specified script after installation.
<b>--installer-config &lt;path&gt;</b>	Apply the specified installer configuration file.
<b>--live-ignition &lt;path&gt;</b>	Merge the specified Ignition config file into a new configuration fragment for the live environment.
<b>--live-karg-append &lt;arg&gt;</b>	Add a kernel argument to each boot of the live environment.
<b>--live-karg-delete &lt;arg&gt;</b>	Delete a kernel argument from each boot of the live environment.
<b>--live-karg-replace &lt;k=o=n&gt;</b>	Replace a kernel argument in each boot of the live environment, in the form <b>key=old=new</b> .
<b>-f, --force</b>	Overwrite an existing Ignition config.
<b>-o, --output &lt;path&gt;</b>	Write the ISO to a new output file.
<b>-h, --help</b>	Print help information.

**coreos-installer PXE subcommands**

<i>Subcommand</i>	<i>Description</i>
Note that not all of these options are accepted by all subcommands.	
<b>coreos-installer pxe customize &lt;options&gt; &lt;path&gt;</b>	Customize a RHCOS live PXE boot config.
<b>coreos-installer pxe ignition wrap &lt;options&gt;</b>	Wrap an Ignition config in an image.
<b>coreos-installer pxe ignition unwrap &lt;options&gt; &lt;image_name&gt;</b>	Show the wrapped Ignition config in an image.

**coreos-installer PXE customize subcommand options**

<i>Option</i>	<i>Description</i>
Note that not all of these options are accepted by all subcommands.	

<b>--dest-ignition &lt;path&gt;</b>	Merge the specified Ignition config file into a new configuration fragment for the destination system.
<b>--dest-console &lt;spec&gt;</b>	Specify the kernel and bootloader console for the destination system.
<b>--dest-device &lt;path&gt;</b>	Install and overwrite the specified destination device.
<b>--network-keyfile &lt;path&gt;</b>	Configure networking by using the specified NetworkManager keyfile for live and destination systems.
<b>--ignition-ca &lt;path&gt;</b>	Specify an additional TLS certificate authority to be trusted by Ignition.
<b>--pre-install &lt;path&gt;</b>	Run the specified script before installation.
<b>post-install &lt;path&gt;</b>	Run the specified script after installation.
<b>--installer-config &lt;path&gt;</b>	Apply the specified installer configuration file.
<b>--live-ignition &lt;path&gt;</b>	Merge the specified Ignition config file into a new configuration fragment for the live environment.
<b>-o, --output &lt;path&gt;</b>	Write the initramfs to a new output file.
<b>-h, --help</b>	<p> <b>NOTE</b>  This option is required for PXE environments.</p>

### 2.3.12.3.9.3. **coreos.inst** boot options for ISO or PXE installations

You can automatically invoke **coreos-installer** options at boot time by passing **coreos.inst** boot arguments to the RHCOS live installer. These are provided in addition to the standard boot arguments.

- For ISO installations, the **coreos.inst** options can be added by interrupting the automatic boot at the bootloader menu. You can interrupt the automatic boot by pressing **TAB** while the **RHEL CoreOS (Live)** menu option is highlighted.
- For PXE or iPXE installations, the **coreos.inst** options must be added to the **APPEND** line before the RHCOS live installer is booted.

The following table shows the RHCOS live installer **coreos.inst** boot options for ISO and PXE installations.

**Table 2.40. coreos.inst boot options**

Argument	Description
<b>coreos.inst.install_dev</b>	<p>Required. The block device on the system to install to.</p> <p> <b>NOTE</b></p> <p>It is recommended to use the full path, such as <b>/dev/sda</b>, although <b>sda</b> is allowed.</p>
<b>coreos.inst.ignition_url</b>	<p>Optional: The URL of the Ignition config to embed into the installed system. If no URL is specified, no Ignition config is embedded. Only HTTP and HTTPS protocols are supported.</p>
<b>coreos.inst.save_partlabel</b>	<p>Optional: Comma-separated labels of partitions to preserve during the install. Glob-style wildcards are permitted. The specified partitions do not need to exist.</p>
<b>coreos.inst.save_partindex</b>	<p>Optional: Comma-separated indexes of partitions to preserve during the install. Ranges <b>m-n</b> are permitted, and either <b>m</b> or <b>n</b> can be omitted. The specified partitions do not need to exist.</p>
<b>coreos.inst.insecure</b>	<p>Optional: Permits the OS image that is specified by <b>coreos.inst.image_url</b> to be unsigned.</p>
<b>coreos.inst.image_url</b>	<p>Optional: Download and install the specified RHCOS image.</p> <ul style="list-style-type: none"> <li>● This argument should not be used in production environments and is intended for debugging purposes only.</li> <li>● While this argument can be used to install a version of RHCOS that does not match the live media, it is recommended that you instead use the media that matches the version you want to install.</li> <li>● If you are using <b>coreos.inst.image_url</b>, you must also use <b>coreos.inst.insecure</b>. This is because the bare-metal media are not GPG-signed for OpenShift Container Platform.</li> <li>● Only HTTP and HTTPS protocols are supported.</li> </ul>

Argument	Description
<b>coreos.inst.skip_reboot</b>	<p>Optional: The system will not reboot after installing. After the install finishes, you will receive a prompt that allows you to inspect what is happening during installation. This argument should not be used in production environments and is intended for debugging purposes only.</p>
<b>coreos.inst.platform_id</b>	<p>Optional: The Ignition platform ID of the platform the RHCOS image is being installed on. Default is <b>metal</b>. This option determines whether or not to request an Ignition config from the cloud provider, such as VMware. For example:</p> <p><b>coreos.inst.platform_id=vmware</b>.</p>
<b>ignition.config.url</b>	<p>Optional: The URL of the Ignition config for the live boot. For example, this can be used to customize how <b>coreos-installer</b> is invoked, or to run code before or after the installation. This is different from <b>coreos.inst.ignition_url</b>, which is the Ignition config for the installed system.</p>

#### 2.3.12.4. Enabling multipathing with kernel arguments on RHCOS

RHCOS supports multipathing on the primary disk, allowing stronger resilience to hardware failure to achieve higher host availability.

You can enable multipathing at installation time for nodes that were provisioned in OpenShift Container Platform 4.8 or later. While postinstallation support is available by activating multipathing via the machine config, enabling multipathing during installation is recommended.

In setups where any I/O to non-optimized paths results in I/O system errors, you must enable multipathing at installation time.



#### IMPORTANT

On IBM Z® and IBM® LinuxONE, you can enable multipathing only if you configured your cluster for it during installation. For more information, see "Installing RHCOS and starting the OpenShift Container Platform bootstrap process" in *Installing a cluster with z/VM on IBM Z® and IBM® LinuxONE*.

The following procedure enables multipath at installation time and appends kernel arguments to the **coreos-installer install** command so that the installed system itself will use multipath beginning from the first boot.



#### NOTE

OpenShift Container Platform does not support enabling multipathing as a day-2 activity on nodes that have been upgraded from 4.6 or earlier.

## Prerequisites

- You have created the Ignition config files for your cluster.
- You have reviewed *Installing RHCOS and starting the OpenShift Container Platform bootstrap process*.

## Procedure

1. To enable multipath and start the **multipathd** daemon, run the following command on the installation host:
 

```
$ mpathconf --enable && systemctl start multipathd.service
```

  - Optional: If booting the PXE or ISO, you can instead enable multipath by adding **rd.multipath=default** from the kernel command line.
2. Append the kernel arguments by invoking the **coreos-installer** program:
  - If there is only one multipath device connected to the machine, it should be available at path **/dev/mapper/mpatha**. For example:

```
$ coreos-installer install /dev/mapper/mpatha \①
--ignition-url=http://host/worker.ign \
--append-karg rd.multipath=default \
--append-karg root=/dev/disk/by-label/dm-mpath-root \
--append-karg rw \
--offline
```

① Indicates the path of the single multipathed device.

- If there are multiple multipath devices connected to the machine, or to be more explicit, instead of using **/dev/mapper/mpatha**, it is recommended to use the World Wide Name (WWN) symlink available in **/dev/disk/by-id**. For example:

```
$ coreos-installer install /dev/disk/by-id/wwn-<wwn_ID> \①
--ignition-url=http://host/worker.ign \
--append-karg rd.multipath=default \
--append-karg root=/dev/disk/by-label/dm-mpath-root \
--append-karg rw \
--offline
```

① Indicates the WWN ID of the target multipathed device. For example, **0xx194e957fcedb4841**.

This symlink can also be used as the **coreos.inst.install\_dev** kernel argument when using special **coreos.inst.\*** arguments to direct the live installer. For more information, see "Installing RHCOS and starting the OpenShift Container Platform bootstrap process".

3. Reboot into the installed system.
4. Check that the kernel arguments worked by going to one of the worker nodes and listing the kernel command-line arguments (in **/proc/cmdline** on the host):

```
$ oc debug node/ip-10-0-141-105.ec2.internal
```

### Example output

```
Starting pod/ip-10-0-141-105ec2internal-debug ...
To use host binaries, run `chroot /host`

sh-4.2# cat /host/proc/cmdline
...
rd.multipath=default root=/dev/disk/by-label/dm-mpath-root
...
sh-4.2# exit
```

You should see the added kernel arguments.

#### 2.3.12.4.1. Enabling multipathing on secondary disks

RHCOS also supports multipathing on a secondary disk. Instead of kernel arguments, you use Ignition to enable multipathing for the secondary disk at installation time.

#### Prerequisites

- You have read the section *Disk partitioning*.
- You have read *Enabling multipathing with kernel arguments on RHCOS*.
- You have installed the Butane utility.

#### Procedure

1. Create a Butane config with information similar to the following:

### Example multipath-config.bu

```
variant: openshift
version: 4.18.0
systemd:
  units:
    - name: mpath-configure.service
      enabled: true
      contents: |
        [Unit]
        Description=Configure Multipath on Secondary Disk
        ConditionFirstBoot=true
        ConditionPathExists=!/etc/multipath.conf
        Before=multipathd.service ①
        DefaultDependencies=no

        [Service]
        Type=oneshot
        ExecStart=/usr/sbin/mpathconf --enable ②

  [Install]
```

```

WantedBy=multi-user.target
- name: mpath-var-lib-container.service
  enabled: true
  contents: |
    [Unit]
    Description=Set Up Multipath On /var/lib/containers
    ConditionFirstBoot=true ③
    Requires=dev-mapper-mpatha.device
    After=dev-mapper-mpatha.device
    After=ostree-remount.service
    Before=kubelet.service
    DefaultDependencies=no

    [Service] ④
    Type=oneshot
    ExecStart=/usr/sbin/mkfs.xfs -L containers -m reflink=1 /dev/mapper/mpatha
    ExecStart=/usr/bin/mkdir -p /var/lib/containers

    [Install]
    WantedBy=multi-user.target
- name: var-lib-containers.mount
  enabled: true
  contents: |
    [Unit]
    Description=Mount /var/lib/containers
    After=mpath-var-lib-containers.service
    Before=kubelet.service ⑤

    [Mount] ⑥
    What=/dev/disk/by-label/dm-mpath-containers
    Where=/var/lib/containers
    Type=xfs

    [Install]
    WantedBy=multi-user.target

```

- 1 The configuration must be set before launching the multipath daemon.
- 2 Starts the **mpathconf** utility.
- 3 This field must be set to the value **true**.
- 4 Creates the filesystem and directory **/var/lib/containers**.
- 5 The device must be mounted before starting any nodes.
- 6 Mounts the device to the **/var/lib/containers** mount point. This location cannot be a symlink.

2. Create the Ignition configuration by running the following command:

```
$ butane --pretty --strict multipath-config.bu > multipath-config.ign
```

3. Continue with the rest of the first boot RHCOS installation process.



## IMPORTANT

Do not add the **rd.multipath** or **root** kernel arguments on the command-line during installation unless the primary disk is also multipathed.

### 2.3.12.5. Installing RHCOS manually on an iSCSI boot device

You can manually install RHCOS on an iSCSI target.

#### Prerequisites

1. You are in the RHCOS live environment.
2. You have an iSCSI target that you want to install RHCOS on.

#### Procedure

1. Mount the iSCSI target from the live environment by running the following command:

```
$ iscsiadadm \
--mode discovery \
--type sendtargets \
--portal <IP_address> \ ①
--login
```

- ① The IP address of the target portal.

2. Install RHCOS onto the iSCSI target by running the following command and using the necessary kernel arguments, for example:

```
$ coreos-installer install \
/dev/disk/by-path/ip-<IP_address>:<port>-iscsi-<target_iqn>-lun-<lun> \ ①
--append-karg rd.iscsi.initiator=<initiator_iqn> \ ②
--append.karg netroot=<target_iqn> \ ③
--console ttyS0,115200n8 \
--ignition-file <path_to_file> \
--offline
```

- ① The location you are installing to. You must provide the IP address of the target portal, the associated port number, the target iSCSI node in IQN format, and the iSCSI logical unit number (LUN).
- ② The iSCSI initiator, or client, name in IQN format. The initiator forms a session to connect to the iSCSI target.
- ③ The the iSCSI target, or server, name in IQN format.

For more information about the iSCSI options supported by **dracut**, see the [dracut.cmdline manual page](#).

3. Unmount the iSCSI disk with the following command:

```
$ iscsiadadm --mode node --logoutall=all
```

This procedure can also be performed using the **coreos-installer iso customize** or **coreos-installer pxe customize** subcommands.

### 2.3.12.6. Installing RHCOS on an iSCSI boot device using iBFT

On a completely diskless machine, the iSCSI target and initiator values can be passed through iBFT. iSCSI multipathing is also supported.

#### Prerequisites

1. You are in the RHCOS live environment.
2. You have an iSCSI target you want to install RHCOS on.
3. Optional: you have multipathed your iSCSI target.

#### Procedure

1. Mount the iSCSI target from the live environment by running the following command:

```
$ iscsiadm \
--mode discovery \
--type sendtargets \
--portal <IP_address> \ ①
--login
```

- ① The IP address of the target portal.

2. Optional: enable multipathing and start the daemon with the following command:

```
$ mpathconf --enable && systemctl start multipathd.service
```

3. Install RHCOS onto the iSCSI target by running the following command and using the necessary kernel arguments, for example:

```
$ coreos-installer install \
/dev/mapper/mpatha \ ①
--append-karg rd.iscsi.firmware=1 \ ②
--append-karg rd.multipath=default \ ③
--console ttyS0 \
--ignition-file <path_to_file> \
--offline
```

- ① The path of a single multipathed device. If there are multiple multipath devices connected, or to be explicit, you can use the World Wide Name (WWN) symlink available in **/dev/disk/by-path**.
- ② The iSCSI parameter is read from the BIOS firmware.
- ③ Optional: include this parameter if you are enabling multipathing.

For more information about the iSCSI options supported by **dracut**, see the [dracut.cmdline manual page](#).

4. Unmount the iSCSI disk:

```
$ iscsidadm --mode node --logout=all
```

This procedure can also be performed using the **coreos-installer iso customize** or **coreos-installer pxe customize** subcommands.

### 2.3.13. Waiting for the bootstrap process to complete

The OpenShift Container Platform bootstrap process begins after the cluster nodes first boot into the persistent RHCOS environment that has been installed to disk. The configuration information provided through the Ignition config files is used to initialize the bootstrap process and install OpenShift Container Platform on the machines. You must wait for the bootstrap process to complete.

#### Prerequisites

- You have created the Ignition config files for your cluster.
- You have configured suitable network, DNS and load balancing infrastructure.
- You have obtained the installation program and generated the Ignition config files for your cluster.
- You installed RHCOS on your cluster machines and provided the Ignition config files that the OpenShift Container Platform installation program generated.

#### Procedure

1. Monitor the bootstrap process:

```
$ ./openshift-install --dir <installation_directory> wait-for bootstrap-complete \ ①  
--log-level=info ②
```

- 1 For **<installation\_directory>**, specify the path to the directory that you stored the installation files in.
- 2 To view different installation details, specify **warn**, **debug**, or **error** instead of **info**.

#### Example output

```
INFO Waiting up to 30m0s for the Kubernetes API at https://api.test.example.com:6443...  
INFO API v1.31.3 up  
INFO Waiting up to 30m0s for bootstrapping to complete...  
INFO It is now safe to remove the bootstrap resources
```

The command succeeds when the Kubernetes API server signals that it has been bootstrapped on the control plane machines.

2. After the bootstrap process is complete, remove the bootstrap machine from the load balancer.

**IMPORTANT**

You must remove the bootstrap machine from the load balancer at this point. You can also remove or reformat the bootstrap machine itself.

**Additional resources**

- See [Monitoring installation progress](#) for more information about monitoring the installation logs and retrieving diagnostic data if installation issues arise.

**2.3.14. Logging in to the cluster by using the CLI**

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

**Prerequisites**

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

**Procedure**

1. Export the **kubeadmin** credentials:

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

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

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

```
$ oc whoami
```

**Example output**

```
system:admin
```

**2.3.15. Approving the certificate signing requests for your machines**

When you add machines to a cluster, two pending certificate signing requests (CSRs) are generated for each machine that you added. You must confirm that these CSRs are approved or, if necessary, approve them yourself. The client requests must be approved first, followed by the server requests.

**Prerequisites**

- You added machines to your cluster.

**Procedure**

1. Confirm that the cluster recognizes the machines:

```
$ oc get nodes
```

#### Example output

NAME	STATUS	ROLES	AGE	VERSION
master-0	Ready	master	63m	v1.31.3
master-1	Ready	master	63m	v1.31.3
master-2	Ready	master	64m	v1.31.3

The output lists all of the machines that you created.



#### NOTE

The preceding output might not include the compute nodes, also known as worker nodes, until some CSRs are approved.

2. Review the pending CSRs and ensure that you see the client requests with the **Pending** or **Approved** status for each machine that you added to the cluster:

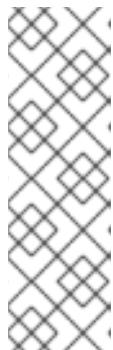
```
$ oc get csr
```

#### Example output

NAME	AGE	REQUESTOR	CONDITION
csr-8b2br	15m	system:serviceaccount:openshift-machine-config-operator:node-bootstrapper	Pending
csr-8vnps	15m	system:serviceaccount:openshift-machine-config-operator:node-bootstrapper	Pending
...			

In this example, two machines are joining the cluster. You might see more approved CSRs in the list.

3. If the CSRs were not approved, after all of the pending CSRs for the machines you added are in **Pending** status, approve the CSRs for your cluster machines:



#### NOTE

Because the CSRs rotate automatically, approve your CSRs within an hour of adding the machines to the cluster. If you do not approve them within an hour, the certificates will rotate, and more than two certificates will be present for each node. You must approve all of these certificates. After the client CSR is approved, the Kubelet creates a secondary CSR for the serving certificate, which requires manual approval. Then, subsequent serving certificate renewal requests are automatically approved by the **machine-approver** if the Kubelet requests a new certificate with identical parameters.



## NOTE

For clusters running on platforms that are not machine API enabled, such as bare metal and other user-provisioned infrastructure, you must implement a method of automatically approving the kubelet serving certificate requests (CSRs). If a request is not approved, then the **oc exec**, **oc rsh**, and **oc logs** commands cannot succeed, because a serving certificate is required when the API server connects to the kubelet. Any operation that contacts the Kubelet endpoint requires this certificate approval to be in place. The method must watch for new CSRs, confirm that the CSR was submitted by the **node-bootstrapper** service account in the **system:node** or **system:admin** groups, and confirm the identity of the node.

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

```
$ oc adm certificate approve <csr_name> ①
```

① **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}\n{{end}}{{end}}' | xargs --no-run-if-empty oc adm certificate approve
```



## NOTE

Some Operators might not become available until some CSRs are approved.

4. Now that your client requests are approved, you must review the server requests for each machine that you added to the cluster:

```
$ oc get csr
```

### Example output

NAME	AGE	REQUESTOR	CONDITION
csr-bfd72	5m26s	system:node:ip-10-0-50-126.us-east-2.compute.internal	Pending
csr-c57lv	5m26s	system:node:ip-10-0-95-157.us-east-2.compute.internal	Pending
...			

5. If the remaining CSRs are not approved, and are in the **Pending** status, approve the CSRs for your cluster machines:

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

```
$ oc adm certificate approve <csr_name> ①
```

① **<csr\_name>** is the name of a CSR from the list of current CSRs.

- To approve all pending CSRs, run the following command:

```
$ oc get csr -o go-template='{{range .items}}{{if not .status}}{{.metadata.name}}\n{{end}}{{end}}' | xargs oc adm certificate approve
```

- After all client and server CSRs have been approved, the machines have the **Ready** status. Verify this by running the following command:

```
$ oc get nodes
```

### Example output

NAME	STATUS	ROLES	AGE	VERSION
master-0	Ready	master	73m	v1.31.3
master-1	Ready	master	73m	v1.31.3
master-2	Ready	master	74m	v1.31.3
worker-0	Ready	worker	11m	v1.31.3
worker-1	Ready	worker	11m	v1.31.3



### NOTE

It can take a few minutes after approval of the server CSRs for the machines to transition to the **Ready** status.

### Additional information

- [Certificate Signing Requests](#)

## 2.3.16. Initial Operator configuration

After the control plane initializes, you must immediately configure some Operators so that they all become available.

### Prerequisites

- Your control plane has initialized.

### Procedure

- Watch the cluster components come online:

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

### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED
SINCE				
authentication	4.18.0	True	False	False
baremetal	4.18.0	True	False	False
cloud-credential	4.18.0	True	False	False
cluster-autoscaler	4.18.0	True	False	False
config-operator	4.18.0	True	False	False

console	4.18.0	True	False	False	26m
csi-snapshot-controller	4.18.0	True	False	False	37m
dns	4.18.0	True	False	False	37m
etcd	4.18.0	True	False	False	36m
image-registry	4.18.0	True	False	False	31m
ingress	4.18.0	True	False	False	30m
insights	4.18.0	True	False	False	31m
kube-apiserver	4.18.0	True	False	False	26m
kube-controller-manager	4.18.0	True	False	False	36m
kube-scheduler	4.18.0	True	False	False	36m
kube-storage-version-migrator	4.18.0	True	False	False	37m
machine-api	4.18.0	True	False	False	29m
machine approver	4.18.0	True	False	False	37m
machine-config	4.18.0	True	False	False	36m
marketplace	4.18.0	True	False	False	37m
monitoring	4.18.0	True	False	False	29m
network	4.18.0	True	False	False	38m
node-tuning	4.18.0	True	False	False	37m
openshift-apiserver	4.18.0	True	False	False	32m
openshift-controller-manager	4.18.0	True	False	False	30m
openshift-samples	4.18.0	True	False	False	32m
operator-lifecycle-manager	4.18.0	True	False	False	37m
operator-lifecycle-manager-catalog	4.18.0	True	False	False	37m
operator-lifecycle-manager-packageserver	4.18.0	True	False	False	32m
service-ca	4.18.0	True	False	False	38m
storage	4.18.0	True	False	False	37m

- Configure the Operators that are not available.

## Additional resources

- See [Gathering logs from a failed installation](#) for details about gathering data in the event of a failed OpenShift Container Platform installation.
- See [Troubleshooting Operator issues](#) for steps to check Operator pod health across the cluster and gather Operator logs for diagnosis.

### 2.3.16.1. Disabling the default OperatorHub catalog sources

Operator catalogs that source content provided by Red Hat and community projects are configured for OperatorHub by default during an OpenShift Container Platform installation. In a restricted network environment, you must disable the default catalogs as a cluster administrator.

#### Procedure

- Disable the sources for the default catalogs by adding **disableAllDefaultSources: true** to the **OperatorHub** object:

```
$ oc patch OperatorHub cluster --type json \
-p '[{"op": "add", "path": "/spec/disableAllDefaultSources", "value": true}]'
```

**TIP**

Alternatively, you can use the web console to manage catalog sources. From the **Administration → Cluster Settings → Configuration → OperatorHub** page, click the **Sources** tab, where you can create, update, delete, disable, and enable individual sources.

### 2.3.16.2. Image registry storage configuration

The Image Registry Operator is not initially available for platforms that do not provide default storage. After installation, you must configure your registry to use storage so that the Registry Operator is made available.

Instructions are shown for configuring a persistent volume, which is required for production clusters. Where applicable, instructions are shown for configuring an empty directory as the storage location, which is available for only non-production clusters.

Additional instructions are provided for allowing the image registry to use block storage types by using the **Recreate** rollout strategy during upgrades.

#### 2.3.16.2.1. Changing the image registry's management state

To start the image registry, you must change the Image Registry Operator configuration's **managementState** from **Removed** to **Managed**.

#### Procedure

- Change **managementState** Image Registry Operator configuration from **Removed** to **Managed**. For example:

```
$ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec": {"managementState": "Managed"}}'
```

#### 2.3.16.2.2. Configuring registry storage for bare metal and other manual installations

As a cluster administrator, following installation you must configure your registry to use storage.

#### Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.
- You have a cluster that uses manually-provisioned Red Hat Enterprise Linux CoreOS (RHCOS) nodes, such as bare metal.
- You have provisioned persistent storage for your cluster, such as Red Hat OpenShift Data Foundation.



#### IMPORTANT

OpenShift Container Platform supports **ReadWriteOnce** access for image registry storage when you have only one replica. **ReadWriteOnce** access also requires that the registry uses the **Recreate** rollout strategy. To deploy an image registry that supports high availability with two or more replicas, **ReadWriteMany** access is required.

- Must have 100Gi capacity.

## Procedure

1. To configure your registry to use storage, change the **spec.storage.pvc** in the **configs.imageregistry/cluster** resource.



### NOTE

When you use shared storage, review your security settings to prevent outside access.

2. Verify that you do not have a registry pod:

```
$ oc get pod -n openshift-image-registry -l docker-registry=default
```

### Example output

```
No resources found in openshift-image-registry namespace
```



### NOTE

If you do have a registry pod in your output, you do not need to continue with this procedure.

3. Check the registry configuration:

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

### Example output

```
storage:  
pvc:  
claim:
```

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

4. Check the **clusteroperator** status:

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

### Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
MESSAGE					
image-registry	4.18	True	False	False	6h50m

5. Ensure that your registry is set to managed to enable building and pushing of images.

- Run:

```
$ oc edit configs.imageregistry/cluster
```

Then, change the line

```
managementState: Removed
```

to

```
managementState: Managed
```

### 2.3.16.2.3. Configuring storage for the image registry in non-production clusters

You must configure storage for the Image Registry Operator. For non-production clusters, you can set the image registry to an empty directory. If you do so, all images are lost if you restart the registry.

#### Procedure

- To set the image registry storage to an empty directory:

```
$ oc patch configs.imageregistry.operator.openshift.io cluster --type merge --patch '{"spec": {"storage":{"emptyDir":{}}}}'
```



#### WARNING

Configure this option for only non-production clusters.

If you run this command before the Image Registry Operator initializes its components, the **oc patch** command fails with the following error:

```
Error from server (NotFound): configs.imageregistry.operator.openshift.io "cluster" not found
```

Wait a few minutes and run the command again.

### 2.3.16.2.4. Configuring block registry storage for bare metal

To allow the image registry to use block storage types during upgrades as a cluster administrator, you can use the **Recreate** rollout strategy.



#### IMPORTANT

Block storage volumes, or block persistent volumes, are supported but not recommended for use with the image registry on production clusters. An installation where the registry is configured on block storage is not highly available because the registry cannot have more than one replica.

If you choose to use a block storage volume with the image registry, you must use a filesystem persistent volume claim (PVC).

## Procedure

- Enter the following command to set the image registry storage as a block storage type, patch the registry so that it uses the **Recreate** rollout strategy, and runs with only one (1) replica:

```
$ oc patch config.imageregistry.operator.openshift.io/cluster --type=merge -p '{"spec": {"rolloutStrategy": "Recreate", "replicas": 1}}'
```

- Provision the PV for the block storage device, and create a PVC for that volume. The requested block volume uses the ReadWriteOnce (RWO) access mode.

- Create a **pvc.yaml** file with the following contents to define a VMware vSphere **PersistentVolumeClaim** object:

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: image-registry-storage ①
  namespace: openshift-image-registry ②
spec:
  accessModes:
    - ReadWriteOnce ③
  resources:
    requests:
      storage: 100Gi ④
```

- ① A unique name that represents the **PersistentVolumeClaim** object.
- ② The namespace for the **PersistentVolumeClaim** object, which is **openshift-image-registry**.
- ③ The access mode of the persistent volume claim. With **ReadWriteOnce**, the volume can be mounted with read and write permissions by a single node.
- ④ The size of the persistent volume claim.

- Enter the following command to create the **PersistentVolumeClaim** object from the file:

```
$ oc create -f pvc.yaml -n openshift-image-registry
```

- Enter the following command to edit the registry configuration so that it references the correct PVC:

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

### Example output

```
storage:
pvc:
claim: ①
```

- ① By creating a custom PVC, you can leave the **claim** field blank for the default automatic creation of an **image-registry-storage** PVC.

## 2.3.17. Completing installation on user-provisioned infrastructure

After you complete the Operator configuration, you can finish installing the cluster on infrastructure that you provide.

### Prerequisites

- Your control plane has initialized.
- You have completed the initial Operator configuration.

### Procedure

1. Confirm that all the cluster components are online with the following command:

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

### Example output

NAME SINCE	VERSION	AVAILABLE	PROGRESSING	DEGRADED
authentication	4.18.0	True	False	False 19m
baremetal	4.18.0	True	False	False 37m
cloud-credential	4.18.0	True	False	False 40m
cluster-autoscaler	4.18.0	True	False	False 37m
config-operator	4.18.0	True	False	False 38m
console	4.18.0	True	False	False 26m
csi-snapshot-controller	4.18.0	True	False	False 37m
dns	4.18.0	True	False	False 37m
etcd	4.18.0	True	False	False 36m
image-registry	4.18.0	True	False	False 31m
ingress	4.18.0	True	False	False 30m
insights	4.18.0	True	False	False 31m
kube-apiserver	4.18.0	True	False	False 26m
kube-controller-manager	4.18.0	True	False	False 36m
kube-scheduler	4.18.0	True	False	False 36m
kube-storage-version-migrator	4.18.0	True	False	False 37m
machine-api	4.18.0	True	False	False 29m
machine-approver	4.18.0	True	False	False 37m
machine-config	4.18.0	True	False	False 36m
marketplace	4.18.0	True	False	False 37m
monitoring	4.18.0	True	False	False 29m
network	4.18.0	True	False	False 38m
node-tuning	4.18.0	True	False	False 37m
openshift-apiserver	4.18.0	True	False	False 32m
openshift-controller-manager	4.18.0	True	False	False 30m
openshift-samples	4.18.0	True	False	False 32m
operator-lifecycle-manager	4.18.0	True	False	False 37m
operator-lifecycle-manager-catalog	4.18.0	True	False	False 37m
operator-lifecycle-manager-packageserver	4.18.0	True	False	False 32m
service-ca	4.18.0	True	False	False 38m
storage	4.18.0	True	False	False 37m

Alternatively, the following command notifies you when all of the clusters are available. It also retrieves and displays credentials:

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

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

### Example output

```
INFO Waiting up to 30m0s for the cluster to initialize...
```

The command succeeds when the Cluster Version Operator finishes deploying the OpenShift Container Platform cluster from Kubernetes API server.



### IMPORTANT

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

- Confirm that the Kubernetes API server is communicating with the pods.

- To view a list of all pods, use the following command:

```
$ oc get pods --all-namespaces
```

### Example output

NAMESPACE	NAME	READY	STATUS
RESTARTS	AGE		
openshift-apiserver-operator	openshift-apiserver-operator-85cb746d55-zqhs8	1/1	
Running 1 9m			
openshift-apiserver	apiserver-67b9g	1/1	Running 0
3m			
openshift-apiserver	apiserver-ljcmx	1/1	Running 0
1m			
openshift-apiserver	apiserver-z25h4	1/1	Running 0
2m			
openshift-authentication-operator	authentication-operator-69d5d8bf84-vh2n8	1/1	
Running 0 5m			
...			

- b. View the logs for a pod that is listed in the output of the previous command by using the following command:

```
$ oc logs <pod_name> -n <namespace> ①
```

- ① Specify the pod name and namespace, as shown in the output of the previous command.

If the pod logs display, the Kubernetes API server can communicate with the cluster machines.

3. For an installation with Fibre Channel Protocol (FCP), additional steps are required to enable multipathing. Do not enable multipathing during installation.  
See "Enabling multipathing with kernel arguments on RHCOS" in the *Postinstallation machine configuration tasks* documentation for more information.
4. Register your cluster on the [Cluster registration](#) page.

### 2.3.18. Telemetry access for OpenShift Container Platform

In OpenShift Container Platform 4.18, the Telemetry service, which runs by default to provide metrics about cluster health and the success of updates, requires internet access. If your cluster is connected to the internet, Telemetry runs automatically, and your cluster is registered to [OpenShift Cluster Manager](#).

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

#### Additional resources

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

### 2.3.19. Next steps

- [Validating an installation](#).
- [Customize your cluster](#).
- [Configure image streams](#) for the Cluster Samples Operator and the **must-gather** tool.
- Learn how to [use Operator Lifecycle Manager in disconnected environments](#).
- If the mirror registry that you used to install your cluster has a trusted CA, add it to the cluster by [configuring additional trust stores](#).
- If necessary, you can [opt out of remote health reporting](#).
- If necessary, see [Registering your disconnected cluster](#)

## 2.4. SCALING A USER-PROVISIONED CLUSTER WITH THE BARE METAL OPERATOR

After deploying a user-provisioned infrastructure cluster, you can use the Bare Metal Operator (BMO) and other metal<sup>3</sup> components to scale bare-metal hosts in the cluster. This approach helps you to scale a user-provisioned cluster in a more automated way.

## 2.4.1. About scaling a user-provisioned cluster with the Bare Metal Operator

You can scale user-provisioned infrastructure clusters by using the Bare Metal Operator (BMO) and other metal<sup>3</sup> components. User-provisioned infrastructure installations do not feature the Machine API Operator. The Machine API Operator typically manages the lifecycle of bare-metal nodes in a cluster. However, it is possible to use the BMO and other metal<sup>3</sup> components to scale nodes in user-provisioned clusters without requiring the Machine API Operator.

### 2.4.1.1. Prerequisites for scaling a user-provisioned cluster

- You installed a user-provisioned infrastructure cluster on bare metal.
- You have baseboard management controller (BMC) access to the hosts.

### 2.4.1.2. Limitations for scaling a user-provisioned cluster

- You cannot use a provisioning network to scale user-provisioned infrastructure clusters by using the Bare Metal Operator (BMO).
  - Consequentially, you can only use bare-metal host drivers that support virtual media networking booting, for example **redfish-virtualmedia** and **idrac-virtualmedia**.
- You cannot scale **MachineSet** objects in user-provisioned infrastructure clusters by using the BMO.

## 2.4.2. Configuring a provisioning resource to scale user-provisioned clusters

Create a **Provisioning** custom resource (CR) to enable Metal platform components on a user-provisioned infrastructure cluster.

### Prerequisites

- You installed a user-provisioned infrastructure cluster on bare metal.

### Procedure

1. Create a **Provisioning** CR.
  - a. Save the following YAML in the **provisioning.yaml** file:

```
apiVersion: metal3.io/v1alpha1
kind: Provisioning
metadata:
  name: provisioning-configuration
spec:
  provisioningNetwork: "Disabled"
  watchAllNamespaces: false
```

**NOTE**

OpenShift Container Platform 4.18 does not support enabling a provisioning network when you scale a user-provisioned cluster by using the Bare Metal Operator.

2. Create the **Provisioning** CR by running the following command:

```
$ oc create -f provisioning.yaml
```

**Example output**

```
provisioning.metal3.io/provisioning-configuration created
```

**Verification**

- Verify that the provisioning service is running by running the following command:

```
$ oc get pods -n openshift-machine-api
```

**Example output**

NAME	READY	STATUS	RESTARTS	AGE
cluster-autoscaler-operator-678c476f4c-jjdn5	2/2	Running	0	5d21h
cluster-baremetal-operator-6866f7b976-gmvgh	2/2	Running	0	5d21h
control-plane-machine-set-operator-7d8566696c-bh4jz	1/1	Running	0	5d21h
ironic-proxy-64bdw	1/1	Running	0	5d21h
ironic-proxy-rbggf	1/1	Running	0	5d21h
ironic-proxy-vj54c	1/1	Running	0	5d21h
machine-api-controllers-544d6849d5-tgj9l	7/7	Running	1 (5d21h ago)	5d21h
machine-api-operator-5c4ff4b86d-6fjmq	2/2	Running	0	5d21h
metal3-6d98f84cc8-zn2mx	5/5	Running	0	5d21h
metal3-image-customization-59d745768d-bhrp7	1/1	Running	0	5d21h

**2.4.3. Provisioning new hosts in a user-provisioned cluster by using the BMO**

You can use the Bare Metal Operator (BMO) to provision bare-metal hosts in a user-provisioned cluster by creating a **BareMetalHost** custom resource (CR).

**NOTE**

Provisioning bare-metal hosts to the cluster by using the BMO sets the **spec.externallyProvisioned** specification in the **BareMetalHost** custom resource to **false** by default. Do not set the **spec.externallyProvisioned** specification to **true**, because this setting results in unexpected behavior.

**Prerequisites**

- You created a user-provisioned bare-metal cluster.
- You have baseboard management controller (BMC) access to the hosts.
- You deployed a provisioning service in the cluster by creating a **Provisioning** CR.

## Procedure

- Create a configuration file for the bare-metal node. Depending if you use either a static configuration or a DHCP server, choose one of the following example **bmh.yaml** files and configure it to your needs by replacing values in the YAML to match your environment:

- To deploy with a static configuration, create the following **bmh.yaml** file:

```

---
apiVersion: v1
kind: Secret
metadata:
  name: openshift-worker-<num>-network-config-secret 1
  namespace: openshift-machine-api
type: Opaque
stringData:
  nmstate: | 2
    interfaces: 3
      - name: <nic1_name> 4
        type: ethernet
        state: up
        ipv4:
          address:
            - ip: <ip_address> 5
              prefix-length: 24
            enabled: true
        dns-resolver:
          config:
            server:
              - <dns_ip_address> 6
        routes:
          config:
            - destination: 0.0.0.0/0
              next-hop-address: <next_hop_ip_address> 7
              next-hop-interface: <next_hop_nic1_name> 8
    ---
  apiVersion: v1
  kind: Secret
  metadata:
    name: openshift-worker-<num>-bmc-secret
    namespace: openshift-machine-api
  type: Opaque
  data:
    username: <base64_of_uid> 9
    password: <base64_of_pwd>
  ---
  apiVersion: metal3.io/v1alpha1
  kind: BareMetalHost
  metadata:
    name: openshift-worker-<num>
    namespace: openshift-machine-api
  spec:
    online: true
    bootMACAddress: <nice1_mac_address> 10
    bmc:

```

```

address: <protocol>://<bmc_url> 11
credentialsName: openshift-worker-<num>-bmc-secret
disableCertificateVerification: false
customDeploy:
  method: install_coreos
userData:
  name: worker-user-data-managed
  namespace: openshift-machine-api
rootDeviceHints:
  deviceName: <root_device_hint> 12
preprovisioningNetworkDataName: openshift-worker-<num>-network-config-secret

```

- 1** Replace all instances of **<num>** with a unique compute node number for the bare-metal nodes in the **name**, **credentialsName**, and **preprovisioningNetworkDataName** fields.
  - 2** Add the NMState YAML syntax to configure the host interfaces. To configure the network interface for a newly created node, specify the name of the secret that has the network configuration. Follow the **nmstate** syntax to define the network configuration for your node. See "Preparing the bare-metal node" for details on configuring NMState syntax.
  - 3** Optional: If you have configured the network interface with **nmstate**, and you want to disable an interface, set **state: up** with the IP addresses set to **enabled: false**.
  - 4** Replace **<nict1\_name>** with the name of the bare-metal node's first network interface controller (NIC).
  - 5** Replace **<ip\_address>** with the IP address of the bare-metal node's NIC.
  - 6** Replace **<dns\_ip\_address>** with the IP address of the bare-metal node's DNS resolver.
  - 7** Replace **<next\_hop\_ip\_address>** with the IP address of the bare-metal node's external gateway.
  - 8** Replace **<next\_hop\_nic1\_name>** with the name of the bare-metal node's external gateway.
  - 9** Replace **<base64\_of\_uid>** and **<base64\_of\_pwd>** with the base64 string of the user name and password.
  - 10** Replace **<nict1\_mac\_address>** with the MAC address of the bare-metal node's first NIC. See the "BMC addressing" section for additional BMC configuration options.
  - 11** Replace **<protocol>** with the BMC protocol, such as IPMI, Redfish, or others. Replace **<bmc\_url>** with the URL of the bare-metal node's baseboard management controller.
  - 12** Optional: Replace **<root\_device\_hint>** with a device path when specifying a root device hint. See "Root device hints" for additional details.
- When configuring the network interface with a static configuration by using **nmstate**, set **state: up** with the IP addresses set to **enabled: false**:

```

---  
apiVersion: v1

```

```

kind: Secret
metadata:
  name: openshift-worker-<num>-network-config-secret
  namespace: openshift-machine-api
# ...
interfaces:
- name: <nice_name>
  type: ethernet
  state: up
  ipv4:
    enabled: false
  ipv6:
    enabled: false
# ...

```

- To deploy with a DHCP configuration, create the following **bmh.yaml** file:

```

---
apiVersion: v1
kind: Secret
metadata:
  name: openshift-worker-<num>-bmc-secret 1
  namespace: openshift-machine-api
type: Opaque
data:
  username: <base64_of_uid> 2
  password: <base64_of_pwd>
---
apiVersion: metal3.io/v1alpha1
kind: BareMetalHost
metadata:
  name: openshift-worker-<num>
  namespace: openshift-machine-api
spec:
  online: true
  bootMACAddress: <nice1_mac_address> 3
  bmc:
    address: <protocol>://<bmc_url> 4
    credentialsName: openshift-worker-<num>-bmc
    disableCertificateVerification: false
  customDeploy:
    method: install_coreos
  userData:
    name: worker-user-data-managed
    namespace: openshift-machine-api
  rootDeviceHints:
    deviceName: <root_device_hint> 5

```

- Replace **<num>** with a unique compute node number for the bare-metal nodes in the **name** and **credentialsName** fields.
- Replace **<base64\_of\_uid>** and **<base64\_of\_pwd>** with the base64 string of the user name and password.
- Replace **<nice1\_mac\_address>** with the MAC address of the bare-metal node's first NIC. See the "BMC addressing" section for additional BMC configuration options.

MAC. SEE THE BMC ADDRESSING SECTION FOR ADDITIONAL BMC CONFIGURATION OPTIONS.

- 4 Replace <protocol> with the BMC protocol, such as IPMI, Redfish, or others. Replace <bmc\_url> with the URL of the bare-metal node's baseboard management controller.
- 5 Optional: Replace <root\_device\_hint> with a device path when specifying a root device hint. See "Root device hints" for additional details.



## IMPORTANT

If the MAC address of an existing bare-metal node matches the MAC address of the bare-metal host that you are attempting to provision, then the installation will fail. If the host enrollment, inspection, cleaning, or other steps fail, the Bare Metal Operator retries the installation continuously. See "Diagnosing a duplicate MAC address when provisioning a new host in the cluster" for additional details.

2. Create the bare-metal node by running the following command:

```
$ oc create -f bmh.yaml
```

### Example output

```
secret/openshift-worker-<num>-network-config-secret created
secret/openshift-worker-<num>-bmc-secret created
baremetalhost.metal3.io/openshift-worker-<num> created
```

3. Inspect the bare-metal node by running the following command:

```
$ oc -n openshift-machine-api get bmh openshift-worker-<num>
```

where:

<num>

Specifies the compute node number.

### Example output

NAME	STATE	CONSUMER	ONLINE	ERROR
openshift-worker-<num>	provisioned	true		

4. Approve all certificate signing requests (CSRs).

- a. Get the list of pending CSRs by running the following command:

```
$ oc get csr
```

### Example output

NAME	AGE	SIGNERNAME	REQUESTOR
REQUESTEDDURATION CONDITION			

```
csr-gfm9f 33s kubernetes.io/kube-apiserver-client-kubelet
system:serviceaccount:openshift-machine-config-operator:node-bootstrapper <none> Pending
```

- b. Approve the CSR by running the following command:

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

#### Example output

```
certificatesigningrequest.certificates.k8s.io/<csr_name> approved
```

### Verification

- Verify that the node is ready by running the following command:

```
$ oc get nodes
```

#### Example output

NAME	STATUS	ROLES	AGE	VERSION
app1	Ready	worker	47s	v1.24.0+dc5a2fd
controller1	Ready	master,worker	2d22h	v1.24.0+dc5a2fd

### Additional resources

- [Preparing the bare-metal node](#)
- [Root device hints](#)
- [Diagnosing a duplicate MAC address when provisioning a new host in the cluster](#)

#### 2.4.4. Optional: Managing existing hosts in a user-provisioned cluster by using the BMO

Optionally, you can use the Bare Metal Operator (BMO) to manage existing bare-metal controller hosts in a user-provisioned cluster by creating a **BareMetalHost** object for the existing host. It is not a requirement to manage existing user-provisioned hosts; however, you can enroll them as externally-provisioned hosts for inventory purposes.



#### IMPORTANT

To manage existing hosts by using the BMO, you must set the **spec.externallyProvisioned** specification in the **BareMetalHost** custom resource to **true** to prevent the BMO from re-provisioning the host.

### Prerequisites

- You created a user-provisioned bare-metal cluster.
- You have baseboard management controller (BMC) access to the hosts.

- You deployed a provisioning service in the cluster by creating a **Provisioning** CR.

## Procedure

1. Create the **Secret** CR and the **BareMetalHost** CR.
  - a. Save the following YAML in the **controller.yaml** file:

```

---
apiVersion: v1
kind: Secret
metadata:
  name: controller1-bmc
  namespace: openshift-machine-api
type: Opaque
data:
  username: <base64_of_uid>
  password: <base64_of_pwd>
---
apiVersion: metal3.io/v1alpha1
kind: BareMetalHost
metadata:
  name: controller1
  namespace: openshift-machine-api
spec:
  bmc:
    address: <protocol>://<bmc_url> 1
    credentialsName: "controller1-bmc"
    bootMACAddress: <nict1_mac_address>
    customDeploy:
      method: install_coreos
    externallyProvisioned: true 2
    online: true
    userData:
      name: controller-user-data-managed
      namespace: openshift-machine-api

```

- 1** You can only use bare-metal host drivers that support virtual media networking booting, for example **redfish-virtualmedia** and **idrac-virtualmedia**.
- 2** You must set the value to true to prevent the BMO from re-provisioning the bare-metal controller host.

2. Create the bare-metal host object by running the following command:

```
$ oc create -f controller.yaml
```

### Example output

```
secret/controller1-bmc created
baremetalhost.metal3.io/controller1 created
```

## Verification

- Verify that the BMO created the bare-metal host object by running the following command:

```
$ oc get bmh -A
```

#### Example output

NAMESPACE	NAME	STATE	CONSUMER	ONLINE	ERROR
AGE					
openshift-machine-api	controller1	externally provisioned		true	13s

### 2.4.5. Removing hosts from a user-provisioned cluster by using the BMO

You can use the Bare Metal Operator (BMO) to remove bare-metal hosts from a user-provisioned cluster.

#### Prerequisites

- You created a user-provisioned bare-metal cluster.
- You have baseboard management controller (BMC) access to the hosts.
- You deployed a provisioning service in the cluster by creating a **Provisioning** CR.

#### Procedure

- Cordon and drain the node by running the following command:

```
$ oc adm drain app1 --force --ignore-daemonsets=true
```

#### Example output

```
node/app1 cordoned
WARNING: ignoring DaemonSet-managed Pods: openshift-cluster-node-tuning-
operator/tuned-tvthg, openshift-dns/dns-
default-9q6rz, openshift-dns/node-resolver-zvt42, openshift-image-registry/node-ca-mzxth,
openshift-ingress-cana
ry/ingress-canary-qq5lf, openshift-machine-config-operator/machine-config-daemon-v79dm,
openshift-monitoring/nod
e-exporter-2vn59, openshift-multus/multus-additional-cni-plugins-wssvj, openshift-
multus/multus-fn8tg, openshift-
-multus/network-metrics-daemon-5qv55, openshift-network-diagnostics/network-check-
target-jqxn2, openshift-ovn-ku
bernetes/ovnkube-node-rsvqq
evicting pod openshift-operator-lifecycle-manager/collect-profiles-27766965-258vp
evicting pod openshift-operator-lifecycle-manager/collect-profiles-27766950-kg5mk
evicting pod openshift-operator-lifecycle-manager/collect-profiles-27766935-stf4s
pod/collect-profiles-27766965-258vp evicted
pod/collect-profiles-27766950-kg5mk evicted
pod/collect-profiles-27766935-stf4s evicted
node/app1 drained
```

- Delete the **customDeploy** specification from the **BareMetalHost** CR.

- a. Edit the **BareMetalHost** CR for the host by running the following command:

```
$ oc edit bmh -n openshift-machine-api <host_name>
```

- b. Delete the lines **spec.customDeploy** and **spec.customDeploy.method**:

```
...
customDeploy:
method: install_coreos
```

- c. Verify that the provisioning state of the host changes to **deprovisioning** by running the following command:

```
$ oc get bmh -A
```

#### Example output

NAMESPACE	NAME	STATE	CONSUMER	ONLINE
ERROR	AGE			
openshift-machine-api	controller1	externally provisioned	true	58m
openshift-machine-api	worker1	deprovisioning	true	57m

3. Delete the host by running the following command when the **BareMetalHost** state changes to **available**:

```
$ oc delete bmh -n openshift-machine-api <bmh_name>
```



#### NOTE

You can run this step without having to edit the **BareMetalHost** CR. It might take some time for the **BareMetalHost** state to change from **deprovisioning** to **available**.

4. Delete the node by running the following command:

```
$ oc delete node <node_name>
```

#### Verification

- Verify that you deleted the node by running the following command:

```
$ oc get nodes
```

#### Example output

NAME	STATUS	ROLES	AGE	VERSION
controller1	Ready	master,worker	2d23h	v1.24.0+dc5a2fd

## 2.5. INSTALLATION CONFIGURATION PARAMETERS FOR BARE METAL

Before you deploy an OpenShift Container Platform cluster, you provide a customized **install-config.yaml** installation configuration file that describes the details for your environment.

## 2.5.1. Available installation configuration parameters for bare metal

The following tables specify the required, optional, and bare metal-specific installation configuration parameters that you can set as part of the installation process.



### NOTE

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

### 2.5.1.1. Required configuration parameters

Required installation configuration parameters are described in the following table:

**Table 2.41. Required parameters**

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

Parameter	Description	Values
platform:	The configuration for the specific platform upon which to perform the installation: <b>aws</b> , <b>baremetal</b> , <b>azure</b> , <b>gcp</b> , <b>ibmcloud</b> , <b>nutanix</b> , <b>openstack</b> , <b>powervs</b> , <b>vsphere</b> , or <code>{}</code> . For additional information about <b>platform</b> . <b>&lt;platform&gt;</b> parameters, consult the table for your specific platform that follows.	Object
pullSecret:	Get a <a href="#">pull secret</a> from Red Hat OpenShift Cluster Manager to authenticate downloading container images for OpenShift Container Platform components from services such as Quay.io.	<pre>{   "auths": {     "cloud.openshift.com": {       "auth": "b3Blb=",       "email": "you@example.com"     },     "quay.io": {       "auth": "b3Blb=",       "email": "you@example.com"     }   } }</pre>

### 2.5.1.2. Network configuration parameters

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

Consider the following information before you configure network parameters for your cluster:

- If you use the Red Hat OpenShift Networking OVN-Kubernetes network plugin, both IPv4 and IPv6 address families are supported.
- If you deployed nodes in an OpenShift Container Platform cluster with a network that supports both IPv4 and non-link-local IPv6 addresses, configure your cluster to use a dual-stack network.
  - For clusters configured for dual-stack networking, both IPv4 and IPv6 traffic must use the same network interface as the default gateway. This ensures that in a multiple network interface controller (NIC) environment, a cluster can detect what NIC to use based on the available network interface. For more information, see "OVN-Kubernetes IPv6 and dual-stack limitations" in *About the OVN-Kubernetes network plugin*.
  - To prevent network connectivity issues, do not install a single-stack IPv4 cluster on a host that supports dual-stack networking.

If you configure your cluster to use both IP address families, review the following requirements:

- Both IP families must use the same network interface for the default gateway.
- Both IP families must have the default gateway.
- You must specify IPv4 and IPv6 addresses in the same order for all network configuration parameters. For example, in the following configuration IPv4 addresses are listed before IPv6 addresses.

```

networking:
  clusterNetwork:
    - cidr: 10.128.0.0/14
      hostPrefix: 23
    - cidr: fd00:10:128::/56
      hostPrefix: 64
  serviceNetwork:
    - 172.30.0.0/16
    - fd00:172:16::/112

```

**Table 2.42. Network parameters**

Parameter	Description	Values
networking:	The configuration for the cluster network.	<p>Object</p>  <p><b>NOTE</b></p> <p>You cannot modify parameters specified by the <b>networking</b> object after installation.</p>
networking: networkType:	The Red Hat OpenShift Networking network plugin to install.	<b>OVNKubernetes.</b> <b>OVNKubernetes</b> is a CNI plugin for Linux networks and hybrid networks that contain both Linux and Windows servers. The default value is <b>OVNKubernetes</b> .
networking: clusterNetwork:	<p>The IP address blocks for pods.</p> <p>The default value is <b>10.128.0.0/14</b> with a host prefix of <b>/23</b>.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre> networking:   clusterNetwork:     - cidr: 10.128.0.0/14       hostPrefix: 23     - cidr: fd01::/48       hostPrefix: 64 </pre>

Parameter	Description	Values
networking: clusterNetwork: cidr:	<p>Required if you use <b>networking.clusterNetwork</b>. An IP address block.</p> <p>If you use the OVN-Kubernetes network plugin, you can specify IPv4 and IPv6 networks.</p>	An IP address block in Classless Inter-Domain Routing (CIDR) notation. The prefix length for an IPv4 block is between <b>0</b> and <b>32</b> . The prefix length for an IPv6 block is between <b>0</b> and <b>128</b> . For example, <b>10.128.0.0/14</b> or <b>fd01::/48</b> .
networking: clusterNetwork: hostPrefix:	The subnet prefix length to assign to each individual node. For example, if <b>hostPrefix</b> is set to <b>23</b> then each node is assigned a /23 subnet out of the given <b>cidr</b> . A <b>hostPrefix</b> value of <b>23</b> provides 510 ( $2^{(32 - 23)} - 2$ ) pod IP addresses.	<p>A subnet prefix.</p> <p>For an IPv4 network the default value is <b>23</b>. For an IPv6 network the default value is <b>64</b>. The default value is also the minimum value for IPv6.</p>
networking: serviceNetwork:	<p>The IP address block for services. The default value is <b>172.30.0.0/16</b>.</p> <p>The OVN-Kubernetes network plugin supports only a single IP address block for the service network.</p> <p>If you use the OVN-Kubernetes network plugin, you can specify an IP address block for both of the IPv4 and IPv6 address families.</p>	<p>An array with an IP address block in CIDR format. For example:</p> <pre>networking: serviceNetwork: - 172.30.0.0/16 - fd02::/12</pre>
networking: machineNetwork:	<p>The IP address blocks for machines.</p> <p>If you specify multiple IP address blocks, the blocks must not overlap.</p>	<p>An array of objects. For example:</p> <pre>networking: machineNetwork: - cidr: 10.0.0.0/16</pre>
networking: machineNetwork: cidr:	<p>Required if you use <b>networking.machineNetwork</b>. An IP address block. The default value is <b>10.0.0.0/16</b> for all platforms other than libvirt and IBM Power® Virtual Server. For libvirt, the default value is <b>192.168.126.0/24</b>. For IBM Power® Virtual Server, the default value is <b>192.168.0.0/24</b>.</p>	<p>An IP network block in CIDR notation.</p> <p>For example, <b>10.0.0.0/16</b> or <b>fd00::/48</b>.</p>  <p><b>NOTE</b></p> <p>Set the <b>networking.machineNetwork</b> to match the CIDR that the preferred NIC resides in.</p>

Parameter	Description	Values
networking: ovnKubernetesConfig: ipv4: internalJoinSubnet:	Configures the IPv4 join subnet that is used internally by <b>ovn-kubernetes</b> . This subnet must not overlap with any other subnet that OpenShift Container Platform is using, including the node network. The size of the subnet must be larger than the number of nodes. You cannot change the value after installation.	An IP network block in CIDR notation. The default value is <b>100.64.0.0/16</b> .

### 2.5.1.3. Optional configuration parameters

Optional installation configuration parameters are described in the following table:

**Table 2.43. Optional parameters**

Parameter	Description	Values
additionalTrustBundle:	A PEM-encoded X.509 certificate bundle that is added to the nodes' trusted certificate store. This trust bundle may also be used when a proxy has been configured.	String
capabilities:	Controls the installation of optional core cluster components. You can reduce the footprint of your OpenShift Container Platform cluster by disabling optional components. For more information, see the "Cluster capabilities" page in <i>Installing</i> .	String array
capabilities: baselineCapabilitySet:	Selects an initial set of optional capabilities to enable. Valid values are <b>None</b> , <b>v4.11</b> , <b>v4.12</b> and <b>vCurrent</b> . The default value is <b>vCurrent</b> .	String
capabilities: additionalEnabledCapabilities:	Extends the set of optional capabilities beyond what you specify in <b>baselineCapabilitySet</b> . You may specify multiple capabilities in this parameter.	String array

Parameter	Description	Values
cpuPartitioningMode:	<p>Enables workload partitioning, which isolates OpenShift Container Platform services, cluster management workloads, and infrastructure pods to run on a reserved set of CPUs.</p> <p>Workload partitioning can only be enabled during installation and cannot be disabled after installation. While this field enables workload partitioning, it does not configure workloads to use specific CPUs. For more information, see the <a href="#">Workload partitioning</a> page in the <i>Scalability and Performance</i> section.</p>	<b>None</b> or <b>AllNodes</b> . <b>None</b> is the default value.
compute:	The configuration for the machines that comprise the compute nodes.	Array of <b>MachinePool</b> objects.
compute:architecture:	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are <b>amd64</b> and <b>arm64</b> .	String
compute:hyperthreading:	<p>Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b>, on compute machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.</p> <div> </div> <p><b>IMPORTANT</b></p> <p>If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.</p>	<b>Enabled</b> or <b>Disabled</b>
compute:name:	Required if you use <b>compute</b> . The name of the machine pool.	<b>worker</b>

Parameter	Description	Values
compute:platform:	Required if you use <b>compute</b> . Use this parameter to specify the cloud provider to host the worker machines. This parameter value must match the <b>controlPlane.platform</b> parameter value.	<b>aws, azure, gcp, ibmcloud, nutanix, openstack, powervs, vsphere, or {}</b>
compute:replicas:	The number of compute machines, which are also known as worker machines, to provision.	A positive integer greater than or equal to <b>2</b> . The default value is <b>3</b> .
featureSet:	Enables the cluster for a feature set. A feature set is a collection of OpenShift Container Platform features that are not enabled by default. For more information about enabling a feature set during installation, see "Enabling features using feature gates".	String. The name of the feature set to enable, such as <b>TechPreviewNoUpgrade</b> .
controlPlane:	The configuration for the machines that comprise the control plane.	Array of <b>MachinePool</b> objects.
controlPlane:architecture:	Determines the instruction set architecture of the machines in the pool. Currently, clusters with varied architectures are not supported. All pools must specify the same architecture. Valid values are <b>amd64</b> and <b>arm64</b> .	String
controlPlane:hyperthreading:	Whether to enable or disable simultaneous multithreading, or <b>hyperthreading</b> , on control plane machines. By default, simultaneous multithreading is enabled to increase the performance of your machines' cores.	<b>Enabled</b> or <b>Disabled</b>

**IMPORTANT**

If you disable simultaneous multithreading, ensure that your capacity planning accounts for the dramatically decreased machine performance.

Parameter	Description	Values
controlPlane: name:	Required if you use <b>controlPlane</b> . The name of the machine pool.	<b>master</b>
controlPlane: platform:	Required if you use <b>controlPlane</b> . Use this parameter to specify the cloud provider that hosts the control plane machines. This parameter value must match the <b>compute.platform</b> parameter value.	<b>aws, azure, gcp, ibmcloud, nutanix, openstack, powervs, vsphere, or {}</b>
controlPlane: replicas:	The number of control plane machines to provision.	Supported values are <b>3</b> , or <b>1</b> when deploying single-node OpenShift.
credentialsMode:	The Cloud Credential Operator (CCO) mode. If no mode is specified, the CCO dynamically tries to determine the capabilities of the provided credentials, with a preference for mint mode on the platforms where multiple modes are supported.	<b>Mint, Passthrough, Manual</b> or an empty string ("").
fips:	<p>Enable or disable FIPS mode. The default is <b>false</b> (disabled). If FIPS mode is enabled, the Red Hat Enterprise Linux CoreOS (RHCOS) machines that OpenShift Container Platform runs on bypass the default Kubernetes cryptography suite and use the cryptography modules that are provided with RHCOS instead.</p>  <p><b>NOTE</b></p> <p>Not all CCO modes are supported for all cloud providers. For more information about CCO modes, see the "Managing cloud provider credentials" entry in the <i>Authentication and authorization</i> content.</p>	<b>false or true</b>

Parameter	Description	IMPORTANT	Values
		<p>To enable FIPS mode for your cluster, you must run the installation program from a Red Hat Enterprise Linux (RHEL) computer configured to operate in FIPS mode. For more information about configuring FIPS mode on RHEL, see <a href="#">Switching RHEL to FIPS mode</a>.</p> <p>When running Red Hat Enterprise Linux (RHEL) or Red Hat Enterprise Linux CoreOS (RHCOS) booted in FIPS mode, OpenShift Container Platform core components use the RHEL cryptographic libraries that have been submitted to NIST for FIPS 140-2/140-3 Validation on only the x86_64, ppc64le, and s390x architectures.</p>	

#### NOTE

If you are using Azure File storage, you cannot enable FIPS mode.

Parameter	Description	Values
imageContentSources:	Sources and repositories for the release-image content.	Array of objects. Includes a <b>source</b> and, optionally, <b>mirrors</b> , as described in the following rows of this table.
imageContentSources: source:	Required if you use <b>imageContentSources</b> . Specify the repository that users refer to, for example, in image pull specifications.	String
imageContentSources: mirrors:	Specify one or more repositories that may also contain the same images.	Array of strings
publish:	How to publish or expose the user-facing endpoints of your cluster, such as the Kubernetes API, OpenShift routes.	<p><b>Internal</b> or <b>External</b>. The default value is <b>External</b>.</p> <p>Setting this field to <b>Internal</b> is not supported on non-cloud platforms.</p>  <p><b>IMPORTANT</b></p> <p>If the value of the field is set to <b>Internal</b>, the cluster will become non-functional. For more information, refer to <a href="#">BZ#1953035</a>.</p>
sshKey:	The SSH key to authenticate access to your cluster machines.	<p>For example, <b>sshKey: ssh-ed25519 AAAA...</b></p>  <p><b>NOTE</b></p> <p>For production OpenShift Container Platform clusters on which you want to perform installation debugging or disaster recovery, specify an SSH key that your <b>ssh-agent</b> process uses.</p>

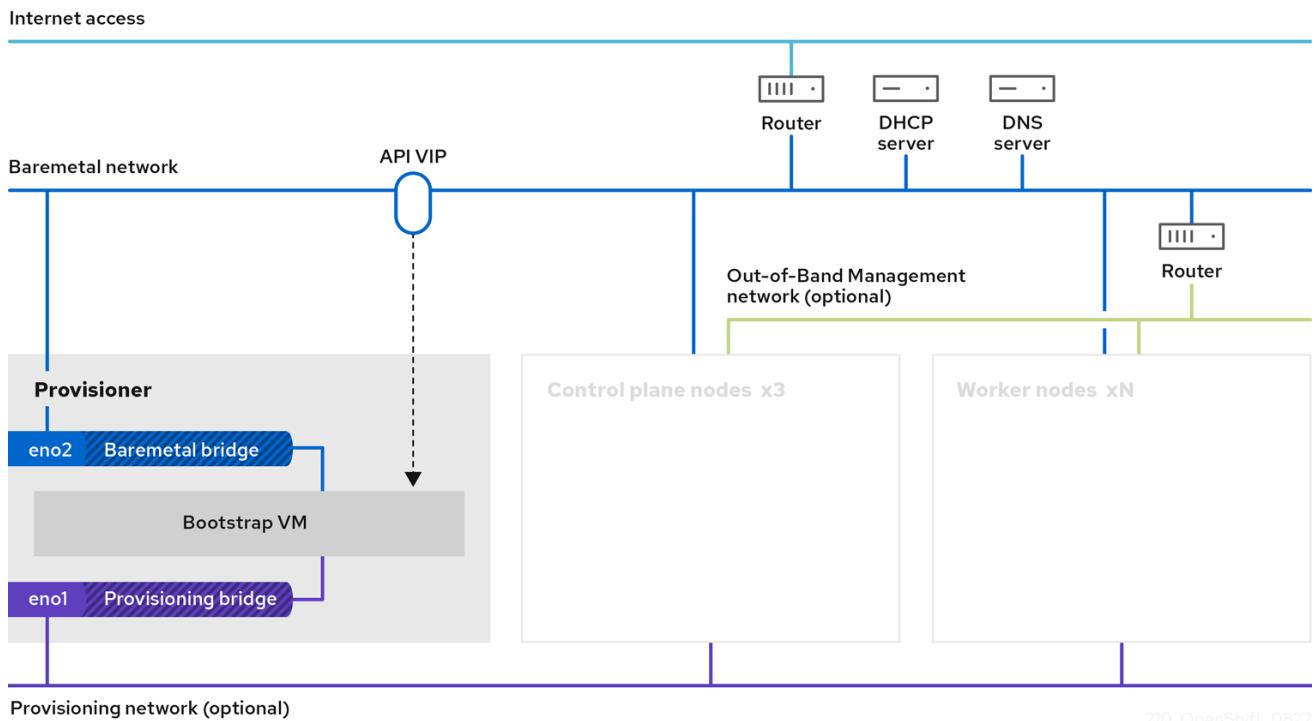
## Additional resources

- [OVN-Kubernetes IPv6 and dual-stack limitations](#)

# CHAPTER 3. INSTALLER-PROVISIONED INFRASTRUCTURE

## 3.1. OVERVIEW

Installer-provisioned installation on bare metal nodes deploys and configures the infrastructure that an OpenShift Container Platform cluster runs on. This guide provides a methodology to achieving a successful installer-provisioned bare-metal installation. The following diagram illustrates the installation environment in phase 1 of deployment:



For the installation, the key elements in the previous diagram are:

- **Provisioner:** A physical machine that runs the installation program and hosts the bootstrap VM that deploys the control plane of a new OpenShift Container Platform cluster.
- **Bootstrap VM:** A virtual machine used in the process of deploying an OpenShift Container Platform cluster.
- **Network bridges:** The bootstrap VM connects to the bare metal network and to the provisioning network, if present, via network bridges, **eno1** and **eno2**.
- **API VIP:** An API virtual IP address (VIP) is used to provide failover of the API server across the control plane nodes. The API VIP first resides on the bootstrap VM. A script generates the **keepalived.conf** configuration file before launching the service. The VIP moves to one of the control plane nodes after the bootstrap process has completed and the bootstrap VM stops.

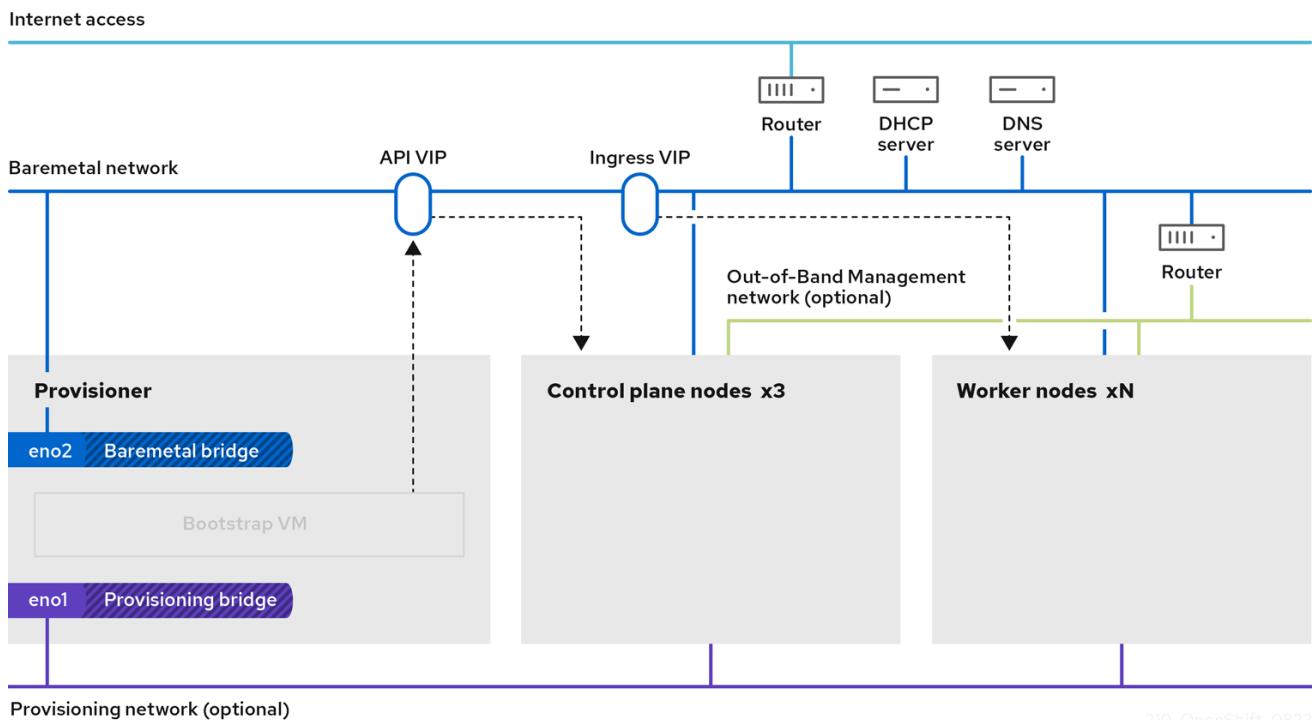
In phase 2 of the deployment, the provisioner destroys the bootstrap VM automatically and moves the virtual IP addresses (VIPs) to the appropriate nodes.

The **keepalived.conf** file sets the control plane machines with a lower Virtual Router Redundancy Protocol (VRRP) priority than the bootstrap VM, which ensures that the API on the control plane machines is fully functional before the API VIP moves from the bootstrap VM to the control plane. Once

the API VIP moves to one of the control plane nodes, traffic sent from external clients to the API VIP routes to an **haproxy** load balancer running on that control plane node. This instance of **haproxy** load balances the API VIP traffic across the control plane nodes.

The Ingress VIP moves to the compute nodes. The **keepalived** instance also manages the Ingress VIP.

The following diagram illustrates phase 2 of deployment:



After this point, the node used by the provisioner can be removed or repurposed. From here, all additional provisioning tasks are carried out by the control plane.



### NOTE

For installer-provisioned infrastructure installations, CoreDNS exposes port 53 at the node level, making it accessible from other routable networks.

### Additional resources

- [Using DNS forwarding](#)



### IMPORTANT

The provisioning network is optional, but it is required for PXE booting. If you deploy without a provisioning network, you must use a virtual media baseboard management controller (BMC) addressing option such as **redfish-virtualmedia** or **idrac-virtualmedia**.

## 3.2. PREREQUISITES

Installer-provisioned installation of OpenShift Container Platform requires:

1. One provisioner node with Red Hat Enterprise Linux (RHEL) 9.x installed. The provisioner can be removed after installation.

2. Three control plane nodes
3. Baseboard management controller (BMC) access to each node
4. At least one network:
  - a. One required routable network
  - b. One optional provisioning network
  - c. One optional management network

Before starting an installer-provisioned installation of OpenShift Container Platform, ensure the hardware environment meets the following requirements.

### 3.2.1. Node requirements

Installer-provisioned installation involves a number of hardware node requirements:

- **CPU architecture:** All nodes must use **x86\_64** or **aarch64** CPU architecture.
- **Similar nodes:** Red Hat recommends nodes have an identical configuration per role. That is, Red Hat recommends nodes be the same brand and model with the same CPU, memory, and storage configuration.
- **Baseboard Management Controller:** The **provisioner** node must be able to access the baseboard management controller (BMC) of each OpenShift Container Platform cluster node. You may use IPMI, Redfish, or a proprietary protocol.
- **Latest generation:** Nodes must be of the most recent generation. Installer-provisioned installation relies on BMC protocols, which must be compatible across nodes. Additionally, RHEL 9.x ships with the most recent drivers for RAID controllers. Ensure that the nodes are recent enough to support RHEL 9.x for the **provisioner** node and RHCOS 9.x for the control plane and worker nodes.
- **Registry node:** (Optional) If setting up a disconnected mirrored registry, it is recommended the registry reside in its own node.
- **Provisioner node:** Installer-provisioned installation requires one **provisioner** node.
- **Control plane:** Installer-provisioned installation requires three control plane nodes for high availability. You can deploy an OpenShift Container Platform cluster with only three control plane nodes, making the control plane nodes schedulable as worker nodes. Smaller clusters are more resource efficient for administrators and developers during development, production, and testing.
- **Worker nodes:** While not required, a typical production cluster has two or more worker nodes.



#### IMPORTANT

Do not deploy a cluster with only one worker node, because the cluster will deploy with routers and ingress traffic in a degraded state.

- **Network interfaces:** Each node must have at least one network interface for the routable **baremetal** network. Each node must have one network interface for a **provisioning** network when using the **provisioning** network for deployment. Using the **provisioning** network is the

default configuration.



### NOTE

Only one network card (NIC) on the same subnet can route traffic through the gateway. By default, Address Resolution Protocol (ARP) uses the lowest numbered NIC. Use a single NIC for each node in the same subnet to ensure that network load balancing works as expected. When using multiple NICs for a node in the same subnet, use a single bond or team interface. Then add the other IP addresses to that interface in the form of an alias IP address. If you require fault tolerance or load balancing at the network interface level, use an alias IP address on the bond or team interface. Alternatively, you can disable a secondary NIC on the same subnet or ensure that it has no IP address.

- **Unified Extensible Firmware Interface (UEFI):** Installer-provisioned installation requires UEFI boot on all OpenShift Container Platform nodes when using IPv6 addressing on the **provisioning** network. In addition, UEFI Device PXE Settings must be set to use the IPv6 protocol on the **provisioning** network NIC, but omitting the **provisioning** network removes this requirement.



### IMPORTANT

When starting the installation from virtual media such as an ISO image, delete all old UEFI boot table entries. If the boot table includes entries that are not generic entries provided by the firmware, the installation might fail.

- **Secure Boot:** Many production scenarios require nodes with Secure Boot enabled to verify the node only boots with trusted software, such as UEFI firmware drivers, EFI applications, and the operating system. You may deploy with Secure Boot manually or managed.
  - Manually:** To deploy an OpenShift Container Platform cluster with Secure Boot manually, you must enable UEFI boot mode and Secure Boot on each control plane node and each worker node. Red Hat supports Secure Boot with manually enabled UEFI and Secure Boot only when installer-provisioned installations use Redfish virtual media. See "Configuring nodes for Secure Boot manually" in the "Configuring nodes" section for additional details.
  - Managed:** To deploy an OpenShift Container Platform cluster with managed Secure Boot, you must set the **bootMode** value to **UEFISecureBoot** in the **install-config.yaml** file. Red Hat only supports installer-provisioned installation with managed Secure Boot on 10th generation HPE hardware and 13th generation Dell hardware running firmware version **2.75.75.75** or greater. Deploying with managed Secure Boot does not require Redfish virtual media. See "Configuring managed Secure Boot" in the "Setting up the environment for an OpenShift installation" section for details.



### NOTE

Red Hat does not support managing self-generated keys, or other keys, for Secure Boot.

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

Each cluster machine must meet the following minimum requirements:

**Table 3.1. Minimum resource requirements**

Machine	Operating System	CPU [1]	RAM	Storage	Input/Output Per Second (IOPS) [2]
Bootstrap	RHEL	4	16 GB	100 GB	300
Control plane	RHCOS	4	16 GB	100 GB	300
Compute	RHCOS	2	8 GB	100 GB	300

1. One CPU is equivalent to one physical core when simultaneous multithreading (SMT), or Hyper-Threading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio: (threads per core × cores) × sockets = CPUs.
2. OpenShift Container Platform and Kubernetes are sensitive to disk performance, and faster storage is recommended, particularly for etcd on the control plane nodes. Note that on many cloud platforms, storage size and IOPS scale together, so you might need to over-allocate storage volume to obtain sufficient performance.



### NOTE

For OpenShift Container Platform version 4.18, RHCOS is based on RHEL version 9.4, which updates the micro-architecture requirements. The following list contains the minimum instruction set architectures (ISA) that each architecture requires:

- x86-64 architecture requires x86-64-v2 ISA
- ARM64 architecture requires ARMv8.0-A ISA
- IBM Power architecture requires Power 9 ISA
- s390x architecture requires z14 ISA

For more information, see [Architectures](#) (RHEL documentation).

If an instance type for your platform meets the minimum requirements for cluster machines, it is supported to use in OpenShift Container Platform.

### 3.2.3. Planning a bare metal cluster for OpenShift Virtualization

If you will use OpenShift Virtualization, it is important to be aware of several requirements before you install your bare metal cluster.

- If you want to use live migration features, you must have multiple worker nodes *at the time of cluster installation*. This is because live migration requires the cluster-level high availability (HA) flag to be set to true. The HA flag is set when a cluster is installed and cannot be changed afterwards. If there are fewer than two worker nodes defined when you install your cluster, the HA flag is set to false for the life of the cluster.

**NOTE**

You can install OpenShift Virtualization on a single-node cluster, but single-node OpenShift does not support high availability.

- Live migration requires shared storage. Storage for OpenShift Virtualization must support and use the ReadWriteMany (RWX) access mode.
- If you plan to use Single Root I/O Virtualization (SR-IOV), ensure that your network interface controllers (NICs) are supported by OpenShift Container Platform.

**Additional resources**

- [Preparing your cluster for OpenShift Virtualization](#)
- [About Single Root I/O Virtualization \(SR-IOV\) hardware networks](#)
- [Connecting a virtual machine to an SR-IOV network](#)

**3.2.4. Firmware requirements for installing with virtual media**

The installation program for installer-provisioned OpenShift Container Platform clusters validates the hardware and firmware compatibility with Redfish virtual media. The installation program does not begin installation on a node if the node firmware is not compatible. The following tables list the minimum firmware versions tested and verified to work for installer-provisioned OpenShift Container Platform clusters deployed by using Redfish virtual media.

**NOTE**

Red Hat does not test every combination of firmware, hardware, or other third-party components. For further information about third-party support, see [Red Hat third-party support policy](#). For information about updating the firmware, see the hardware documentation for the nodes or contact the hardware vendor.

**Table 3.2. Firmware compatibility for HP hardware with Redfish virtual media**

Model	Management	Firmware versions
11th Generation	iLO6	1.57 or later
10th Generation	iLO5	2.63 or later

**Table 3.3. Firmware compatibility for Dell hardware with Redfish virtual media**

Model	Management	Firmware versions
16th Generation	iDRAC 9	v7.10.70.00
15th Generation	iDRAC 9	v6.10.30.00, v7.10.50.00, and v7.10.70.00

Model	Management	Firmware versions
14th Generation	iDRAC 9	v6.10.30.00

**Table 3.4. Firmware compatibility for Cisco UCS hardware with Redfish virtual media**

Model	Management	Firmware versions
UCS X-Series servers	Intersight Managed Mode	5.2(2) or later
FI-Attached UCS C-Series servers	Intersight Managed Mode	4.3 or later
Standalone UCS C-Series servers	Standalone / Intersight	4.3 or later

**NOTE**

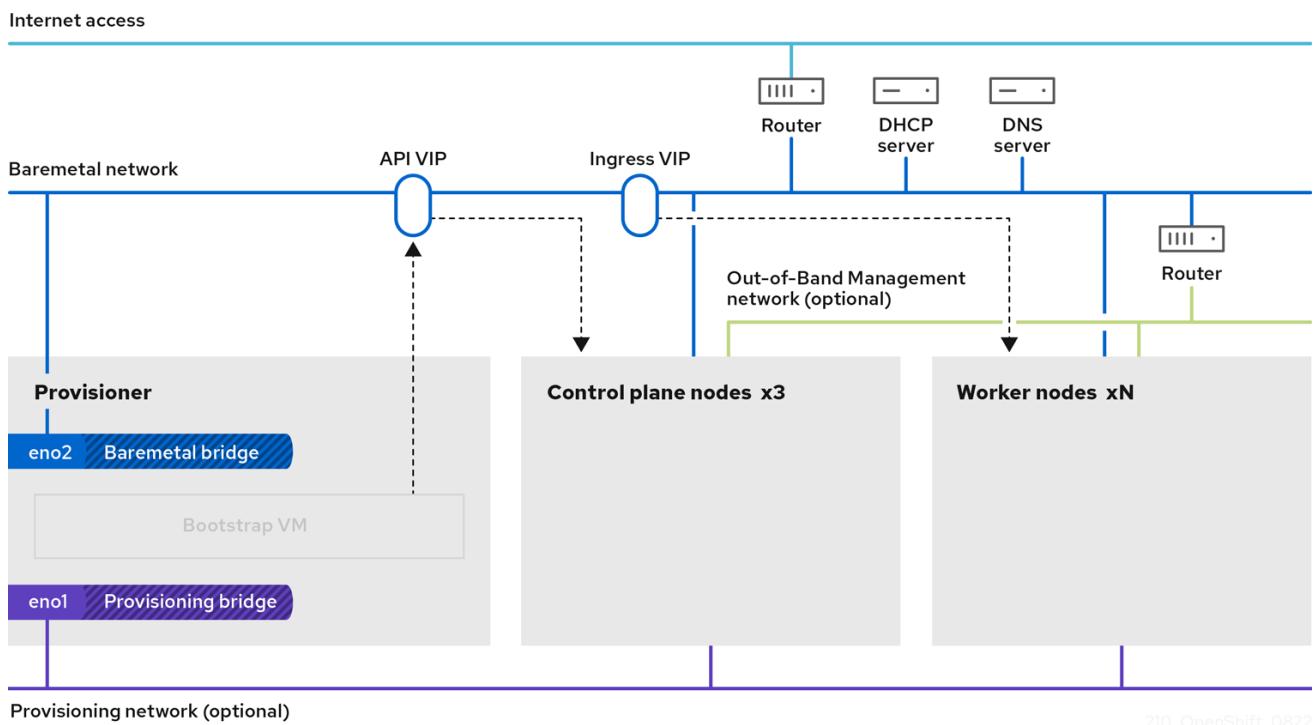
Always confirm that your server supports Red Hat Enterprise Linux CoreOS (RHCOS) on [UCSHCL](#).

**Additional resources**

[Unable to discover new bare metal hosts using the BMC](#)

**3.2.5. Network requirements**

Installer-provisioned installation of OpenShift Container Platform involves multiple network requirements. First, installer-provisioned installation involves an optional non-routable **provisioning** network for provisioning the operating system on each bare-metal node. Second, installer-provisioned installation involves a routable **baremetal** network.



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### 3.2.5.1. Ensuring required ports are open

Certain ports must be open between cluster nodes for installer-provisioned installations to complete successfully. In certain situations, such as using separate subnets for far edge worker nodes, you must ensure that the nodes in these subnets can communicate with nodes in the other subnets on the following required ports.

**Table 3.5. Required ports**

Port	Description
<b>67,68</b>	When using a provisioning network, cluster nodes access the <b>dnsmasq</b> DHCP server over their provisioning network interfaces using ports <b>67</b> and <b>68</b> .
<b>69</b>	When using a provisioning network, cluster nodes communicate with the TFTP server on port <b>69</b> using their provisioning network interfaces. The TFTP server runs on the bootstrap VM. The bootstrap VM runs on the provisioner node.
<b>80</b>	When not using the image caching option or when using virtual media, the provisioner node must have port <b>80</b> open on the <b>baremetal</b> machine network interface to stream the Red Hat Enterprise Linux CoreOS (RHCOS) image from the provisioner node to the cluster nodes.
<b>123</b>	The cluster nodes must access the NTP server on port <b>123</b> using the <b>baremetal</b> machine network.

Port	Description
<b>5050</b>	The Ironic Inspector API runs on the control plane nodes and listens on port <b>5050</b> . The Inspector API is responsible for hardware introspection, which collects information about the hardware characteristics of the bare-metal nodes.
<b>5051</b>	Port <b>5050</b> uses port <b>5051</b> as a proxy.
<b>6180</b>	When deploying with virtual media and not using TLS, the provisioner node and the control plane nodes must have port <b>6180</b> open on the <b>baremetal</b> machine network interface so that the baseboard management controller (BMC) of the worker nodes can access the RHCOS image. Starting with OpenShift Container Platform 4.13, the default HTTP port is <b>6180</b> .
<b>6183</b>	When deploying with virtual media and using TLS, the provisioner node and the control plane nodes must have port <b>6183</b> open on the <b>baremetal</b> machine network interface so that the BMC of the worker nodes can access the RHCOS image.
<b>6385</b>	The Ironic API server runs initially on the bootstrap VM and later on the control plane nodes and listens on port <b>6385</b> . The Ironic API allows clients to interact with Ironic for bare-metal node provisioning and management, including operations such as enrolling new nodes, managing their power state, deploying images, and cleaning the hardware.
<b>6388</b>	Port <b>6385</b> uses port <b>6388</b> as a proxy.
<b>8080</b>	When using image caching without TLS, port <b>8080</b> must be open on the provisioner node and accessible by the BMC interfaces of the cluster nodes.
<b>8083</b>	When using the image caching option with TLS, port <b>8083</b> must be open on the provisioner node and accessible by the BMC interfaces of the cluster nodes.
<b>9999</b>	By default, the Ironic Python Agent (IPA) listens on TCP port <b>9999</b> for API calls from the Ironic conductor service. Communication between the bare-metal node where IPA is running and the Ironic conductor service uses this port.

### 3.2.5.2. Increase the network MTU

Before deploying OpenShift Container Platform, increase the network maximum transmission unit (MTU) to 1500 or more. If the MTU is lower than 1500, the Ironic image that is used to boot the node might fail to communicate with the Ironic inspector pod, and inspection will fail. If this occurs, installation stops because the nodes are not available for installation.

### 3.2.5.3. Configuring NICs

OpenShift Container Platform deploys with two networks:

- **provisioning:** The **provisioning** network is an optional non-routable network used for provisioning the underlying operating system on each node that is a part of the OpenShift Container Platform cluster. The network interface for the **provisioning** network on each cluster node must have the BIOS or UEFI configured to PXE boot.

The **provisioningNetworkInterface** configuration setting specifies the **provisioning** network NIC name on the control plane nodes, which must be identical on the control plane nodes. The **bootMACAddress** configuration setting provides a means to specify a particular NIC on each node for the **provisioning** network.

The **provisioning** network is optional, but it is required for PXE booting. If you deploy without a **provisioning** network, you must use a virtual media BMC addressing option such as **redfish-virtualmedia** or **idrac-virtualmedia**.

- **baremetal:** The **baremetal** network is a routable network. You can use any NIC to interface with the **baremetal** network provided the NIC is not configured to use the **provisioning** network.



#### IMPORTANT

When using a VLAN, each NIC must be on a separate VLAN corresponding to the appropriate network.

### 3.2.5.4. DNS requirements

Clients access the OpenShift Container Platform cluster nodes over the **baremetal** network. A network administrator must configure a subdomain or subzone where the canonical name extension is the cluster name.

`<cluster_name>.<base_domain>`

For example:

`test-cluster.example.com`

OpenShift Container Platform includes functionality that uses cluster membership information to generate A/AAAA records. This resolves the node names to their IP addresses. After the nodes are registered with the API, the cluster can disperse node information without using CoreDNS-mDNS. This eliminates the network traffic associated with multicast DNS.

CoreDNS requires both TCP and UDP connections to the upstream DNS server to function correctly. Ensure the upstream DNS server can receive both TCP and UDP connections from OpenShift Container Platform cluster nodes.

In OpenShift Container Platform deployments, DNS name resolution is required for the following components:

- The Kubernetes API

- The OpenShift Container Platform application wildcard ingress API

A/AAAA records are used for name resolution and PTR records are used for reverse name resolution. Red Hat Enterprise Linux CoreOS (RHCOS) uses the reverse records or DHCP to set the hostnames for all the nodes.

Installer-provisioned installation includes functionality that uses cluster membership information to generate A/AAAA records. This resolves the node names to their IP addresses. In each record, **<cluster\_name>** is the cluster name and **<base\_domain>** is the base domain that you specify in the **install-config.yaml** file. A complete DNS record takes the form: **<component>. <cluster\_name>. <base\_domain>..**

**Table 3.6. Required DNS records**

Component	Record	Description
Kubernetes API	<b>api.&lt;cluster_name&gt;. &lt;base_domain&gt;.</b>	An A/AAAA record and a PTR record identify the API load balancer. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.
Routes	<b>*.apps.&lt;cluster_name&gt;. &lt;base_domain&gt;.</b>	The wildcard A/AAAA record refers to the application ingress load balancer. The application ingress load balancer targets the nodes that run the Ingress Controller pods. The Ingress Controller pods run on the worker nodes by default. These records must be resolvable by both clients external to the cluster and from all the nodes within the cluster.  For example, <b>console-openshift-console.apps. &lt;cluster_name&gt;. &lt;base_domain&gt;</b> is used as a wildcard route to the OpenShift Container Platform console.

## TIP

You can use the **dig** command to verify DNS resolution.

### 3.2.5.5. Dynamic Host Configuration Protocol (DHCP) requirements

By default, installer-provisioned installation deploys **ironic-dnsmasq** with DHCP enabled for the **provisioning** network. No other DHCP servers should be running on the **provisioning** network when the **provisioningNetwork** configuration setting is set to **managed**, which is the default value. If you have a DHCP server running on the **provisioning** network, you must set the **provisioningNetwork** configuration setting to **unmanaged** in the **install-config.yaml** file.

Network administrators must reserve IP addresses for each node in the OpenShift Container Platform cluster for the **baremetal** network on an external DHCP server.

### 3.2.5.6. Reserving IP addresses for nodes with the DHCP server

For the **baremetal** network, a network administrator must reserve several IP addresses, including:

1. Two unique virtual IP addresses.

- One virtual IP address for the API endpoint.
  - One virtual IP address for the wildcard ingress endpoint.
2. One IP address for the provisioner node.
  3. One IP address for each control plane node.
  4. One IP address for each worker node, if applicable.



## RESERVING IP ADDRESSES SO THEY BECOME STATIC IP ADDRESSES

Some administrators prefer to use static IP addresses so that each node's IP address remains constant in the absence of a DHCP server. To configure static IP addresses with NMState, see "(Optional) Configuring node network interfaces" in the "Setting up the environment for an OpenShift installation" section.



## NETWORKING BETWEEN EXTERNAL LOAD BALANCERS AND CONTROL PLANE NODES

External load balancing services and the control plane nodes must run on the same L2 network, and on the same VLAN when using VLANs to route traffic between the load balancing services and the control plane nodes.



### IMPORTANT

The storage interface requires a DHCP reservation or a static IP.

The following table provides an exemplary embodiment of fully qualified domain names. The API and name server addresses begin with canonical name extensions. The hostnames of the control plane and worker nodes are exemplary, so you can use any host naming convention you prefer.

Usage	Host Name	IP
API	<code>api.&lt;cluster_name&gt;.&lt;base_domain&gt;</code>	<ip>
Ingress LB (apps)	<code>*.apps.&lt;cluster_name&gt;.&lt;base_domain&gt;</code>	<ip>
Provisioner node	<code>provisioner.&lt;cluster_name&gt;.&lt;base_domain&gt;</code>	<ip>
Control-plane-0	<code>openshift-control-plane-0.&lt;cluster_name&gt;.&lt;base_domain&gt;</code>	<ip>
Control-plane-1	<code>openshift-control-plane-1.&lt;cluster_name&gt;.&lt;base_domain&gt;</code>	<ip>
Control-plane-2	<code>openshift-control-plane-2.&lt;cluster_name&gt;.&lt;base_domain&gt;</code>	<ip>
Worker-0	<code>openshift-worker-0.&lt;cluster_name&gt;.&lt;base_domain&gt;</code>	<ip>

Usage	Host Name	IP
Worker-1	<b>openshift-worker-1.&lt;cluster_name&gt;. &lt;base_domain&gt;</b>	<ip>
Worker-n	<b>openshift-worker-n.&lt;cluster_name&gt;. &lt;base_domain&gt;</b>	<ip>



#### NOTE

If you do not create DHCP reservations, the installation program requires reverse DNS resolution to set the hostnames for the Kubernetes API node, the provisioner node, the control plane nodes, and the worker nodes.

#### 3.2.5.7. Provisioner node requirements

You must specify the MAC address for the provisioner node in your installation configuration. The **bootMacAddress** specification is typically associated with PXE network booting. However, the Ironic provisioning service also requires the **bootMacAddress** specification to identify nodes during the inspection of the cluster, or during node redeployment in the cluster.

The provisioner node requires layer 2 connectivity for network booting, DHCP and DNS resolution, and local network communication. The provisioner node requires layer 3 connectivity for virtual media booting.

#### 3.2.5.8. Network Time Protocol (NTP)

Each OpenShift Container Platform node in the cluster must have access to an NTP server. OpenShift Container Platform nodes use NTP to synchronize their clocks. For example, cluster nodes use SSL/TLS certificates that require validation, which might fail if the date and time between the nodes are not in sync.



#### IMPORTANT

Define a consistent clock date and time format in each cluster node's BIOS settings, or installation might fail.

You can reconfigure the control plane nodes to act as NTP servers on disconnected clusters, and reconfigure worker nodes to retrieve time from the control plane nodes.

#### 3.2.5.9. Port access for the out-of-band management IP address

The out-of-band management IP address is on a separate network from the node. To ensure that the out-of-band management can communicate with the provisioner node during installation, the out-of-band management IP address must be granted access to port **6180** on the provisioner node and on the OpenShift Container Platform control plane nodes. TLS port **6183** is required for virtual media installation, for example, by using Redfish.

#### Additional resources

- Using DNS forwarding

### 3.2.6. Configuring nodes

#### Configuring nodes when using the provisioning network

Each node in the cluster requires the following configuration for proper installation.



#### WARNING

A mismatch between nodes will cause an installation failure.

While the cluster nodes can contain more than two NICs, the installation process only focuses on the first two NICs. In the following table, NIC1 is a non-routable network (**provisioning**) that is only used for the installation of the OpenShift Container Platform cluster.

NIC	Network	VLAN
NIC1	<b>provisioning</b>	<provisioning_vlan>
NIC2	<b>baremetal</b>	<baremetal_vlan>

The Red Hat Enterprise Linux (RHEL) 9.x installation process on the provisioner node might vary. To install Red Hat Enterprise Linux (RHEL) 9.x using a local Satellite server or a PXE server, PXE-enable NIC2.

PXE	Boot order
NIC1 PXE-enabled <b>provisioning</b> network	1
NIC2 <b>baremetal</b> network. PXE-enabled is optional.	2



#### NOTE

Ensure PXE is disabled on all other NICs.

Configure the control plane and worker nodes as follows:

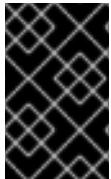
PXE	Boot order
NIC1 PXE-enabled (provisioning network)	1

#### Configuring nodes without the provisioning network

The installation process requires one NIC:

NIC	Network	VLAN
NICx	<b>baremetal</b>	<baremetal_vlan>

NICx is a routable network (**baremetal**) that is used for the installation of the OpenShift Container Platform cluster, and routable to the internet.



### IMPORTANT

The **provisioning** network is optional, but it is required for PXE booting. If you deploy without a **provisioning** network, you must use a virtual media BMC addressing option such as **redfish-virtualmedia** or **idrac-virtualmedia**.

### Configuring nodes for Secure Boot manually

Secure Boot prevents a node from booting unless it verifies the node is using only trusted software, such as UEFI firmware drivers, EFI applications, and the operating system.



### NOTE

Red Hat only supports manually configured Secure Boot when deploying with Redfish virtual media.

To enable Secure Boot manually, refer to the hardware guide for the node and execute the following:

### Procedure

1. Boot the node and enter the BIOS menu.
2. Set the node's boot mode to **UEFI Enabled**.
3. Enable Secure Boot.



### IMPORTANT

Red Hat does not support Secure Boot with self-generated keys.

### 3.2.7. Out-of-band management

Nodes typically have an additional NIC used by the baseboard management controllers (BMCs). These BMCs must be accessible from the provisioner node.

Each node must be accessible via out-of-band management. When using an out-of-band management network, the provisioner node requires access to the out-of-band management network for a successful OpenShift Container Platform installation.

The out-of-band management setup is out of scope for this document. Using a separate management network for out-of-band management can enhance performance and improve security. However, using the provisioning network or the bare metal network are valid options.



## NOTE

The bootstrap VM features a maximum of two network interfaces. If you configure a separate management network for out-of-band management, and you are using a provisioning network, the bootstrap VM requires routing access to the management network through one of the network interfaces. In this scenario, the bootstrap VM can then access three networks:

- the bare metal network
- the provisioning network
- the management network routed through one of the network interfaces

### 3.2.8. Required data for installation

Prior to the installation of the OpenShift Container Platform cluster, gather the following information from all cluster nodes:

- Out-of-band management IP
  - Examples
    - Dell (iDRAC) IP
    - HP (iLO) IP
    - Fujitsu (iRMC) IP

#### When using the **provisioning** network

- NIC (**provisioning**) MAC address
- NIC (**baremetal**) MAC address

#### When omitting the **provisioning** network

- NIC (**baremetal**) MAC address

### 3.2.9. Validation checklist for nodes

#### When using the **provisioning** network

- NIC1 VLAN is configured for the **provisioning** network.
- NIC1 for the **provisioning** network is PXE-enabled on the provisioner, control plane, and worker nodes.
- NIC2 VLAN is configured for the **baremetal** network.
- PXE has been disabled on all other NICs.
- DNS is configured with API and Ingress endpoints.
- Control plane and worker nodes are configured.

- All nodes accessible via out-of-band management.
- (Optional) A separate management network has been created.
- Required data for installation.

#### When omitting the provisioning network

- NIC1 VLAN is configured for the **baremetal** network.
- DNS is configured with API and Ingress endpoints.
- Control plane and worker nodes are configured.
- All nodes accessible via out-of-band management.
- (Optional) A separate management network has been created.
- Required data for installation.

### 3.3. SETTING UP THE ENVIRONMENT FOR AN OPENSHIFT INSTALLATION

#### 3.3.1. Installing RHEL on the provisioner node

With the configuration of the prerequisites complete, the next step is to install RHEL 9.x on the provisioner node. The installer uses the provisioner node as the orchestrator while installing the OpenShift Container Platform cluster. For the purposes of this document, installing RHEL on the provisioner node is out of scope. However, options include but are not limited to using a RHEL Satellite server, PXE, or installation media.

#### 3.3.2. Preparing the provisioner node for OpenShift Container Platform installation

Perform the following steps to prepare the environment.

##### Procedure

1. Log in to the provisioner node via **ssh**.
2. Create a non-root user (**kni**) and provide that user with **sudo** privileges:

```
# useradd kni  
  
# passwd kni  
  
# echo "kni ALL=(root) NOPASSWD:ALL" | tee -a /etc/sudoers.d/kni  
  
# chmod 0440 /etc/sudoers.d/kni
```

3. Create an **ssh** key for the new user:

```
# su - kni -c "ssh-keygen -t ed25519 -f /home/kni/.ssh/id_rsa -N ""
```

4. Log in as the new user on the provisioner node:

```
# su - kni
```

5. Use Red Hat Subscription Manager to register the provisioner node:

```
$ sudo subscription-manager register --username=<user> --password=<pass> --auto-attach
```

```
$ sudo subscription-manager repos --enable=rhel-9-for-<architecture>-appstream-rpms --enable=rhel-9-for-<architecture>-baseos-rpms
```



#### NOTE

For more information about Red Hat Subscription Manager, see [Registering a RHEL system with command-line tools](#).

6. Install the following packages:

```
$ sudo dnf install -y libvirt qemu-kvm mkisofs python3-devel jq ipmitool
```

7. Modify the user to add the **libvirt** group to the newly created user:

```
$ sudo usermod --append --groups libvirt <user>
```

8. Restart **firewalld** and enable the **http** service:

```
$ sudo systemctl start firewalld
```

```
$ sudo firewall-cmd --zone=public --add-service=http --permanent
```

```
$ sudo firewall-cmd --reload
```

9. Start the modular **libvirt** daemon sockets:

```
$ for drv in qemu interface network nodedev nwfilter secret storage; do sudo systemctl start virt${drv}d{,-ro,-admin}.socket; done
```

10. Create the **default** storage pool and start it:

```
$ sudo virsh pool-define-as --name default --type dir --target /var/lib/libvirt/images
```

```
$ sudo virsh pool-start default
```

```
$ sudo virsh pool-autostart default
```

11. Create a **pull-secret.txt** file:

```
$ vim pull-secret.txt
```

In a web browser, navigate to [Install OpenShift on Bare Metal with installer-provisioned infrastructure](#). Click **Copy pull secret**. Paste the contents into the **pull-secret.txt** file and save the contents in the **kni** user's home directory.

### 3.3.3. Checking NTP server synchronization

The OpenShift Container Platform installation program installs the **chrony** Network Time Protocol (NTP) service on the cluster nodes. To complete installation, each node must have access to an NTP time server. You can verify NTP server synchronization by using the **chrony** service.

For disconnected clusters, you must configure the NTP servers on the control plane nodes. For more information see the *Additional resources* section.

#### Prerequisites

- You installed the **chrony** package on the target node.

#### Procedure

1. Log in to the node by using the **ssh** command.
2. View the NTP servers available to the node by running the following command:

```
$ chronyc sources
```

#### Example output

MS Name/IP address	Stratum	Poll	Reach	LastRx	Last sample
time.cloudflare.com	3	10	377	187	-209us[-209us] +/- 32ms
t1.time.ir2.yahoo.com	2	10	377	185	-4382us[-4382us] +/- 23ms
time.cloudflare.com	3	10	377	198	-996us[-1220us] +/- 33ms
brenbox.westnet.ie	1	10	377	193	-9538us[-9761us] +/- 24ms

3. Use the **ping** command to ensure that the node can access an NTP server, for example:

```
$ ping time.cloudflare.com
```

#### Example output

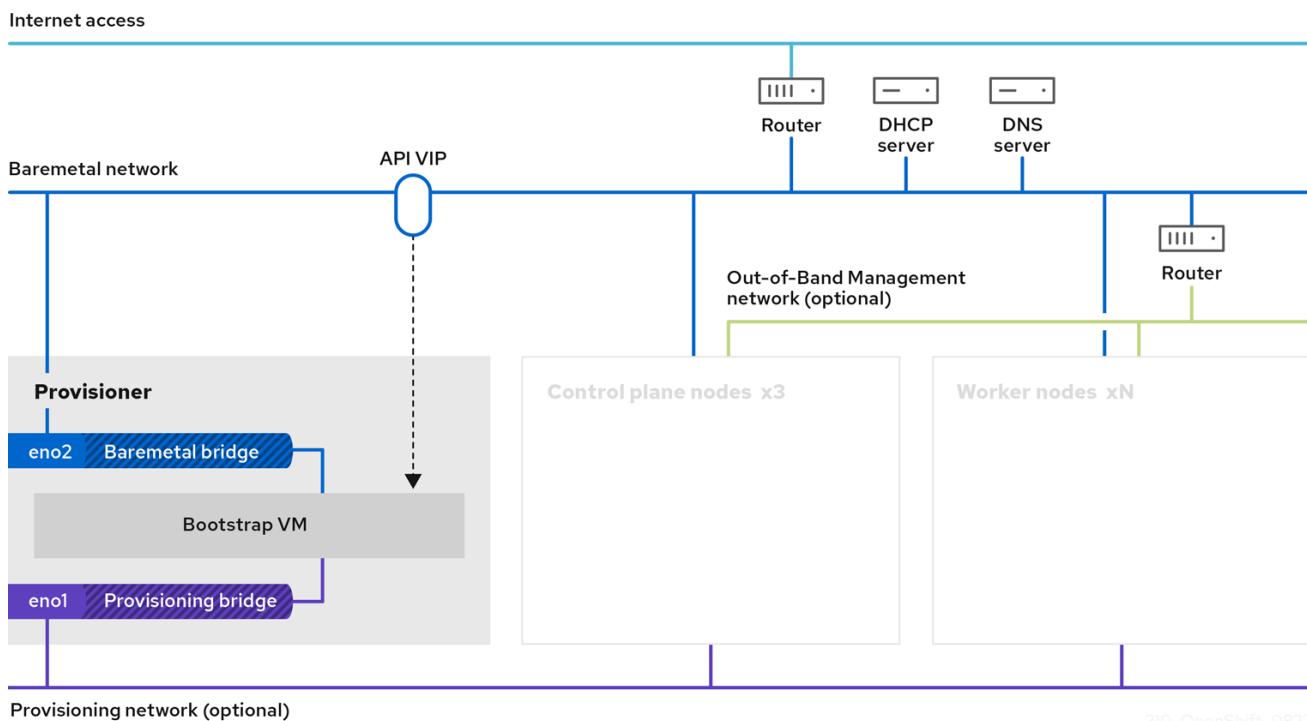
```
PING time.cloudflare.com (162.159.200.123) 56(84) bytes of data.  
64 bytes from time.cloudflare.com (162.159.200.123): icmp_seq=1 ttl=54 time=32.3 ms  
64 bytes from time.cloudflare.com (162.159.200.123): icmp_seq=2 ttl=54 time=30.9 ms  
64 bytes from time.cloudflare.com (162.159.200.123): icmp_seq=3 ttl=54 time=36.7 ms  
...
```

#### Additional resources

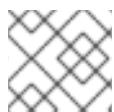
- [Optional: Configuring NTP for disconnected clusters](#)
- [Network Time Protocol \(NTP\)](#)

### 3.3.4. Configuring networking

Before installation, you must configure the networking on the provisioner node. Installer-provisioned clusters deploy with a bare-metal bridge and network, and an optional provisioning bridge and network.



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#### NOTE

You can also configure networking from the web console.

#### Procedure

1. Export the bare-metal network NIC name by running the following command:

```
$ export PUB_CONN=<baremetal_nic_name>
```

2. Configure the bare-metal network:



#### NOTE

The SSH connection might disconnect after executing these steps.

- a. For a network using DHCP, run the following command:

```
$ sudo nohup bash -c "
nmcli con down \"\$PUB_CONN\"
nmcli con delete \"\$PUB_CONN\"
# RHEL 8.1 appends the word \"System\" in front of the connection, delete in case it
exists
nmcli con down \"System \$PUB_CONN\"
nmcli con delete \"System \$PUB_CONN\"
nmcli connection add ifname baremetal type bridge <con_name> baremetal bridge.stp
"
```

no ①

```
nmcli con add type bridge-slave ifname "\"$PUB_CONN\"" master baremetal
pkkill dhclient;dhclient baremetal
"
```

① Replace <con\_name> with the connection name.

b. For a network using static IP addressing and no DHCP network, run the following command:

```
$ sudo nohup bash -c "
nmcli con down \"\$PUB_CONN\"
nmcli con delete \"\$PUB_CONN\"
# RHEL 8.1 appends the word \"System\" in front of the connection, delete in case it
exists
nmcli con down \"System \$PUB_CONN\"
nmcli con delete \"System \$PUB_CONN\"
nmcli connection add ifname baremetal type bridge con-name baremetal bridge.stp no
ip4.method manual ip4.addr \"x.x.x.x/yy\" ip4.gateway \"a.a.a.a\" ip4.dns \"b.b.b.b\" ①
nmcli con add type bridge-slave ifname \"\$PUB_CONN\" master baremetal
nmcli con up baremetal
"
```

① Replace <con\_name> with the connection name. Replace **x.x.x.x/yy** with the IP address and CIDR for the network. Replace **a.a.a.a** with the network gateway. Replace **b.b.b.b** with the IP address of the DNS server.

3. Optional: If you are deploying with a provisioning network, export the provisioning network NIC name by running the following command:

```
$ export PROV_CONN=<prov_nic_name>
```

4. Optional: If you are deploying with a provisioning network, configure the provisioning network by running the following command:

```
$ sudo nohup bash -c "
nmcli con down \"\$PROV_CONN\"
nmcli con delete \"\$PROV_CONN\"
nmcli connection add ifname provisioning type bridge con-name provisioning
nmcli con add type bridge-slave ifname \"\$PROV_CONN\" master provisioning
nmcli connection modify provisioning ipv6.addresses fd00:1101::1/64 ipv6.method manual
nmcli con down provisioning
nmcli con up provisioning
"
```

#### NOTE

The SSH connection might disconnect after executing these steps.

The IPv6 address can be any address that is not routable through the bare-metal network.

Ensure that UEFI is enabled and UEFI PXE settings are set to the IPv6 protocol when using IPv6 addressing.

5. Optional: If you are deploying with a provisioning network, configure the IPv4 address on the provisioning network connection by running the following command:

```
$ nmcli connection modify provisioning ipv4.addresses 172.22.0.254/24 ipv4.method manual
```

6. SSH back into the **provisioner** node (if required) by running the following command:

```
# ssh kni@provisioner.<cluster-name>.<domain>
```

7. Verify that the connection bridges have been properly created by running the following command:

```
$ sudo nmcli con show
```

### Example output

NAME	UUID	TYPE	DEVICE
baremetal	4d5133a5-8351-4bb9-bfd4-3af264801530	bridge	baremetal
provisioning	43942805-017f-4d7d-a2c2-7cb3324482ed	bridge	provisioning
virbr0	d9bca40f-eee1-410b-8879-a2d4bb0465e7	bridge	virbr0
bridge-slave-eno1	76a8ed50-c7e5-4999-b4f6-6d9014dd0812	ethernet	eno1
bridge-slave-eno2	f31c3353-54b7-48de-893a-02d2b34c4736	ethernet	eno2

### 3.3.5. Creating a manifest object that includes a customized **br-ex** bridge

As an alternative to using the **configure-ovs.sh** shell script to set a **br-ex** bridge on a bare-metal platform, you can create a **MachineConfig** object that includes an NMState configuration file. The NMState configuration file creates a customized **br-ex** bridge network configuration on each node in your cluster.

Consider the following use cases for creating a manifest object that includes a customized **br-ex** bridge:

- You want to make postinstallation changes to the bridge, such as changing the Open vSwitch (OVS) or OVN-Kubernetes **br-ex** bridge network. The **configure-ovs.sh** shell script does not support making postinstallation changes to the bridge.
- You want to deploy the bridge on a different interface than the interface available on a host or server IP address.
- You want to make advanced configurations to the bridge that are not possible with the **configure-ovs.sh** shell script. Using the script for these configurations might result in the bridge failing to connect multiple network interfaces and facilitating data forwarding between the interfaces.



#### NOTE

If you require an environment with a single network interface controller (NIC) and default network settings, use the **configure-ovs.sh** shell script.

After you install Red Hat Enterprise Linux CoreOS (RHCOS) and the system reboots, the Machine Config Operator injects Ignition configuration files into each node in your cluster, so that each node received the **br-ex** bridge network configuration. To prevent configuration conflicts, the **configure-ovs.sh** shell script receives a signal to not configure the **br-ex** bridge.

## Prerequisites

- Optional: You have installed the [nmstate](#) API so that you can validate the NMState configuration.

## Procedure

- 1 Create a NMState configuration file that has decoded base64 information for your customized **br-ex** bridge network:

### Example of an NMState configuration for a customized **br-ex** bridge network

```

interfaces:
- name: enp2s0 ①
  type: ethernet ②
  state: up ③
  ipv4:
    enabled: false ④
  ipv6:
    enabled: false
- name: br-ex
  type: ovs-bridge
  state: up
  ipv4:
    enabled: false
    dhcp: false
  ipv6:
    enabled: false
    dhcp: false
  bridge:
    options:
      mcast-snooping-enable: true
    port:
      - name: enp2s0 ⑤
      - name: br-ex
- name: br-ex
  type: ovs-interface
  state: up
  copy-mac-from: enp2s0
  ipv4:
    enabled: true
    dhcp: true
  ipv6:
    enabled: false
    dhcp: false
# ...

```

- 1 Name of the interface.
- 2 The type of ethernet.
- 3 The requested state for the interface after creation.
- 4 Disables IPv4 and IPv6 in this example.

- 5 The node NIC to which the bridge attaches.

2. Use the **cat** command to base64-encode the contents of the NMState configuration:

```
$ cat <nmstate_configuration>.yaml | base64 1
```

- 1 Replace **<nmstate\_configuration>** with the name of your NMState resource YAML file.

3. Create a **MachineConfig** manifest file and define a customized **br-ex** bridge network configuration analogous to the following example:

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker 1
  name: 10-br-ex-worker 2
spec:
  config:
    ignition:
      version: 3.2.0
    storage:
      files:
        - contents:
            source: data:text/plain;charset=utf-8;base64,
<base64_encoded_nmstate_configuration> 3
          mode: 0644
          overwrite: true
          path: /etc/nmstate/openshift/cluster.yaml
# ...
```

- 1 For each node in your cluster, specify the hostname path to your node and the base-64 encoded Ignition configuration file data for the machine type. If you have a single global configuration specified in an **/etc/nmstate/openshift/cluster.yaml** configuration file that you want to apply to all nodes in your cluster, you do not need to specify the hostname path for each node. The **worker** role is the default role for nodes in your cluster. The **.yaml** extension does not work when specifying the hostname path for each node or all nodes in the **MachineConfig** manifest file.
- 2 The name of the policy.
- 3 Writes the encoded base64 information to the specified path.

### 3.3.5.1. Scaling each machine set to compute nodes

To apply a customized **br-ex** bridge configuration to all compute nodes in your OpenShift Container Platform cluster, you must edit your **MachineConfig** custom resource (CR) and modify its roles. Additionally, you must create a **BareMetalHost** CR that defines information for your bare-metal machine, such as hostname, credentials, and so on.

After you configure these resources, you must scale machine sets, so that the machine sets can apply the resource configuration to each compute node and reboot the nodes.

## Prerequisites

- You created a **MachineConfig** manifest object that includes a customized **br-ex** bridge configuration.

## Procedure

1. Edit the **MachineConfig** CR by entering the following command:

```
$ oc edit mc <machineconfig_custom_resource_name>
```

2. Add each compute node configuration to the CR, so that the CR can manage roles for each defined compute node in your cluster.
3. Create a **Secret** object named **extraworker-secret** that has a minimal static IP configuration.
4. Apply the **extraworker-secret** secret to each node in your cluster by entering the following command. This step provides each compute node access to the Ignition config file.

```
$ oc apply -f ./extraworker-secret.yaml
```

5. Create a **BareMetalHost** resource and specify the network secret in the **preprovisioningNetworkDataName** parameter:

### Example BareMetalHost resource with an attached network secret

```
apiVersion: metal3.io/v1alpha1
kind: BareMetalHost
spec:
# ...
  preprovisioningNetworkDataName: ostest-extraworker-0-network-config-secret
# ...
```

6. To manage the **BareMetalHost** object within the **openshift-machine-api** namespace of your cluster, change to the namespace by entering the following command:

```
$ oc project openshift-machine-api
```

7. Get the machine sets:

```
$ oc get machinesets
```

8. Scale each machine set by entering the following command. You must run this command for each machine set.

```
$ oc scale machineset <machineset_name> --replicas=<n> ①
```

- ① Where **<machineset\_name>** is the name of the machine set and **<n>** is the number of compute nodes.

### 3.3.6. Establishing communication between subnets

In a typical OpenShift Container Platform cluster setup, all nodes, including the control plane and compute nodes, reside in the same network. However, for edge computing scenarios, it can be beneficial to locate compute nodes closer to the edge. This often involves using different network segments or subnets for the remote nodes than the subnet used by the control plane and local compute nodes. Such a setup can reduce latency for the edge and allow for enhanced scalability.

Before installing OpenShift Container Platform, you must configure the network properly to ensure that the edge subnets containing the remote nodes can reach the subnet containing the control plane nodes and receive traffic from the control plane too.



## IMPORTANT

During cluster installation, assign permanent IP addresses to nodes in the network configuration of the **install-config.yaml** configuration file. If you do not do this, nodes might get assigned a temporary IP address that can impact how traffic reaches the nodes. For example, if a node has a temporary IP address assigned to it and you configured a bonded interface for a node, the bonded interface might receive a different IP address.

You can run control plane nodes in the same subnet or multiple subnets by configuring a user-managed load balancer in place of the default load balancer. With a multiple subnet environment, you can reduce the risk of your OpenShift Container Platform cluster from failing because of a hardware failure or a network outage. For more information, see "Services for a user-managed load balancer" and "Configuring a user-managed load balancer".

Running control plane nodes in a multiple subnet environment requires completion of the following key tasks:

- Configuring a user-managed load balancer instead of the default load balancer by specifying **UserManaged** in the **loadBalancer.type** parameter of the **install-config.yaml** file.
- Configuring a user-managed load balancer address in the **ingressVIPs** and **apiVIPs** parameters of the **install-config.yaml** file.
- Adding the multiple subnet Classless Inter-Domain Routing (CIDR) and the user-managed load balancer IP addresses to the **networking.machineNetworks** parameter in the **install-config.yaml** file.



## NOTE

Deploying a cluster with multiple subnets requires using virtual media, such as **redfish-virtualmedia** and **idrac-virtualmedia**.

This procedure details the network configuration required to allow the remote compute nodes in the second subnet to communicate effectively with the control plane nodes in the first subnet and to allow the control plane nodes in the first subnet to communicate effectively with the remote compute nodes in the second subnet.

In this procedure, the cluster spans two subnets:

- The first subnet (**10.0.0.0**) contains the control plane and local compute nodes.
- The second subnet (**192.168.0.0**) contains the edge compute nodes.

## Procedure

1. Configure the first subnet to communicate with the second subnet:

- a. Log in as **root** to a control plane node by running the following command:

```
$ sudo su -
```

- b. Get the name of the network interface by running the following command:

```
# nmcli dev status
```

- c. Add a route to the second subnet (**192.168.0.0**) via the gateway by running the following command:

```
# nmcli connection modify <interface_name> +ipv4.routes "192.168.0.0/24 via <gateway>"
```

Replace **<interface\_name>** with the interface name. Replace **<gateway>** with the IP address of the actual gateway.

### Example

```
# nmcli connection modify eth0 +ipv4.routes "192.168.0.0/24 via 192.168.0.1"
```

- d. Apply the changes by running the following command:

```
# nmcli connection up <interface_name>
```

Replace **<interface\_name>** with the interface name.

- e. Verify the routing table to ensure the route has been added successfully:

```
# ip route
```

- f. Repeat the previous steps for each control plane node in the first subnet.



### NOTE

Adjust the commands to match your actual interface names and gateway.

2. Configure the second subnet to communicate with the first subnet:

- a. Log in as **root** to a remote compute node by running the following command:

```
$ sudo su -
```

- b. Get the name of the network interface by running the following command:

```
# nmcli dev status
```

- c. Add a route to the first subnet (**10.0.0.0**) via the gateway by running the following command:

```
# nmcli connection modify <interface_name> +ipv4.routes "10.0.0.0/24 via <gateway>"
```

Replace **<interface\_name>** with the interface name. Replace **<gateway>** with the IP address of the actual gateway.

### Example

```
# nmcli connection modify eth0 +ipv4.routes "10.0.0.0/24 via 10.0.0.1"
```

- d. Apply the changes by running the following command:

```
# nmcli connection up <interface_name>
```

Replace **<interface\_name>** with the interface name.

- e. Verify the routing table to ensure the route has been added successfully by running the following command:

```
# ip route
```

- f. Repeat the previous steps for each compute node in the second subnet.



### NOTE

Adjust the commands to match your actual interface names and gateway.

3. After you have configured the networks, test the connectivity to ensure the remote nodes can reach the control plane nodes and the control plane nodes can reach the remote nodes.

- a. From the control plane nodes in the first subnet, ping a remote node in the second subnet by running the following command:

```
$ ping <remote_node_ip_address>
```

If the ping is successful, it means the control plane nodes in the first subnet can reach the remote nodes in the second subnet. If you do not receive a response, review the network configurations and repeat the procedure for the node.

- b. From the remote nodes in the second subnet, ping a control plane node in the first subnet by running the following command:

```
$ ping <control_plane_node_ip_address>
```

If the ping is successful, it means the remote compute nodes in the second subnet can reach the control plane in the first subnet. If you do not receive a response, review the network configurations and repeat the procedure for the node.

### Additional resources

- [Configuring host network interfaces](#)

### 3.3.7. Retrieving the OpenShift Container Platform installer

Use the **stable-4.x** version of the installation program and your selected architecture to deploy the generally available stable version of OpenShift Container Platform:

```
$ export VERSION=stable-4.18  
  
$ export RELEASE_ARCH=<architecture>  
  
$ export RELEASE_IMAGE=$(curl -s https://mirror.openshift.com/pub/openshift-v4/$RELEASE_ARCH/clients/ocp/$VERSION/release.txt | grep 'Pull From: quay.io' | awk -F ' ' '{print $3}')
```

### 3.3.8. Extracting the OpenShift Container Platform installer

After retrieving the installer, the next step is to extract it.

#### Procedure

1. Set the environment variables:

```
$ export cmd=openshift-baremetal-install  
  
$ export pullsecret_file=~/pull-secret.txt  
  
$ export extract_dir=$(pwd)
```

2. Get the **oc** binary:

```
$ curl -s https://mirror.openshift.com/pub/openshift-v4/clients/ocp/$VERSION/openshift-client-linux.tar.gz | tar zxvf - oc
```

3. Extract the installer:

```
$ sudo cp oc /usr/local/bin  
  
$ oc adm release extract --registry-config "${pullsecret_file}" --command=$cmd --to  
"${extract_dir}" ${RELEASE_IMAGE}  
  
$ sudo cp openshift-baremetal-install /usr/local/bin
```

### 3.3.9. Creating an RHCOS images cache

To employ image caching, you must download the Red Hat Enterprise Linux CoreOS (RHCOS) image used by the bootstrap VM to provision the cluster nodes. Image caching is optional, but it is especially useful when running the installation program on a network with limited bandwidth.



#### NOTE

The installation program no longer needs the **clusterOSImage** RHCOS image because the correct image is in the release payload.

If you are running the installation program on a network with limited bandwidth and the RHCOS images download takes more than 15 to 20 minutes, the installation program will timeout. Caching images on a web server will help in such scenarios.



### WARNING

If you enable TLS for the HTTPD server, you must confirm the root certificate is signed by an authority trusted by the client and verify the trusted certificate chain between your OpenShift Container Platform hub and spoke clusters and the HTTPD server. Using a server configured with an untrusted certificate prevents the images from being downloaded to the image creation service. Using untrusted HTTPS servers is not supported.

Install a container that contains the images.

### Procedure

1. Install **podman**:

```
$ sudo dnf install -y podman
```

2. Open firewall port **8080** to be used for RHCOS image caching:

```
$ sudo firewall-cmd --add-port=8080/tcp --zone=public --permanent
```

```
$ sudo firewall-cmd --reload
```

3. Create a directory to store the **bootstraposimage**:

```
$ mkdir /home/kni/rhcos_image_cache
```

4. Set the appropriate SELinux context for the newly created directory:

```
$ sudo semanage fcontext -a -t httpd_sys_content_t "/home/kni/rhcos_image_cache(/.*)?"
```

```
$ sudo restorecon -Rv /home/kni/rhcos_image_cache/
```

5. Get the URI for the RHCOS image that the installation program will deploy on the bootstrap VM:

```
$ export RHCOS_QEMU_URI=$(/usr/local/bin/openshift-baremetal-install coreos print-stream-json | jq -r --arg ARCH "$(arch)" '.architectures[$ARCH].artifacts.qemu.formats["qcow2.gz"].disk.location')
```

6. Get the name of the image that the installation program will deploy on the bootstrap VM:

```
$ export RHCOS_QEMU_NAME=${RHCOS_QEMU_URI##*/}
```

7. Get the SHA hash for the RHCOS image that will be deployed on the bootstrap VM:

```
$ export RHCOS_QEMU_UNCOMPRESSED_SHA256=$(/usr/local/bin/openshift-baremetal-install coreos print-stream-json | jq -r --arg ARCH "$(arch)" '.architectures[$ARCH].artifacts.qemu.formats["qcow2.gz"].disk["uncompressed-sha256"]')
```

8. Download the image and place it in the **/home/kni/rhcos\_image\_cache** directory:

```
$ curl -L ${RHCOS_QEMU_URI} -o /home/kni/rhcos_image_cache/${RHCOS_QEMU_NAME}
```

9. Confirm SELinux type is of **httpd\_sys\_content\_t** for the new file:

```
$ ls -Z /home/kni/rhcos_image_cache
```

10. Create the pod:

```
$ podman run -d --name rhcos_image_cache \①
-v /home/kni/rhcos_image_cache:/var/www/html \
-p 8080:8080/tcp \
registry.access.redhat.com/ubi9/httpd-24
```

- ① Creates a caching webserver with the name **rhcos\_image\_cache**. This pod serves the **bootstrapOSImage** image in the **install-config.yaml** file for deployment.

11. Generate the **bootstrapOSImage** configuration:

```
$ export BAREMETAL_IP=$(ip addr show dev baremetal | awk '/inet /{print $2}' | cut -d"/" -f1)

$ export
BOOTSTRAP_OS_IMAGE="http://${BAREMETAL_IP}:8080/${RHCOS_QEMU_NAME}?sha256=${RHCOS_QEMU_UNCOMPRESSED_SHA256}"

$ echo "  bootstrapOSImage=${BOOTSTRAP_OS_IMAGE}"
```

12. Add the required configuration to the **install-config.yaml** file under **platform.baremetal**:

```
platform:
baremetal:
  bootstrapOSImage: <bootstrap_os_image> ①
```

- ① Replace **<bootstrap\_os\_image>** with the value of **\$BOOTSTRAP\_OS\_IMAGE**.

See the "Configuring the install-config.yaml file" section for additional details.

### 3.3.10. Services for a user-managed load balancer

You can configure an OpenShift Container Platform cluster to use a user-managed load balancer in place of the default load balancer.



## IMPORTANT

Configuring a user-managed load balancer depends on your vendor's load balancer.

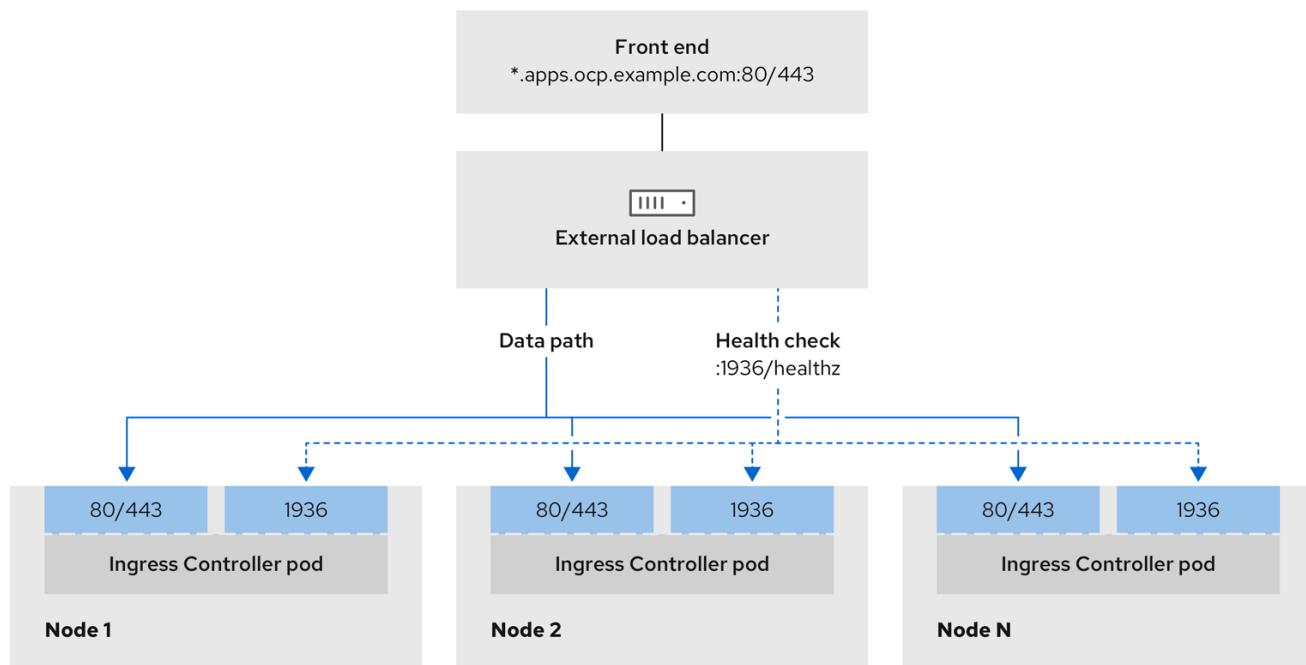
The information and examples in this section are for guideline purposes only. Consult the vendor documentation for more specific information about the vendor's load balancer.

Red Hat supports the following services for a user-managed load balancer:

- Ingress Controller
- OpenShift API
- OpenShift MachineConfig API

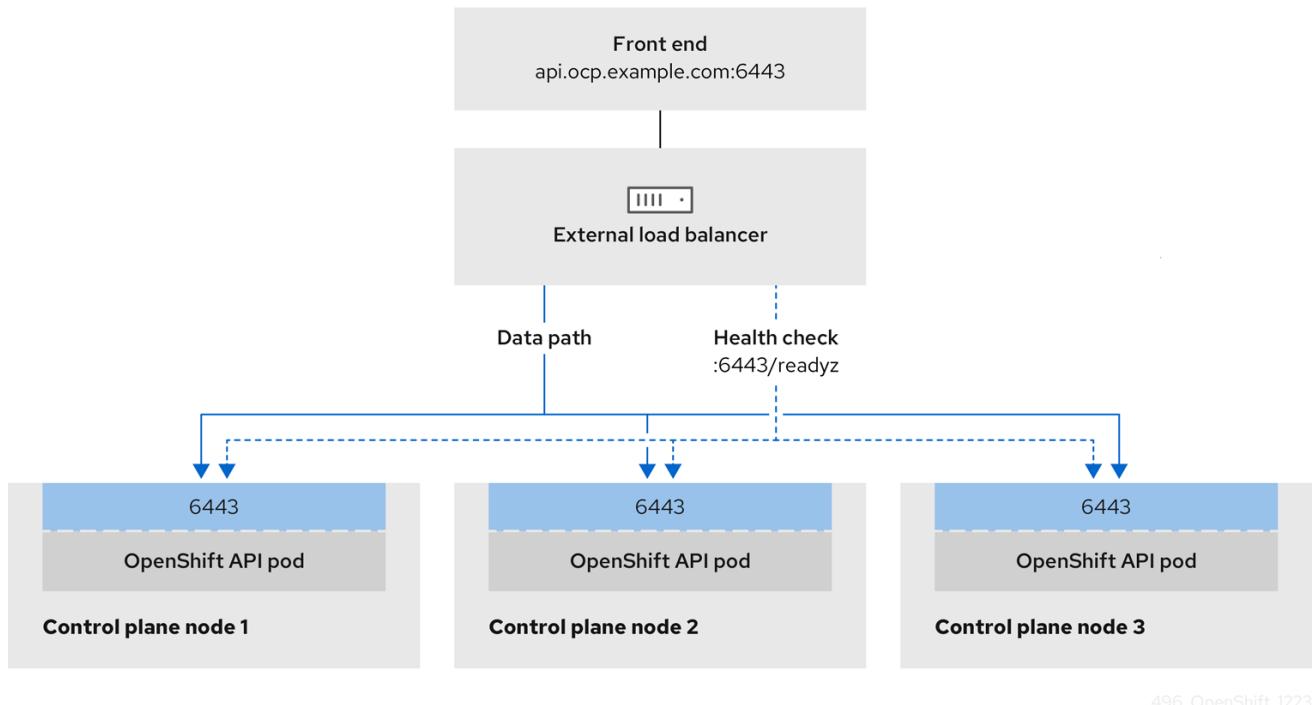
You can choose whether you want to configure one or all of these services for a user-managed load balancer. Configuring only the Ingress Controller service is a common configuration option. To better understand each service, view the following diagrams:

**Figure 3.1. Example network workflow that shows an Ingress Controller operating in an OpenShift Container Platform environment**



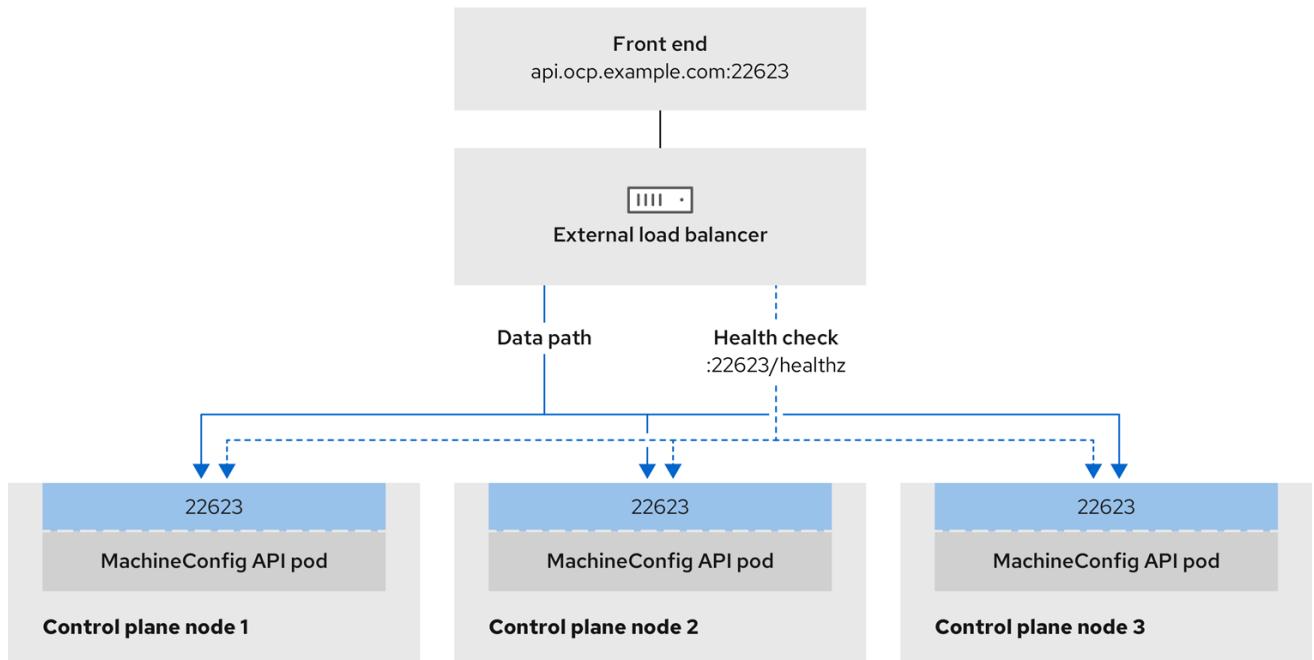
496\_OpenShift\_1223

**Figure 3.2. Example network workflow that shows an OpenShift API operating in an OpenShift Container Platform environment**



496\_OpenShift\_I223

**Figure 3.3. Example network workflow that shows an OpenShift MachineConfig API operating in an OpenShift Container Platform environment**



496\_OpenShift\_I223

The following configuration options are supported for user-managed load balancers:

- Use a node selector to map the Ingress Controller to a specific set of nodes. You must assign a static IP address to each node in this set, or configure each node to receive the same IP address from the Dynamic Host Configuration Protocol (DHCP). Infrastructure nodes commonly receive this type of configuration.

- Target all IP addresses on a subnet. This configuration can reduce maintenance overhead, because you can create and destroy nodes within those networks without reconfiguring the load balancer targets. If you deploy your ingress pods by using a machine set on a smaller network, such as a /27 or /28, you can simplify your load balancer targets.

### TIP

You can list all IP addresses that exist in a network by checking the machine config pool's resources.

Before you configure a user-managed load balancer for your OpenShift Container Platform cluster, consider the following information:

- For a front-end IP address, you can use the same IP address for the front-end IP address, the Ingress Controller's load balancer, and API load balancer. Check the vendor's documentation for this capability.
- For a back-end IP address, ensure that an IP address for an OpenShift Container Platform control plane node does not change during the lifetime of the user-managed load balancer. You can achieve this by completing one of the following actions:
  - Assign a static IP address to each control plane node.
  - Configure each node to receive the same IP address from the DHCP every time the node requests a DHCP lease. Depending on the vendor, the DHCP lease might be in the form of an IP reservation or a static DHCP assignment.
- Manually define each node that runs the Ingress Controller in the user-managed load balancer for the Ingress Controller back-end service. For example, if the Ingress Controller moves to an undefined node, a connection outage can occur.

#### 3.3.10.1. Configuring a user-managed load balancer

You can configure an OpenShift Container Platform cluster to use a user-managed load balancer in place of the default load balancer.



### IMPORTANT

Before you configure a user-managed load balancer, ensure that you read the "Services for a user-managed load balancer" section.

Read the following prerequisites that apply to the service that you want to configure for your user-managed load balancer.



### NOTE

MetalLB, which runs on a cluster, functions as a user-managed load balancer.

#### OpenShift API prerequisites

- You defined a front-end IP address.
- TCP ports 6443 and 22623 are exposed on the front-end IP address of your load balancer. Check the following items:

- Port 6443 provides access to the OpenShift API service.
- Port 22623 can provide ignition startup configurations to nodes.
- The front-end IP address and port 6443 are reachable by all users of your system with a location external to your OpenShift Container Platform cluster.
- The front-end IP address and port 22623 are reachable only by OpenShift Container Platform nodes.
- The load balancer backend can communicate with OpenShift Container Platform control plane nodes on port 6443 and 22623.

## Ingress Controller prerequisites

- You defined a front-end IP address.
- TCP ports 443 and 80 are exposed on the front-end IP address of your load balancer.
- The front-end IP address, port 80 and port 443 are be reachable by all users of your system with a location external to your OpenShift Container Platform cluster.
- The front-end IP address, port 80 and port 443 are reachable to all nodes that operate in your OpenShift Container Platform cluster.
- The load balancer backend can communicate with OpenShift Container Platform nodes that run the Ingress Controller on ports 80, 443, and 1936.

## Prerequisite for health check URL specifications

You can configure most load balancers by setting health check URLs that determine if a service is available or unavailable. OpenShift Container Platform provides these health checks for the OpenShift API, Machine Configuration API, and Ingress Controller backend services.

The following examples show health check specifications for the previously listed backend services:

### Example of a Kubernetes API health check specification

```
Path: HTTPS:6443/readyz
Healthy threshold: 2
Unhealthy threshold: 2
Timeout: 10
Interval: 10
```

### Example of a Machine Config API health check specification

```
Path: HTTPS:22623/healthz
Healthy threshold: 2
Unhealthy threshold: 2
Timeout: 10
Interval: 10
```

### Example of an Ingress Controller health check specification

```
Path: HTTP:1936/healthz/ready
```

```
Healthy threshold: 2
Unhealthy threshold: 2
Timeout: 5
Interval: 10
```

## Procedure

- Configure the HAProxy Ingress Controller, so that you can enable access to the cluster from your load balancer on ports 6443, 22623, 443, and 80. Depending on your needs, you can specify the IP address of a single subnet or IP addresses from multiple subnets in your HAProxy configuration.

### Example HAProxy configuration with one listed subnet

```
# ...
listen my-cluster-api-6443
    bind 192.168.1.100:6443
    mode tcp
    balance roundrobin
    option httpchk
    http-check connect
    http-check send meth GET uri /readyz
    http-check expect status 200
    server my-cluster-master-2 192.168.1.101:6443 check inter 10s rise 2 fall 2
    server my-cluster-master-0 192.168.1.102:6443 check inter 10s rise 2 fall 2
    server my-cluster-master-1 192.168.1.103:6443 check inter 10s rise 2 fall 2

listen my-cluster-machine-config-api-22623
    bind 192.168.1.100:22623
    mode tcp
    balance roundrobin
    option httpchk
    http-check connect
    http-check send meth GET uri /healthz
    http-check expect status 200
    server my-cluster-master-2 192.168.1.101:22623 check inter 10s rise 2 fall 2
    server my-cluster-master-0 192.168.1.102:22623 check inter 10s rise 2 fall 2
    server my-cluster-master-1 192.168.1.103:22623 check inter 10s rise 2 fall 2

listen my-cluster-apps-443
    bind 192.168.1.100:443
    mode tcp
    balance roundrobin
    option httpchk
    http-check connect
    http-check send meth GET uri /healthz/ready
    http-check expect status 200
    server my-cluster-worker-0 192.168.1.111:443 check port 1936 inter 10s rise 2 fall 2
    server my-cluster-worker-1 192.168.1.112:443 check port 1936 inter 10s rise 2 fall 2
    server my-cluster-worker-2 192.168.1.113:443 check port 1936 inter 10s rise 2 fall 2

listen my-cluster-apps-80
    bind 192.168.1.100:80
    mode tcp
    balance roundrobin
```

```
option httpchk
http-check connect
http-check send meth GET uri /healthz/ready
http-check expect status 200
server my-cluster-worker-0 192.168.1.111:80 check port 1936 inter 10s rise 2 fall 2
server my-cluster-worker-1 192.168.1.112:80 check port 1936 inter 10s rise 2 fall 2
server my-cluster-worker-2 192.168.1.113:80 check port 1936 inter 10s rise 2 fall 2
# ...
```

### Example HAProxy configuration with multiple listed subnets

```
# ...
listen api-server-6443
    bind *:6443
    mode tcp
        server master-00 192.168.83.89:6443 check inter 1s
        server master-01 192.168.84.90:6443 check inter 1s
        server master-02 192.168.85.99:6443 check inter 1s
        server bootstrap 192.168.80.89:6443 check inter 1s

listen machine-config-server-22623
    bind *:22623
    mode tcp
        server master-00 192.168.83.89:22623 check inter 1s
        server master-01 192.168.84.90:22623 check inter 1s
        server master-02 192.168.85.99:22623 check inter 1s
        server bootstrap 192.168.80.89:22623 check inter 1s

listen ingress-router-80
    bind *:80
    mode tcp
    balance source
        server worker-00 192.168.83.100:80 check inter 1s
        server worker-01 192.168.83.101:80 check inter 1s

listen ingress-router-443
    bind *:443
    mode tcp
    balance source
        server worker-00 192.168.83.100:443 check inter 1s
        server worker-01 192.168.83.101:443 check inter 1s

listen ironic-api-6385
    bind *:6385
    mode tcp
    balance source
        server master-00 192.168.83.89:6385 check inter 1s
        server master-01 192.168.84.90:6385 check inter 1s
        server master-02 192.168.85.99:6385 check inter 1s
        server bootstrap 192.168.80.89:6385 check inter 1s

listen inspector-api-5050
    bind *:5050
    mode tcp
    balance source
        server master-00 192.168.83.89:5050 check inter 1s
```

```
server master-01 192.168.84.90:5050 check inter 1s
server master-02 192.168.85.99:5050 check inter 1s
server bootstrap 192.168.80.89:5050 check inter 1s
# ...
```

2. Use the **curl** CLI command to verify that the user-managed load balancer and its resources are operational:

- Verify that the cluster machine configuration API is accessible to the Kubernetes API server resource, by running the following command and observing the response:

```
$ curl https://<loadbalancer_ip_address>:6443/version --insecure
```

If the configuration is correct, you receive a JSON object in response:

```
{
  "major": "1",
  "minor": "11+",
  "gitVersion": "v1.11.0+ad103ed",
  "gitCommit": "ad103ed",
  "gitTreeState": "clean",
  "buildDate": "2019-01-09T06:44:10Z",
  "goVersion": "go1.10.3",
  "compiler": "gc",
  "platform": "linux/amd64"
}
```

- Verify that the cluster machine configuration API is accessible to the Machine config server resource, by running the following command and observing the output:

```
$ curl -v https://<loadbalancer_ip_address>:22623/healthz --insecure
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 200 OK
Content-Length: 0
```

- Verify that the controller is accessible to the Ingress Controller resource on port 80, by running the following command and observing the output:

```
$ curl -I -L -H "Host: console-openshift-console.apps.<cluster_name>.<base_domain>" http://<load_balancer_front_end_IP_address>
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 302 Found
content-length: 0
location: https://console-openshift-console.apps.ocp4.private.opequon.net/
cache-control: no-cache
```

- Verify that the controller is accessible to the Ingress Controller resource on port 443, by running the following command and observing the output:

```
$ curl -I -L --insecure --resolve console-openshift-console.apps.<cluster_name>. <base_domain>:443:<Load Balancer Front End IP Address> https://console-openshift-console.apps.<cluster_name>.<base_domain>
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 200 OK
referrer-policy: strict-origin-when-cross-origin
set-cookie: csrf-
token=UIYWOyQ62LWjw2h003xtYSKlh1a0Py2hhctw0WmV2YEdhJFyQwWcGBsja261dG
LgaYO0nxzVERhiXt6QepA7g==; Path=/; Secure; SameSite=Lax
x-content-type-options: nosniff
x-dns-prefetch-control: off
x-frame-options: DENY
x-xss-protection: 1; mode=block
date: Wed, 04 Oct 2023 16:29:38 GMT
content-type: text/html; charset=utf-8
set-cookie:
1e2670d92730b515ce3a1bb65da45062=1bf5e9573c9a2760c964ed1659cc1673; path=/
HttpOnly; Secure; SameSite=None
cache-control: private
```

3. Configure the DNS records for your cluster to target the front-end IP addresses of the user-managed load balancer. You must update records to your DNS server for the cluster API and applications over the load balancer.

### Examples of modified DNS records

<load\_balancer\_ip\_address> **A** api.<cluster\_name>.<base\_domain>  
A record pointing to Load Balancer Front End

<load\_balancer\_ip\_address> **A** apps.<cluster\_name>.<base\_domain>  
A record pointing to Load Balancer Front End



#### IMPORTANT

DNS propagation might take some time for each DNS record to become available. Ensure that each DNS record propagates before validating each record.

4. For your OpenShift Container Platform cluster to use the user-managed load balancer, you must specify the following configuration in your cluster's **install-config.yaml** file:

```
# ...
platform:
baremetal:
loadBalancer:
type: UserManaged 1
apiVIPs:
- <api_ip> 2
```

```
ingressVIPs:
- <ingress_ip> ③
# ...
```

- 1 Set **UserManaged** for the **type** parameter to specify a user-managed load balancer for your cluster. The parameter defaults to **OpenShiftManagedDefault**, which denotes the default internal load balancer. For services defined in an **openshift-kni-infra** namespace, a user-managed load balancer can deploy the **coredns** service to pods in your cluster but ignores **keepalived** and **haproxy** services.
- 2 Required parameter when you specify a user-managed load balancer. Specify the user-managed load balancer's public IP address, so that the Kubernetes API can communicate with the user-managed load balancer.
- 3 Required parameter when you specify a user-managed load balancer. Specify the user-managed load balancer's public IP address, so that the user-managed load balancer can manage ingress traffic for your cluster.

## Verification

1. Use the **curl** CLI command to verify that the user-managed load balancer and DNS record configuration are operational:
  - a. Verify that you can access the cluster API, by running the following command and observing the output:

```
$ curl https://api.<cluster_name>.<base_domain>:6443/version --insecure
```

If the configuration is correct, you receive a JSON object in response:

```
{
  "major": "1",
  "minor": "11+",
  "gitVersion": "v1.11.0+ad103ed",
  "gitCommit": "ad103ed",
  "gitTreeState": "clean",
  "buildDate": "2019-01-09T06:44:10Z",
  "goVersion": "go1.10.3",
  "compiler": "gc",
  "platform": "linux/amd64"
}
```

- b. Verify that you can access the cluster machine configuration, by running the following command and observing the output:

```
$ curl -v https://api.<cluster_name>.<base_domain>:22623/healthz --insecure
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 200 OK
Content-Length: 0
```

- c. Verify that you can access each cluster application on port, by running the following command and observing the output:

```
$ curl http://console-openshift-console.apps.<cluster_name>.<base_domain> -I -L --insecure
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 302 Found
content-length: 0
location: https://console-openshift-console.apps.<cluster-name>.<base domain>/
cache-control: no-cacheHTTP/1.1 200 OK
referrer-policy: strict-origin-when-cross-origin
set-cookie: csrf-
token=39HoZgztDnzJkq/JuLJMeoKNXIfiVv2YgZc09c3TBOBU4NI6kDXaJH1LdicNhN1UsQ
Wzon4Dor9GWGfopaTEQ==; Path=/; Secure
x-content-type-options: nosniff
x-dns-prefetch-control: off
x-frame-options: DENY
x-xss-protection: 1; mode=block
date: Tue, 17 Nov 2020 08:42:10 GMT
content-type: text/html; charset=utf-8
set-cookie:
1e2670d92730b515ce3a1bb65da45062=9b714eb87e93cf34853e87a92d6894be; path=/;
HttpOnly; Secure; SameSite=None
cache-control: private
```

- d. Verify that you can access each cluster application on port 443, by running the following command and observing the output:

```
$ curl https://console-openshift-console.apps.<cluster_name>.<base_domain> -I -L --insecure
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 200 OK
referrer-policy: strict-origin-when-cross-origin
set-cookie: csrf-
token=UIYWOyQ62LWjw2h003xtYSKlh1a0Py2hhctw0WmV2YEdhJFyQwWcGBsja261dGLgaYO0nxzVERhiXt6QepA7g==; Path=/; Secure; SameSite=Lax
x-content-type-options: nosniff
x-dns-prefetch-control: off
x-frame-options: DENY
x-xss-protection: 1; mode=block
date: Wed, 04 Oct 2023 16:29:38 GMT
content-type: text/html; charset=utf-8
set-cookie:
1e2670d92730b515ce3a1bb65da45062=1bf5e9573c9a2760c964ed1659cc1673; path=/;
HttpOnly; Secure; SameSite=None
cache-control: private
```

### 3.3.11. Setting the cluster node hostnames through DHCP

On Red Hat Enterprise Linux CoreOS (RHCOS) machines, **NetworkManager** sets the hostnames. By default, DHCP provides the hostnames to **NetworkManager**, which is the recommended method.

**NetworkManager** gets the hostnames through a reverse DNS lookup in the following cases:

- If DHCP does not provide the hostnames
- If you use kernel arguments to set the hostnames
- If you use another method to set the hostnames

Reverse DNS lookup occurs after the network has been initialized on a node, and can increase the time it takes **NetworkManager** to set the hostname. Other system services can start prior to **NetworkManager** setting the hostname, which can cause those services to use a default hostname such as **localhost**.

## TIP

You can avoid the delay in setting hostnames by using DHCP to provide the hostname for each cluster node. Additionally, setting the hostnames through DHCP can bypass manual DNS record name configuration errors in environments that have a DNS split-horizon implementation.

### 3.3.12. Configuring the install-config.yaml file

#### 3.3.12.1. Configuring the install-config.yaml file

The **install-config.yaml** file requires some additional details. Most of the information teaches the installation program and the resulting cluster enough about the available hardware that it is able to fully manage it.



#### NOTE

The installation program no longer needs the **clusterOSImage** RHCOS image because the correct image is in the release payload.

1. Configure **install-config.yaml**. Change the appropriate variables to match the environment, including **pullSecret** and **sshKey**:

```
apiVersion: v1
baseDomain: <domain>
metadata:
  name: <cluster_name>
networking:
  machineNetwork:
    - cidr: <public_cidr>
  networkType: OVNKubernetes
compute:
  - name: worker
    replicas: 2 ①
  controlPlane:
    name: master
    replicas: 3
    platform:
      baremetal: {}
platform:
```

```
baremetal:  
  additionalNTPServers: ②  
    - <ntp_domain_or_ip>  
  apiVIPs:  
    - <api_ip>  
  ingressVIPs:  
    - <wildcard_ip>  
  provisioningNetworkCIDR: <CIDR>  
  bootstrapExternalStaticIP: <bootstrap_static_ip_address> ③  
  bootstrapExternalStaticGateway: <bootstrap_static_gateway> ④  
  bootstrapExternalStaticDNS: <bootstrap_static_dns> ⑤  
  hosts:  
    - name: openshift-master-0  
      role: master  
      bmc:  
        address: ipmi://<out_of_band_ip> ⑥  
        username: <user>  
        password: <password>  
      bootMACAddress: <NIC1_mac_address>  
      rootDeviceHints:  
        deviceName: "<installation_disk_drive_path>" ⑦  
    - name: <openshift_master_1>  
      role: master  
      bmc:  
        address: ipmi://<out_of_band_ip>  
        username: <user>  
        password: <password>  
      bootMACAddress: <NIC1_mac_address>  
      rootDeviceHints:  
        deviceName: "<installation_disk_drive_path>"  
    - name: <openshift_master_2>  
      role: master  
      bmc:  
        address: ipmi://<out_of_band_ip>  
        username: <user>  
        password: <password>  
      bootMACAddress: <NIC1_mac_address>  
      rootDeviceHints:  
        deviceName: "<installation_disk_drive_path>"  
    - name: <openshift_worker_0>  
      role: worker  
      bmc:  
        address: ipmi://<out_of_band_ip>  
        username: <user>  
        password: <password>  
      bootMACAddress: <NIC1_mac_address>  
    - name: <openshift_worker_1>  
      role: worker  
      bmc:  
        address: ipmi://<out_of_band_ip>  
        username: <user>  
        password: <password>  
      bootMACAddress: <NIC1_mac_address>  
      rootDeviceHints:
```

```

deviceName: "<installation_disk_drive_path>"
pullSecret: '<pull_secret>'
sshKey: '<ssh_pub_key>'
```

- 1 Scale the compute machines based on the number of compute nodes that are part of the OpenShift Container Platform cluster. Valid options for the **replicas** value are **0** and integers greater than or equal to **2**. Set the number of replicas to **0** to deploy a three-node cluster, which contains only three control plane machines. A three-node cluster is a smaller, more resource-efficient cluster that can be used for testing, development, and production. You cannot install the cluster with only one compute node.
- 2 An optional list of additional NTP server domain names or IP addresses to add to each host configuration when the cluster host clocks are out of synchronization.
- 3 When deploying a cluster with static IP addresses, you must set the **bootstrapExternalStaticIP** configuration setting to specify the static IP address of the bootstrap VM when there is no DHCP server on the bare metal network.
- 4 When deploying a cluster with static IP addresses, you must set the **bootstrapExternalStaticGateway** configuration setting to specify the gateway IP address for the bootstrap VM when there is no DHCP server on the bare metal network.
- 5 When deploying a cluster with static IP addresses, you must set the **bootstrapExternalStaticDNS** configuration setting to specify the DNS address for the bootstrap VM when there is no DHCP server on the bare metal network.
- 6 See the BMC addressing sections for more options.
- 7 To set the path to the installation disk drive, enter the kernel name of the disk. For example, **/dev/sda**.

## IMPORTANT

Because the disk discovery order is not guaranteed, the kernel name of the disk can change across booting options for machines with multiple disks. For example, **/dev/sda** becomes **/dev/sdb** and vice versa. To avoid this issue, you must use persistent disk attributes, such as the disk World Wide Name (WWN) or **/dev/disk/by-path/**. It is recommended to use the **/dev/disk/by-path/<device\_path>** link to the storage location. To use the disk WWN, replace the **deviceName** parameter with the **wwnWithExtension** parameter. Depending on the parameter that you use, enter either of the following values:

- The disk name. For example, **/dev/sda**, or **/dev/disk/by-path/**.
- The disk WWN. For example, **"0x64cd98f04fde100024684cf3034da5c2"**. Ensure that you enter the disk WWN value within quotes so that it is used as a string value and not a hexadecimal value.

Failure to meet these requirements for the **rootDeviceHints** parameter might result in the following error:

```
ironic-inspector inspection failed: No disks satisfied root device hints
```

**NOTE**

Before OpenShift Container Platform 4.12, the cluster installation program only accepted an IPv4 address or an IPv6 address for the **apiVIP** and **ingressVIP** configuration settings. In OpenShift Container Platform 4.12 and later, these configuration settings are deprecated. Instead, use a list format in the **apiVIPs** and **ingressVIPs** configuration settings to specify IPv4 addresses, IPv6 addresses, or both IP address formats.

2. Create a directory to store the cluster configuration:

```
$ mkdir ~/clusterconfigs
```

3. Copy the **install-config.yaml** file to the new directory:

```
$ cp install-config.yaml ~/clusterconfigs
```

4. Ensure all bare metal nodes are powered off prior to installing the OpenShift Container Platform cluster:

```
$ ipmitool -I lanplus -U <user> -P <password> -H <management-server-ip> power off
```

5. Remove old bootstrap resources if any are left over from a previous deployment attempt:

```
for i in $(sudo virsh list | tail -n +3 | grep bootstrap | awk {'print $2'});
do
    sudo virsh destroy $i;
    sudo virsh undefine $i;
    sudo virsh vol-delete $i --pool $i;
    sudo virsh vol-delete $i.ign --pool $i;
    sudo virsh pool-destroy $i;
    sudo virsh pool-undefine $i;
done
```

### 3.3.12.2. Additional **install-config** parameters

See the following tables for the required parameters, the **hosts** parameter, and the **bmc** parameter for the **install-config.yaml** file.

**Table 3.7. Required parameters**

Parameters	Default	Description
<b>baseDomain</b>		The domain name for the cluster. For example, <b>example.com</b> .
<b>bootMode</b>	<b>UEFI</b>	The boot mode for a node. Options are <b>legacy</b> , <b>UEFI</b> , and <b>UEFISecureBoot</b> . If <b>bootMode</b> is not set, Ironic sets it while inspecting the node.

Parameters	Default	Description
platform: baremetal: bootstrapExternalStaticDNS		The static network DNS of the bootstrap node. You must set this value when deploying a cluster with static IP addresses when there is no Dynamic Host Configuration Protocol (DHCP) server on the bare-metal network. If you do not set this value, the installation program will use the value from <b>bootstrapExternalStaticGateway</b> , which causes problems when the IP address values of the gateway and DNS are different.
platform: baremetal: bootstrapExternalStaticIP		The static IP address for the bootstrap VM. You must set this value when deploying a cluster with static IP addresses when there is no DHCP server on the bare-metal network.
platform: baremetal: bootstrapExternalStaticGateway		The static IP address of the gateway for the bootstrap VM. You must set this value when deploying a cluster with static IP addresses when there is no DHCP server on the bare-metal network.
<b>sshKey</b>		The <b>sshKey</b> configuration setting has the key in the <code>~/.ssh/id_rsa.pub</code> file required to access the control plane nodes and compute nodes. Typically, this key is from the <b>provisioner</b> node.
<b>pullSecret</b>		The <b>pullSecret</b> configuration setting has a copy of the pull secret downloaded from the <a href="#">Install OpenShift on Bare Metal</a> page when preparing the provisioner node.
metadata: name:		The name of the OpenShift Container Platform cluster. For example, <b>openshift</b> .
networking: machineNetwork: - cidr:		The public CIDR (Classless Inter-Domain Routing) of the external network. For example, <b>10.0.0.0/24</b> .
compute: - name: worker		The OpenShift Container Platform cluster requires you to provide a name for compute nodes even if there are zero nodes.

Parameters	Default	Description
compute: replicas: 2		Replicas sets the number of compute nodes in the OpenShift Container Platform cluster.
controlPlane: name: master		The OpenShift Container Platform cluster requires a name for control plane nodes.
controlPlane: replicas: 3		Replicas sets the number of control plane nodes included as part of the OpenShift Container Platform cluster.
<b>provisioningNetworkInterface</b>		The name of the network interface on nodes connected to the provisioning network. For OpenShift Container Platform 4.9 and later releases, use the <b>bootMACAddress</b> configuration setting to enable Ironic to identify the IP address of the NIC instead of using the <b>provisioningNetworkInterface</b> configuration setting to identify the name of the NIC.
<b>defaultMachinePlatform</b>		The default configuration used for machine pools without a platform configuration.

Parameters	Default	Description
<b>apiVIPs</b>		<p>(Optional) The virtual IP address for Kubernetes API communication.</p> <p>You must either provide this setting in the <b>install-config.yaml</b> file as a reserved IP from the <b>MachineNetwork</b> parameter or preconfigured in the DNS so that the default name resolves correctly. Use the virtual IP address and not the FQDN when adding a value to the <b>apiVIPs</b> configuration setting in the <b>install-config.yaml</b> file. The primary IP address must be from the IPv4 network when using dual stack networking. If not set, the installation program uses <b>api.&lt;cluster_name&gt;</b>.  <b>&lt;base_domain&gt;</b> to derive the IP address from the DNS.</p>  <p><b>NOTE</b></p> <p>Before OpenShift Container Platform 4.12, the cluster installation program only accepted an IPv4 address or an IPv6 address for the <b>apiVIP</b> configuration setting. From OpenShift Container Platform 4.12 or later, the <b>apiVIP</b> configuration setting is deprecated. Instead, use a list format for the <b>apiVIPs</b> configuration setting to specify an IPv4 address, an IPv6 address or both IP address formats.</p>
<b>disableCertificateVerification</b>	<b>False</b>	<b>redfish</b> and <b>redfish-virtualmedia</b> need this parameter to manage BMC addresses. The value should be <b>True</b> when using a self-signed certificate for BMC addresses.

Parameters	Default	Description
<b>ingressVIPs</b>		<p>(Optional) The virtual IP address for ingress traffic. You must either provide this setting in the <b>install-config.yaml</b> file as a reserved IP from the <b>MachineNetwork</b> parameter or preconfigured in the DNS so that the default name resolves correctly. Use the virtual IP address and not the FQDN when adding a value to the <b>ingressVIPs</b> configuration setting in the <b>install-config.yaml</b> file. The primary IP address must be from the IPv4 network when using dual stack networking. If not set, the installation program uses <b>test.apps.&lt;cluster_name&gt;. &lt;base_domain&gt;</b> to derive the IP address from the DNS.</p>  <p><b>NOTE</b></p> <p>Before OpenShift Container Platform 4.12, the cluster installation program only accepted an IPv4 address or an IPv6 address for the <b>ingressVIP</b> configuration setting. In OpenShift Container Platform 4.12 and later, the <b>ingressVIP</b> configuration setting is deprecated. Instead, use a list format for the <b>ingressVIPs</b> configuration setting to specify an IPv4 addresses, an IPv6 addresses or both IP address formats.</p>

**Table 3.8. Optional Parameters**

Parameters	Default	Description
platform: baremetal:  additionalNTP Servers:  <ip_address_ or_domain_na me>		<p>An optional list of additional NTP servers to add to each host. You can use an IP address or a domain name to specify each NTP server. Additional NTP servers are user-defined NTP servers that enable preinstallation clock synchronization when the cluster host clocks are out of synchronization.</p>
<b>provisioningDHCRRange</b>	<b>172.22.0.10,172.22.0.100</b>	Defines the IP range for nodes on the provisioning network.

Parameters	Default	Description
<b>provisioningNetworkCIDR</b>	<b>172.22.0.0/24</b>	The CIDR for the network to use for provisioning. The installation program requires this option when not using the default address range on the provisioning network.
<b>clusterProvisioningIP</b>	The third IP address of the <b>provisioningNetworkCIDR</b> .	The IP address within the cluster where the provisioning services run. Defaults to the third IP address of the provisioning subnet. For example, <b>172.22.0.3</b> .
<b>bootstrapProvisioningIP</b>	The second IP address of the <b>provisioningNetworkCIDR</b> .	The IP address on the bootstrap VM where the provisioning services run while the installation program is deploying the control plane (master) nodes. Defaults to the second IP address of the provisioning subnet. For example, <b>172.22.0.2</b> or <b>2620:52:0:1307::2</b> .
<b>externalBridge</b>	<b>baremetal</b>	The name of the bare-metal bridge of the hypervisor attached to the bare-metal network.
<b>provisioningBridge</b>	<b>provisioning</b>	The name of the provisioning bridge on the <b>provisioner</b> host attached to the provisioning network.
<b>architecture</b>		Defines the host architecture for your cluster. Valid values are <b>amd64</b> or <b>arm64</b> .
<b>defaultMachinePlatform</b>		The default configuration used for machine pools without a platform configuration.
<b>bootstrapOSImage</b>		A URL to override the default operating system image for the bootstrap node. The URL must contain a SHA-256 hash of the image. For example: <a href="https://mirror.openshift.com/rhcos-&lt;version&gt;-qemu.qcow2.gz?sha256=&lt;uncompressed_sha256&gt;">https://mirror.openshift.com/rhcos-&lt;version&gt;-qemu.qcow2.gz?sha256=&amp;ltuncompressed_sha256&gt;</a> .

Parameters	Default	Description
<b>provisioningNetwork</b>		<p>The <b>provisioningNetwork</b> configuration setting determines whether the cluster uses the provisioning network. If it does, the configuration setting also determines if the cluster manages the network.</p> <p><b>Disabled:</b> Set this parameter to <b>Disabled</b> to disable the requirement for a provisioning network. When set to <b>Disabled</b>, you must only use virtual media based provisioning, or start the cluster by using the Assisted Installer. If set to <b>Disabled</b> and using power management, BMCs must be accessible from the bare-metal network. If set to <b>Disabled</b>, you must provide two IP addresses on the bare-metal network that the installation program uses for the provisioning services.</p> <p><b>Managed:</b> Set this parameter to <b>Managed</b>, which is the default, to fully manage the provisioning network, including DHCP, TFTP, and so on.</p> <p><b>Unmanaged:</b> Set this parameter to <b>Unmanaged</b> to enable the provisioning network but take care of manual configuration of DHCP. Virtual media provisioning is recommended but PXE is still available if required.</p>
<b>httpProxy</b>		Set this parameter to the appropriate HTTP proxy used within your environment.
<b>httpsProxy</b>		Set this parameter to the appropriate HTTPS proxy used within your environment.
<b>noProxy</b>		Set this parameter to the appropriate list of exclusions for proxy usage within your environment.

## Hosts

The **hosts** parameter is a list of separate bare metal assets used to build the cluster.

**Table 3.9. Hosts**

Name	Default	Description
<b>name</b>		The name of the <b>BareMetalHost</b> resource to associate with the details. For example, <b>openshift-master-0</b> .
<b>role</b>		The role of the bare-metal node. Either <b>master</b> (control plane node) or <b>worker</b> (compute node).

Name	Default	Description
<b>bmc</b>		Connection details for the baseboard management controller. See the BMC addressing section for additional details.
<b>bootMACAddress</b>		The MAC address of the NIC that the host uses for the provisioning network. Ironic retrieves the IP address using the <b>bootMACAddress</b> configuration setting. Then, it binds to the host.
<b>networkConfig</b>		<p>Set this optional parameter to configure the network interface of a host. See "(Optional) Configuring host network interfaces" for additional details.</p> <div style="display: flex; align-items: center;">  <span style="margin-left: 10px;"><b>NOTE</b></span> </div> <p>You must provide a valid MAC address from the host if you disabled the provisioning network.</p>

### 3.3.12.3. BMC addressing

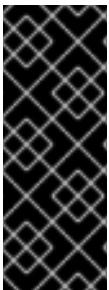
Most vendors support Baseboard Management Controller (BMC) addressing with the Intelligent Platform Management Interface (IPMI). IPMI does not encrypt communications. It is suitable for use within a data center over a secured or dedicated management network. Check with your vendor to see if they support Redfish network boot. Redfish delivers simple and secure management for converged, hybrid IT and the Software Defined Data Center (SDDC). Redfish is human readable and machine capable, and leverages common internet and web services standards to expose information directly to the modern tool chain. If your hardware does not support Redfish network boot, use IPMI.

You can modify the BMC address during installation while the node is in the **Registering** state. If you need to modify the BMC address after the node leaves the **Registering** state, you must disconnect the node from Ironic, edit the **BareMetalHost** resource, and reconnect the node to Ironic. See the *Editing a BareMetalHost resource* section for details.

#### IPMI

Hosts using IPMI use the **ipmi://<out-of-band-ip>:<port>** address format, which defaults to port **623** if not specified. The following example demonstrates an IPMI configuration within the **install-config.yaml** file.

```
platform:
  baremetal:
    hosts:
      - name: openshift-master-0
        role: master
        bmc:
          address: ipmi://<out-of-band-ip>
          username: <user>
          password: <password>
```



## IMPORTANT

The **provisioning** network is required when PXE booting using IPMI for BMC addressing. It is not possible to PXE boot hosts without a **provisioning** network. If you deploy without a **provisioning** network, you must use a virtual media BMC addressing option such as **redfish-virtualmedia** or **idrac-virtualmedia**. See "Redfish virtual media for HPE iLO" in the "BMC addressing for HPE iLO" section or "Redfish virtual media for Dell iDRAC" in the "BMC addressing for Dell iDRAC" section for additional details.

### Redfish network boot

To enable Redfish, use **redfish://** or **redfish+http://** to disable TLS. The installer requires both the hostname or the IP address and the path to the system ID. The following example demonstrates a Redfish configuration within the **install-config.yaml** file.

```
platform:
baremetal:
hosts:
- name: openshift-master-0
role: master
bmc:
address: redfish://<out-of-band-ip>/redfish/v1/Systems/1
username: <user>
password: <password>
```

While it is recommended to have a certificate of authority for the out-of-band management addresses, you must include **disableCertificateVerification: True** in the **bmc** configuration if using self-signed certificates. The following example demonstrates a Redfish configuration using the **disableCertificateVerification: True** configuration parameter within the **install-config.yaml** file.

```
platform:
baremetal:
hosts:
- name: openshift-master-0
role: master
bmc:
address: redfish://<out-of-band-ip>/redfish/v1/Systems/1
username: <user>
password: <password>
disableCertificateVerification: True
```

### Additional resources

- [Editing a BareMetalHost resource](#)

#### 3.3.12.4. Verifying support for Redfish APIs

When installing using the Redfish API, the installation program calls several Redfish endpoints on the baseboard management controller (BMC) when using installer-provisioned infrastructure on bare metal. If you use Redfish, ensure that your BMC supports all of the Redfish APIs before installation.

### Procedure

1. Set the IP address or hostname of the BMC by running the following command:

**\$ export SERVER=<ip\_address>** ①

- ① Replace <ip\_address> with the IP address or hostname of the BMC.

2. Set the ID of the system by running the following command:

**\$ export SystemID=<system\_id>** ①

- ① Replace <system\_id> with the system ID. For example, **System.Embedded.1** or **1**. See the following vendor-specific BMC sections for details.

## List of Redfish APIs

1. Check **power on** support by running the following command:

```
$ curl -u $USER:$PASS -X POST -H'Content-Type: application/json' -H'Accept: application/json' -d '{"ResetType": "On"}'  
https://$SERVER/redfish/v1/Systems/$SystemID/Actions/ComputerSystem.Reset
```

2. Check **power off** support by running the following command:

```
$ curl -u $USER:$PASS -X POST -H'Content-Type: application/json' -H'Accept: application/json' -d '{"ResetType": "ForceOff"}'  
https://$SERVER/redfish/v1/Systems/$SystemID/Actions/ComputerSystem.Reset
```

3. Check the temporary boot implementation that uses **pxe** by running the following command:

```
$ curl -u $USER:$PASS -X PATCH -H "Content-Type: application/json" -H "If-Match: <ETAG>" https://$Server/redfish/v1/Systems/$SystemID/ -d '{"Boot": {"BootSourceOverrideTarget": "pxe", "BootSourceOverrideEnabled": "Once"}}'
```

4. Check the status of setting the firmware boot mode that uses **Legacy** or **UEFI** by running the following command:

```
$ curl -u $USER:$PASS -X PATCH -H "Content-Type: application/json" -H "If-Match: <ETAG>" https://$Server/redfish/v1/Systems/$SystemID/ -d '{"Boot": {"BootSourceOverrideMode": "UEFI"}}'
```

## List of Redfish virtual media APIs

1. Check the ability to set the temporary boot device that uses **cd** or **dvd** by running the following command:

```
$ curl -u $USER:$PASS -X PATCH -H "Content-Type: application/json" -H "If-Match: <ETAG>" https://$Server/redfish/v1/Systems/$SystemID/ -d '{"Boot": {"BootSourceOverrideTarget": "cd", "BootSourceOverrideEnabled": "Once"}}'
```

2. Virtual media might use **POST** or **PATCH**, depending on your hardware. Check the ability to mount virtual media by running one of the following commands:

```
$ curl -u $USER:$PASS -X POST -H "Content-Type: application/json"
```

```
https://$Server/redfish/v1/Managers/$ManagerID/VirtualMedia/$Vmediald -d '{"Image": "https://example.com/test.iso", "TransferProtocolType": "HTTPS", "UserName": "", "Password": ""}'
```

```
$ curl -u $USER:$PASS -X PATCH -H "Content-Type: application/json" -H "If-Match: <ETAG>" https://$Server/redfish/v1/Managers/$ManagerID/VirtualMedia/$Vmediald -d '{"Image": "https://example.com/test.iso", "TransferProtocolType": "HTTPS", "UserName": "", "Password": ""}'
```



## NOTE

The **PowerOn** and **PowerOff** commands for Redfish APIs are the same for the Redfish virtual media APIs. In some hardware, you might only find the **VirtualMedia** resource under **Systems/\$SystemID** instead of **Managers/\$ManagerID**. For the **VirtualMedia** resource, the **UserName** and **Password** fields are optional.



## IMPORTANT

**HTTPS** and **HTTP** are the only supported parameter types for **TransferProtocolTypes**.

### 3.3.12.5. BMC addressing for Dell iDRAC

The **address** configuration setting for each **bmc** entry is a URL for connecting to the OpenShift Container Platform cluster nodes, including the type of controller in the URL scheme and its location on the network. The **username** configuration for each **bmc** entry must specify a user with **Administrator** privileges.

```
platform:
baremetal:
hosts:
- name: <hostname>
role: <master | worker>
bmc:
address: <address> ①
username: <user> ②
password: <password>
```

① The **address** configuration setting specifies the protocol.

② The **username** configuration setting must specify a user with **Administrator** privileges.

For Dell hardware, Red Hat supports integrated Dell Remote Access Controller (iDRAC) virtual media, Redfish network boot, and IPMI.

#### BMC address formats for Dell iDRAC

Protocol	Address Format
iDRAC virtual media	<b>idrac-virtualmedia://&lt;out_of_band_ip&gt;/redfish/v1/Systems/System.Embedded.1</b>

Protocol	Address Format
Redfish network boot	<code>redfish://&lt;out_of_band_ip&gt;/redfish/v1/Systems/System.Embedded.1</code>
IPMI	<code>ipmi://&lt;out_of_band_ip&gt;</code>



## IMPORTANT

Use **idrac-virtualmedia** as the protocol for Redfish virtual media. **redfish-virtualmedia** will not work on Dell hardware. Dell's **idrac-virtualmedia** uses the Redfish standard with Dell's OEM extensions.

See the following sections for additional details.

### Redfish virtual media for Dell iDRAC

For Redfish virtual media on Dell servers, use **idrac-virtualmedia://** in the **address** setting. Using **redfish-virtualmedia://** will not work.



## NOTE

Use **idrac-virtualmedia://** as the protocol for Redfish virtual media. Using **redfish-virtualmedia://** will not work on Dell hardware, because the **idrac-virtualmedia://** protocol corresponds to the **idrac** hardware type and the Redfish protocol in Ironic. Dell's **idrac-virtualmedia://** protocol uses the Redfish standard with Dell's OEM extensions. Ironic also supports the **idrac** type with the WSMAN protocol. Therefore, you must specify **idrac-virtualmedia://** to avoid unexpected behavior when electing to use Redfish with virtual media on Dell hardware.

The following example demonstrates using iDRAC virtual media within the **install-config.yaml** file.

```
platform:
  baremetal:
    hosts:
      - name: openshift-master-0
        role: master
        bmc:
          address: idrac-virtualmedia://<out_of_band_ip>/redfish/v1/Systems/System.Embedded.1
          username: <user>
          password: <password>
```

While it is recommended to have a certificate of authority for the out-of-band management addresses, you must include **disableCertificateVerification: True** in the **bmc** configuration if using self-signed certificates.



## NOTE

Ensure the OpenShift Container Platform cluster nodes have **AutoAttach** enabled through the iDRAC console. The menu path is: **Configuration** → **Virtual Media** → **Attach Mode** → **AutoAttach**.

The following example demonstrates a Redfish configuration that uses the **disableCertificateVerification: True** configuration parameter within the **install-config.yaml** file.

```
platform:  
baremetal:  
hosts:  
- name: openshift-master-0  
role: master  
bmc:  
address: idrac-virtualmedia://<out_of_band_ip>/redfish/v1/Systems/System.Embedded.1  
username: <user>  
password: <password>  
disableCertificateVerification: True
```

### Redfish network boot for iDRAC

To enable Redfish, use **redfish://** or **redfish+http://** to disable transport layer security (TLS). The installation program requires both the hostname or the IP address and the path to the system ID. The following example demonstrates a Redfish configuration within the **install-config.yaml** file.

```
platform:  
baremetal:  
hosts:  
- name: openshift-master-0  
role: master  
bmc:  
address: redfish://<out_of_band_ip>/redfish/v1/Systems/System.Embedded.1  
username: <user>  
password: <password>
```

While it is recommended to have a certificate of authority for the out-of-band management addresses, you must include **disableCertificateVerification: True** in the **bmc** configuration if you use self-signed certificates. The following example demonstrates a Redfish configuration that uses the **disableCertificateVerification: True** configuration parameter within the **install-config.yaml** file.

```
platform:  
baremetal:  
hosts:  
- name: openshift-master-0  
role: master  
bmc:  
address: redfish://<out_of_band_ip>/redfish/v1/Systems/System.Embedded.1  
username: <user>  
password: <password>  
disableCertificateVerification: True
```



## NOTE

There is a known issue on Dell iDRAC 9 with firmware version **04.40.00.00** and all releases up to including the **5.xx** series for installer-provisioned installations on bare metal deployments. The virtual console plugin defaults to eHTML5, an enhanced version of HTML5, which causes problems with the **InsertVirtualMedia** workflow. Set the plugin to use HTML5 to avoid this issue. The menu path is **Configuration → Virtual console → Plug-in Type → HTML5**.

Ensure the OpenShift Container Platform cluster nodes have **AutoAttach** enabled through the iDRAC console. The menu path is: **Configuration → Virtual Media → Attach Mode → AutoAttach**.

### 3.3.12.6. BMC addressing for HPE iLO

The **address** field for each **bmc** entry is a URL for connecting to the OpenShift Container Platform cluster nodes, including the type of controller in the URL scheme and its location on the network.

```
platform:
baremetal:
hosts:
- name: <hostname>
role: <master | worker>
bmc:
address: <address> ①
username: <user>
password: <password>
```

- ① The **address** configuration setting specifies the protocol.

For HPE integrated Lights Out (iLO), Red Hat supports Redfish virtual media, Redfish network boot, and IPMI.

**Table 3.10. BMC address formats for HPE iLO**

Protocol	Address Format
Redfish virtual media	<b>redfish-virtualmedia://&lt;out-of-band-ip&gt;/redfish/v1/Systems/1</b>
Redfish network boot	<b>redfish://&lt;out-of-band-ip&gt;/redfish/v1/Systems/1</b>
IPMI	<b>ipmi://&lt;out-of-band-ip&gt;</b>

See the following sections for additional details.

#### Redfish virtual media for HPE iLO

To enable Redfish virtual media for HPE servers, use **redfish-virtualmedia://** in the **address** setting. The following example demonstrates using Redfish virtual media within the **install-config.yaml** file.

```
platform:
baremetal:
hosts:
```

```

- name: openshift-master-0
  role: master
  bmc:
    address: redfish-virtualmedia://<out-of-band-ip>/redfish/v1/Systems/1
    username: <user>
    password: <password>
```

While it is recommended to have a certificate of authority for the out-of-band management addresses, you must include **disableCertificateVerification: True** in the **bmc** configuration if using self-signed certificates. The following example demonstrates a Redfish configuration using the **disableCertificateVerification: True** configuration parameter within the **install-config.yaml** file.

```

platform:
baremetal:
hosts:
- name: openshift-master-0
  role: master
  bmc:
    address: redfish-virtualmedia://<out-of-band-ip>/redfish/v1/Systems/1
    username: <user>
    password: <password>
    disableCertificateVerification: True
```



#### NOTE

Redfish virtual media is not supported on 9th generation systems running iLO4, because Ironic does not support iLO4 with virtual media.

#### Redfish network boot for HPE iLO

To enable Redfish, use **redfish://** or **redfish+http://** to disable TLS. The installer requires both the hostname or the IP address and the path to the system ID. The following example demonstrates a Redfish configuration within the **install-config.yaml** file.

```

platform:
baremetal:
hosts:
- name: openshift-master-0
  role: master
  bmc:
    address: redfish://<out-of-band-ip>/redfish/v1/Systems/1
    username: <user>
    password: <password>
```

While it is recommended to have a certificate of authority for the out-of-band management addresses, you must include **disableCertificateVerification: True** in the **bmc** configuration if using self-signed certificates. The following example demonstrates a Redfish configuration using the **disableCertificateVerification: True** configuration parameter within the **install-config.yaml** file.

```

platform:
baremetal:
hosts:
- name: openshift-master-0
  role: master
  bmc:
```

```
address: redfish://<out-of-band-ip>/redfish/v1/Systems/1
username: <user>
password: <password>
disableCertificateVerification: True
```

### 3.3.12.7. BMC addressing for Fujitsu iRMC

The **address** field for each **bmc** entry is a URL for connecting to the OpenShift Container Platform cluster nodes, including the type of controller in the URL scheme and its location on the network.

```
platform:
baremetal:
hosts:
- name: <hostname>
  role: <master | worker>
bmc:
  address: <address> ①
  username: <user>
  password: <password>
```

- ① The **address** configuration setting specifies the protocol.

For Fujitsu hardware, Red Hat supports integrated Remote Management Controller (iRMC) and IPMI.

Table 3.11. BMC address formats for Fujitsi iRMC

Protocol	Address Format
iRMC	irmc://<out-of-band-ip>
IPMI	ipmi://<out-of-band-ip>

#### iRMC

Fujitsu nodes can use **irmc://<out-of-band-ip>** and defaults to port **443**. The following example demonstrates an iRMC configuration within the **install-config.yaml** file.

```
platform:
baremetal:
hosts:
- name: openshift-master-0
  role: master
bmc:
  address: irmc://<out-of-band-ip>
  username: <user>
  password: <password>
```



#### NOTE

Currently Fujitsu supports iRMC S5 firmware version 3.05P and above for installer-provisioned installation on bare metal.

### 3.3.12.8. BMC addressing for Cisco CIMC

The **address** field for each **bmc** entry is a URL for connecting to the OpenShift Container Platform cluster nodes, including the type of controller in the URL scheme and its location on the network.

```
platform:
baremetal:
hosts:
- name: <hostname>
  role: <master | worker>
bmc:
  address: <address> ①
  username: <user>
  password: <password>
```

- ① The **address** configuration setting specifies the protocol.

For Cisco UCS C-Series and X-Series servers, Red Hat supports Cisco Integrated Management Controller (CIMC).

**Table 3.12. BMC address format for Cisco CIMC**

Protocol	Address Format
Redfish virtual media	<b>redfish-virtualmedia://&lt;server_kvm_ip&gt;/redfish/v1/Systems/&lt;serial_number&gt;</b>

To enable Redfish virtual media for Cisco UCS C-Series and X-Series servers, use **redfish-virtualmedia://** in the **address** setting. The following example demonstrates using Redfish virtual media within the **install-config.yaml** file.

```
platform:
baremetal:
hosts:
- name: openshift-master-0
  role: master
bmc:
  address: redfish-virtualmedia://<server_kvm_ip>/redfish/v1/Systems/<serial_number>
  username: <user>
  password: <password>
```

While it is recommended to have a certificate of authority for the out-of-band management addresses, you must include **disableCertificateVerification: True** in the **bmc** configuration if using self-signed certificates. The following example demonstrates a Redfish configuration by using the **disableCertificateVerification: True** configuration parameter within the **install-config.yaml** file.

```
platform:
baremetal:
hosts:
- name: openshift-master-0
  role: master
bmc:
  address: redfish-virtualmedia://<server_kvm_ip>/redfish/v1/Systems/<serial_number>
  disableCertificateVerification: true
```

```
username: <user>
password: <password>
disableCertificateVerification: True
```

### 3.3.12.9. Root device hints

The **rootDeviceHints** parameter enables the installer to provision the Red Hat Enterprise Linux CoreOS (RHCOS) image to a particular device. The installer examines the devices in the order it discovers them, and compares the discovered values with the hint values. The installer uses the first discovered device that matches the hint value. The configuration can combine multiple hints, but a device must match all hints for the installer to select it.

Table 3.13. Subfields

Subfield	Description
<b>deviceName</b>	<p>A string containing a Linux device name such as <code>/dev/vda</code> or <code>/dev/disk/by-path/</code>.</p> <p> <b>NOTE</b></p> <p>It is recommended to use the <code>/dev/disk/by-path/&lt;device_path&gt;</code> link to the storage location.</p> <p>The hint must match the actual value exactly.</p>
<b>hctl</b>	<p>A string containing a SCSI bus address like <b>0:0:0:0</b>. The hint must match the actual value exactly.</p>
<b>model</b>	<p>A string containing a vendor-specific device identifier. The hint can be a substring of the actual value.</p>
<b>vendor</b>	<p>A string containing the name of the vendor or manufacturer of the device. The hint can be a substring of the actual value.</p>
<b>serialNumber</b>	<p>A string containing the device serial number. The hint must match the actual value exactly.</p>
<b>minSizeGigabytes</b>	<p>An integer representing the minimum size of the device in gigabytes.</p>
<b>wwn</b>	<p>A string containing the unique storage identifier. The hint must match the actual value exactly.</p>
<b>wwnWithExtension</b>	<p>A string containing the unique storage identifier with the vendor extension appended. The hint must match the actual value exactly.</p>

Subfield	Description
<b>wwnVendorExtension</b>	A string containing the unique vendor storage identifier. The hint must match the actual value exactly.
<b>rotational</b>	A boolean indicating whether the device should be a rotating disk (true) or not (false).

## Example usage

```
- name: master-0
role: master
bmc:
  address: ipmi://10.10.0.3:6203
  username: admin
  password: redhat
bootMACAddress: de:ad:be:ef:00:40
rootDeviceHints:
  deviceName: "/dev/sda"
```

### 3.3.12.10. Setting proxy settings

To deploy an OpenShift Container Platform cluster while using a proxy, make the following changes to the **install-config.yaml** file.

#### Procedure

1. Add proxy values under the **proxy** key mapping:

```
apiVersion: v1
baseDomain: <domain>
proxy:
  httpProxy: http://USERNAME:PASSWORD@proxy.example.com:PORT
  httpsProxy: https://USERNAME:PASSWORD@proxy.example.com:PORT
  noProxy: <WILDCARD_OF_DOMAIN>,<PROVISIONING_NETWORK/CIDR>,
            <BMC_ADDRESS_RANGE/CIDR>
```

The following is an example of **noProxy** with values.

```
noProxy: .example.com,172.22.0.0/24,10.10.0.0/24
```

2. With a proxy enabled, set the appropriate values of the proxy in the corresponding key/value pair.

Key considerations:

- If the proxy does not have an HTTPS proxy, change the value of **httpsProxy** from **https://** to **http://**.
- If the cluster uses a provisioning network, include it in the **noProxy** setting, otherwise the installation program fails.

- Set all of the proxy settings as environment variables within the provisioner node. For example, **HTTP\_PROXY**, **HTTPS\_PROXY**, and **NO\_PROXY**.

### 3.3.12.11. Deploying with no provisioning network

To deploy an OpenShift Container Platform cluster without a **provisioning** network, make the following changes to the **install-config.yaml** file.

```
platform:
  baremetal:
    apiVIPs:
      - <api_VIP>
    ingressVIPs:
      - <ingress_VIP>
    provisioningNetwork: "Disabled" ①
```

- Add the **provisioningNetwork** configuration setting, if needed, and set it to **Disabled**.



#### IMPORTANT

The **provisioning** network is required for PXE booting. If you deploy without a **provisioning** network, you must use a virtual media BMC addressing option such as **redfish-virtualmedia** or **idrac-virtualmedia**. See "Redfish virtual media for HPE iLO" in the "BMC addressing for HPE iLO" section or "Redfish virtual media for Dell iDRAC" in the "BMC addressing for Dell iDRAC" section for additional details.

### 3.3.12.12. Deploying with dual-stack networking

For dual-stack networking in OpenShift Container Platform clusters, you can configure IPv4 and IPv6 address endpoints for cluster nodes. To configure IPv4 and IPv6 address endpoints for cluster nodes, edit the **machineNetwork**, **clusterNetwork**, and **serviceNetwork** configuration settings in the **install-config.yaml** file. Each setting must have two CIDR entries each. For a cluster with the IPv4 family as the primary address family, specify the IPv4 setting first. For a cluster with the IPv6 family as the primary address family, specify the IPv6 setting first.

```
machineNetwork:
  - cidr: {{ extcidrnet }}
  - cidr: {{ extcidrnet6 }}
clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  - cidr: fd02::/48
    hostPrefix: 64
serviceNetwork:
  - 172.30.0.0/16
  - fd03::/112
```



## IMPORTANT

On a bare-metal platform, if you specified an NMState configuration in the **networkConfig** section of your **install-config.yaml** file, add **interfaces.wait-ip: ipv4+ipv6** to the NMState YAML file to resolve an issue that prevents your cluster from deploying on a dual-stack network.

### Example NMState YAML configuration file that includes the `wait-ip` parameter

```
networkConfig:
  nmstate:
    interfaces:
      - name: <interface_name>
        # ...
        wait-ip: ipv4+ipv6
        # ...
```

To provide an interface to the cluster for applications that use IPv4 and IPv6 addresses, configure IPv4 and IPv6 virtual IP (VIP) address endpoints for the Ingress VIP and API VIP services. To configure IPv4 and IPv6 address endpoints, edit the **apiVIPs** and **ingressVIPs** configuration settings in the **install-config.yaml** file. The **apiVIPs** and **ingressVIPs** configuration settings use a list format. The order of the list indicates the primary and secondary VIP address for each service.

```
platform:
  baremetal:
    apiVIPs:
      - <api_ipv4>
      - <api_ipv6>
    ingressVIPs:
      - <wildcard_ipv4>
      - <wildcard_ipv6>
```



## NOTE

For a cluster with dual-stack networking configuration, you must assign both IPv4 and IPv6 addresses to the same interface.

### 3.3.12.13. Configuring host network interfaces

Before installation, you can set the **networkConfig** configuration setting in the **install-config.yaml** file to use NMState to configure host network interfaces.

The most common use case for this functionality is to specify a static IP address on the bare-metal network, but you can also configure other networks such as a storage network. This functionality supports other NMState features such as VLAN, VXLAN, bridges, bonds, routes, MTU, and DNS resolver settings.

## Prerequisites

- Configure a **PTR** DNS record with a valid hostname for each node with a static IP address.
- Install the NMState CLI (**nmstate**).



## IMPORTANT

If you use a provisioning network, configure it by using the **dnsmasq** tool in Ironic. To do a fully static deployment, you must use virtual media.

### Procedure

1. Optional: Consider testing the NMState syntax with **nmstatectl gc** before including the syntax in the **install-config.yaml** file, because the installation program does not check the NMState YAML syntax.



## NOTE

Errors in the YAML syntax might result in a failure to apply the network configuration. Additionally, maintaining the validated YAML syntax is useful when applying changes by using Kubernetes NMState after deployment or when expanding the cluster.

- a. Create an NMState YAML file:

```
interfaces: ①
- name: <nic1_name>
  type: ethernet
  state: up
  ipv4:
    address:
      - ip: <ip_address>
        prefix-length: 24
    enabled: true
  dns-resolver:
    config:
      server:
        - <dns_ip_address>
  routes:
    config:
      - destination: 0.0.0.0/0
        next-hop-address: <next_hop_ip_address>
        next-hop-interface: <next_hop_nic1_name>
```

- 1 Replace **<nic1\_name>**, **<ip\_address>**, **<dns\_ip\_address>**, **<next\_hop\_ip\_address>** and **<next\_hop\_nic1\_name>** with appropriate values.

- b. Test the configuration file by running the following command:

```
$ nmstatectl gc <nmstate_yaml_file>
```

Replace **<nmstate\_yaml\_file>** with the configuration file name.

2. Use the **networkConfig** configuration setting by adding the NMState configuration to hosts within the **install-config.yaml** file:

```
hosts:
- name: openshift-master-0
  role: master
```

```
bmc:
  address: redfish+http://<out_of_band_ip>/redfish/v1/Systems/
  username: <user>
  password: <password>
  disableCertificateVerification: null
bootMACAddress: <NIC1_mac_address>
bootMode: UEFI
rootDeviceHints:
  deviceName: "/dev/sda"
networkConfig: ①
  interfaces: ②
    - name: <nict1_name>
      type: ethernet
      state: up
      ipv4:
        address:
          - ip: <ip_address>
            prefix-length: 24
        enabled: true
  dns-resolver:
    config:
      server:
        - <dns_ip_address>
routes:
  config:
    - destination: 0.0.0.0/0
      next-hop-address: <next_hop_ip_address>
      next-hop-interface: <next_hop_nic1_name>
```

- ① Add the NMState YAML syntax to configure the host interfaces.
- ② Replace <nict1\_name>, <ip\_address>, <dns\_ip\_address>, <next\_hop\_ip\_address> and <next\_hop\_nic1\_name> with appropriate values.



### IMPORTANT

After deploying the cluster, you cannot modify the **networkConfig** configuration setting of **install-config.yaml** file to make changes to the host network interface. Use the Kubernetes NMState Operator to make changes to the host network interface after deployment.

#### 3.3.12.14. Configuring host network interfaces for subnets

For edge computing scenarios, it can be beneficial to locate compute nodes closer to the edge. To locate remote nodes in subnets, you might use different network segments or subnets for the remote nodes than you used for the control plane subnet and local compute nodes. You can reduce latency for the edge and allow for enhanced scalability by setting up subnets for edge computing scenarios.



## IMPORTANT

When using the default load balancer, **OpenShiftManagedDefault** and adding remote nodes to your OpenShift Container Platform cluster, all control plane nodes must run in the same subnet. When using more than one subnet, you can also configure the Ingress VIP to run on the control plane nodes by using a manifest. See "Configuring network components to run on the control plane" for details.

If you have established different network segments or subnets for remote nodes as described in the section on "Establishing communication between subnets", you must specify the subnets in the **machineNetwork** configuration setting if the workers are using static IP addresses, bonds or other advanced networking. When setting the node IP address in the **networkConfig** parameter for each remote node, you must also specify the gateway and the DNS server for the subnet containing the control plane nodes when using static IP addresses. This ensures that the remote nodes can reach the subnet containing the control plane and that they can receive network traffic from the control plane.



## NOTE

Deploying a cluster with multiple subnets requires using virtual media, such as **redfish-virtualmedia** or **idrac-virtualmedia**, because remote nodes cannot access the local provisioning network.

## Procedure

- 1 Add the subnets to the **machineNetwork** in the **install-config.yaml** file when using static IP addresses:

```
networking:
  machineNetwork:
    - cidr: 10.0.0.0/24
    - cidr: 192.168.0.0/24
  networkType: OVNKubernetes
```

- 2 Add the gateway and DNS configuration to the **networkConfig** parameter of each edge compute node using NMState syntax when using a static IP address or advanced networking such as bonds:

```
networkConfig:
  interfaces:
    - name: <interface_name> 1
      type: ethernet
      state: up
      ipv4:
        enabled: true
        dhcp: false
        address:
          - ip: <node_ip> 2
            prefix-length: 24
        gateway: <gateway_ip> 3
  dns-resolver:
    config:
      server:
        - <dns_ip> 4
```

- 1 Replace <interface\_name> with the interface name.
- 2 Replace <node\_ip> with the IP address of the node.
- 3 Replace <gateway\_ip> with the IP address of the gateway.
- 4 Replace <dns\_ip> with the IP address of the DNS server.

### 3.3.12.15. Configuring address generation modes for SLAAC in dual-stack networks

For dual-stack clusters that use Stateless Address AutoConfiguration (SLAAC), you must specify a global value for the **ipv6.addr-gen-mode** network setting. You can set this value using NMState to configure the RAM disk and the cluster configuration files. If you do not configure a consistent **ipv6.addr-gen-mode** in these locations, IPv6 address mismatches can occur between CSR resources and **BareMetalHost** resources in the cluster.

#### Prerequisites

- Install the NMState CLI (**nmstate**).

#### Procedure

- 1 Optional: Consider testing the NMState YAML syntax with the **nmstatectl gc** command before including it in the **install-config.yaml** file because the installation program will not check the NMState YAML syntax.

- a. Create an NMState YAML file:

```
interfaces:
- name: eth0
  ipv6:
    addr-gen-mode: <address_mode> ①
```

- 1 Replace <address\_mode> with the type of address generation mode required for IPv6 addresses in the cluster. Valid values are **eui64**, **stable-privacy**, or **random**.

- b. Test the configuration file by running the following command:

```
$ nmstatectl gc <nmstate_yaml_file> ①
```

- 1 Replace <nmstate\_yaml\_file> with the name of the test configuration file.

- 2 Add the NMState configuration to the **hosts.networkConfig** section within the **install-config.yaml** file:

```
hosts:
- name: openshift-master-0
  role: master
  bmc:
    address: redfish+http://<out_of_band_ip>/redfish/v1/Systems/
    username: <user>
    password: <password>
```

```

    disableCertificateVerification: null
bootMACAddress: <NIC1_mac_address>
bootMode: UEFI
rootDeviceHints:
  deviceName: "/dev/sda"
networkConfig:
  interfaces:
    - name: eth0
      ipv6:
        addr-gen-mode: <address_mode> ①
...

```

- ① Replace **<address\_mode>** with the type of address generation mode required for IPv6 addresses in the cluster. Valid values are **eui64**, **stable-privacy**, or **random**.

### 3.3.12.16. Configuring host network interfaces for dual port NIC

Before installation, you can set the **networkConfig** configuration setting in the **install-config.yaml** file to configure host network interfaces by using NMState to support dual port NIC.

OpenShift Virtualization only supports the following bond modes:

- mode=1 active-backup
- mode=2 balance-xor
- mode=4 802.3ad

#### Prerequisites

- Configure a **PTR** DNS record with a valid hostname for each node with a static IP address.
- Install the NMState CLI (**nmstate**).



#### NOTE

Errors in the YAML syntax might result in a failure to apply the network configuration. Additionally, maintaining the validated YAML syntax is useful when applying changes by using Kubernetes NMState after deployment or when expanding the cluster.

#### Procedure

1. Add the NMState configuration to the **networkConfig** field to hosts within the **install-config.yaml** file:

```

hosts:
  - name: worker-0
    role: worker
    bmc:
      address: redfish+http://<out_of_band_ip>/redfish/v1/Systems/
      username: <user>
      password: <password>
      disableCertificateVerification: false
    bootMACAddress: <NIC1_mac_address>

```

```
bootMode: UEFI
networkConfig: ①
  interfaces: ②
    - name: eno1 ③
      type: ethernet ④
      state: up
      mac-address: 0c:42:a1:55:f3:06
      ipv4:
        enabled: true
        dhcp: false ⑤
      ethernet:
        sr-iov:
          total-vfs: 2 ⑥
      ipv6:
        enabled: false
        dhcp: false
    - name: sriov:eno1:0
      type: ethernet
      state: up ⑦
      ipv4:
        enabled: false ⑧
      ipv6:
        enabled: false
    - name: sriov:eno1:1
      type: ethernet
      state: down
    - name: eno2
      type: ethernet
      state: up
      mac-address: 0c:42:a1:55:f3:07
      ipv4:
        enabled: true
      ethernet:
        sr-iov:
          total-vfs: 2
      ipv6:
        enabled: false
    - name: sriov:eno2:0
      type: ethernet
      state: up
      ipv4:
        enabled: false
      ipv6:
        enabled: false
    - name: sriov:eno2:1
      type: ethernet
      state: down
    - name: bond0
      type: bond
      state: up
      min-tx-rate: 100 ⑨
      max-tx-rate: 200 ⑩
      link-aggregation:
        mode: active-backup ⑪
        options:
```

```

primary: sriov:eno1:0 ⑫
port:
  - sriov:eno1:0
  - sriov:eno2:0
ipv4:
  address:
    - ip: 10.19.16.57 ⑬
      prefix-length: 23
  dhcp: false
  enabled: true
ipv6:
  enabled: false
dns-resolver:
  config:
    server:
      - 10.11.5.160
      - 10.2.70.215
routes:
  config:
    - destination: 0.0.0.0/0
      next-hop-address: 10.19.17.254
      next-hop-interface: bond0 ⑭
      table-id: 254

```

- ① The **networkConfig** field has information about the network configuration of the host, with subfields including **interfaces**, **dns-resolver**, and **routes**.
- ② The **interfaces** field is an array of network interfaces defined for the host.
- ③ The name of the interface.
- ④ The type of interface. This example creates a ethernet interface.
- ⑤ Set this to `false to disable DHCP for the physical function (PF) if it is not strictly required.
- ⑥ Set to the number of SR-IOV virtual functions (VFs) to instantiate.
- ⑦ Set this to **up**.
- ⑧ Set this to **false** to disable IPv4 addressing for the VF attached to the bond.
- ⑨ Sets a minimum transmission rate, in Mbps, for the VF. This sample value sets a rate of 100 Mbps.
  - This value must be less than or equal to the maximum transmission rate.
  - Intel NICs do not support the **min-tx-rate** parameter. For more information, see [BZ#1772847](#).
- ⑩ Sets a maximum transmission rate, in Mbps, for the VF. This sample value sets a rate of 200 Mbps.
- ⑪ Sets the desired bond mode.
- ⑫ Sets the preferred port of the bonding interface. The bond uses the primary device as the first device of the bonding interfaces. The bond does not abandon the primary device interface unless it fails. This setting is particularly useful when one NIC in the bonding

interface is faster and, therefore, able to handle a bigger load. This setting is only valid when the bonding interface is in active-backup mode (mode 1) and balance-tlb (mode 5).

- 13 Sets a static IP address for the bond interface. This is the node IP address.
- 14 Sets **bond0** as the gateway for the default route.



### IMPORTANT

After deploying the cluster, you cannot change the **networkConfig** configuration setting of the **install-config.yaml** file to make changes to the host network interface. Use the Kubernetes NMState Operator to make changes to the host network interface after deployment.

## Additional resources

- [Configuring network bonding](#)

### 3.3.12.17. Configuring multiple cluster nodes

You can simultaneously configure OpenShift Container Platform cluster nodes with identical settings. Configuring multiple cluster nodes avoids adding redundant information for each node to the **install-config.yaml** file. This file contains specific parameters to apply an identical configuration to multiple nodes in the cluster.

Compute nodes are configured separately from the controller node. However, configurations for both node types use the highlighted parameters in the **install-config.yaml** file to enable multi-node configuration. Set the **networkConfig** parameters to **BOND**, as shown in the following example:

```
hosts:
- name: ostest-master-0
[...]
networkConfig: &BOND
interfaces:
- name: bond0
  type: bond
  state: up
  ipv4:
    dhcp: true
    enabled: true
  link-aggregation:
    mode: active-backup
    port:
      - enp2s0
      - enp3s0
- name: ostest-master-1
[...]
networkConfig: *BOND
- name: ostest-master-2
[...]
networkConfig: *BOND
```

**NOTE**

Configuration of multiple cluster nodes is only available for initial deployments on installer-provisioned infrastructure.

### 3.3.12.18. Configuring managed Secure Boot

You can enable managed Secure Boot when deploying an installer-provisioned cluster using Redfish BMC addressing, such as **redfish**, **redfish-virtualmedia**, or **idrac-virtualmedia**. To enable managed Secure Boot, add the **bootMode** configuration setting to each node:

**Example**

```
hosts:
- name: openshift-master-0
  role: master
  bmc:
    address: redfish://<out_of_band_ip> ①
    username: <username>
    password: <password>
  bootMACAddress: <NIC1_mac_address>
  rootDeviceHints:
    deviceName: "/dev/sda"
  bootMode: UEFISecureBoot ②
```

- ① Ensure the **bmc.address** setting uses **redfish**, **redfish-virtualmedia**, or **idrac-virtualmedia** as the protocol. See "BMC addressing for HPE iLO" or "BMC addressing for Dell iDRAC" for additional details.
- ② The **bootMode** setting is **UEFI** by default. Change it to **UEFISecureBoot** to enable managed Secure Boot.

**NOTE**

See "Configuring nodes" in the "Prerequisites" to ensure the nodes can support managed Secure Boot. If the nodes do not support managed Secure Boot, see "Configuring nodes for Secure Boot manually" in the "Configuring nodes" section. Configuring Secure Boot manually requires Redfish virtual media.

**NOTE**

Red Hat does not support Secure Boot with IPMI, because IPMI does not provide Secure Boot management facilities.

### 3.3.13. Manifest configuration files

#### 3.3.13.1. Creating the OpenShift Container Platform manifests

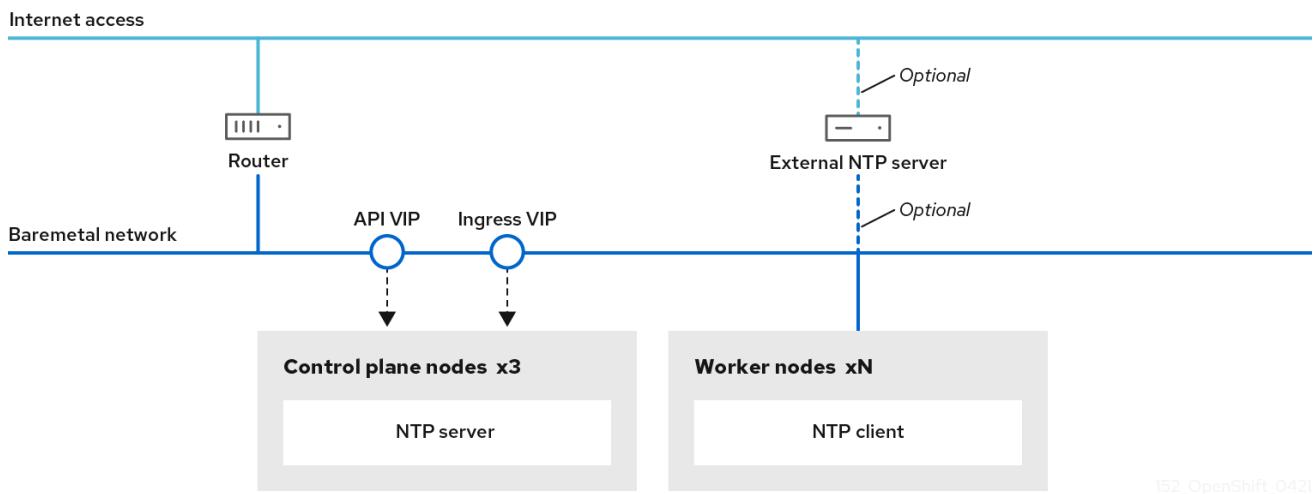
1. Create the OpenShift Container Platform manifests.

```
$ ./openshift-baremetal-install --dir ~/clusterconfigs create manifests
```

INFO Consuming Install Config from target directory  
 WARNING Making control-plane schedulable by setting `MastersSchedulable` to true for Scheduler cluster settings  
 WARNING Discarding the OpenShift Manifest that was provided in the target directory because its dependencies are dirty and it needs to be regenerated

### 3.3.13.2. Configuring NTP for disconnected clusters

OpenShift Container Platform installs the **chrony** Network Time Protocol (NTP) service on the cluster nodes.



OpenShift Container Platform nodes must agree on a date and time to run properly. When compute nodes retrieve the date and time from the NTP servers on the control plane nodes, it enables the installation and operation of clusters that are not connected to a routable network and thereby do not have access to a higher stratum NTP server.

#### Procedure

1. Install Butane on your installation host by using the following command:

```
$ sudo dnf -y install butane
```

2. Create a Butane config, **99-master-chrony-conf-override.bu**, including the contents of the **chrony.conf** file for the control plane nodes.



#### NOTE

See "Creating machine configs with Butane" for information about Butane.

#### Butane config example

```
variant: openshift
version: 4.18.0
metadata:
  name: 99-master-chrony-conf-override
  labels:
    machineconfiguration.openshift.io/role: master
```

```

storage:
files:
- path: /etc/chrony.conf
mode: 0644
overwrite: true
contents:
inline: |
# Use public servers from the pool.ntp.org project.
# Please consider joining the pool (https://www.pool.ntp.org/join.html).

# The Machine Config Operator manages this file
server openshift-master-0.<cluster-name>.<domain> iburst ①
server openshift-master-1.<cluster-name>.<domain> iburst
server openshift-master-2.<cluster-name>.<domain> iburst

stratumweight 0
driftfile /var/lib/chrony/drift
rtcsync
makestep 10 3
bindcmdaddress 127.0.0.1
bindcmdaddress ::1
keyfile /etc/chrony.keys
commandkey 1
generatecommandkey
noclientlog
logchange 0.5
logdir /var/log/chrony

# Configure the control plane nodes to serve as local NTP servers
# for all compute nodes, even if they are not in sync with an
# upstream NTP server.

# Allow NTP client access from the local network.
allow all
# Serve time even if not synchronized to a time source.
local stratum 3 orphan

```

- ① You must replace **<cluster-name>** with the name of the cluster and replace **<domain>** with the fully qualified domain name.

3. Use Butane to generate a **MachineConfig** object file, **99-master-chrony-conf-override.yaml**, containing the configuration to be delivered to the control plane nodes:

```
$ butane 99-master-chrony-conf-override.bu -o 99-master-chrony-conf-override.yaml
```

4. Create a Butane config, **99-worker-chrony-conf-override.bu**, including the contents of the **chrony.conf** file for the compute nodes that references the NTP servers on the control plane nodes.

### Butane config example

```

variant: openshift
version: 4.18.0
metadata:

```

```

name: 99-worker-chrony-conf-override
labels:
  machineconfiguration.openshift.io/role: worker
storage:
files:
- path: /etc/chrony.conf
  mode: 0644
  overwrite: true
  contents:
    inline: |
      # The Machine Config Operator manages this file.
      server openshift-master-0.<cluster-name>.<domain> iburst ①
      server openshift-master-1.<cluster-name>.<domain> iburst
      server openshift-master-2.<cluster-name>.<domain> iburst

      stratumweight 0
      driftfile /var/lib/chrony/drift
      rtcsync
      makestep 10 3
      bindcmdaddress 127.0.0.1
      bindcmdaddress ::1
      keyfile /etc/chrony.keys
      commandkey 1
      generatecommandkey
      noclientlog
      logchange 0.5
      logdir /var/log/chrony

```

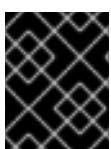
- ① You must replace <cluster-name> with the name of the cluster and replace <domain> with the fully qualified domain name.

5. Use Butane to generate a **MachineConfig** object file, **99-worker-chrony-conf-override.yaml**, containing the configuration to be delivered to the worker nodes:

```
$ butane 99-worker-chrony-conf-override.bu -o 99-worker-chrony-conf-override.yaml
```

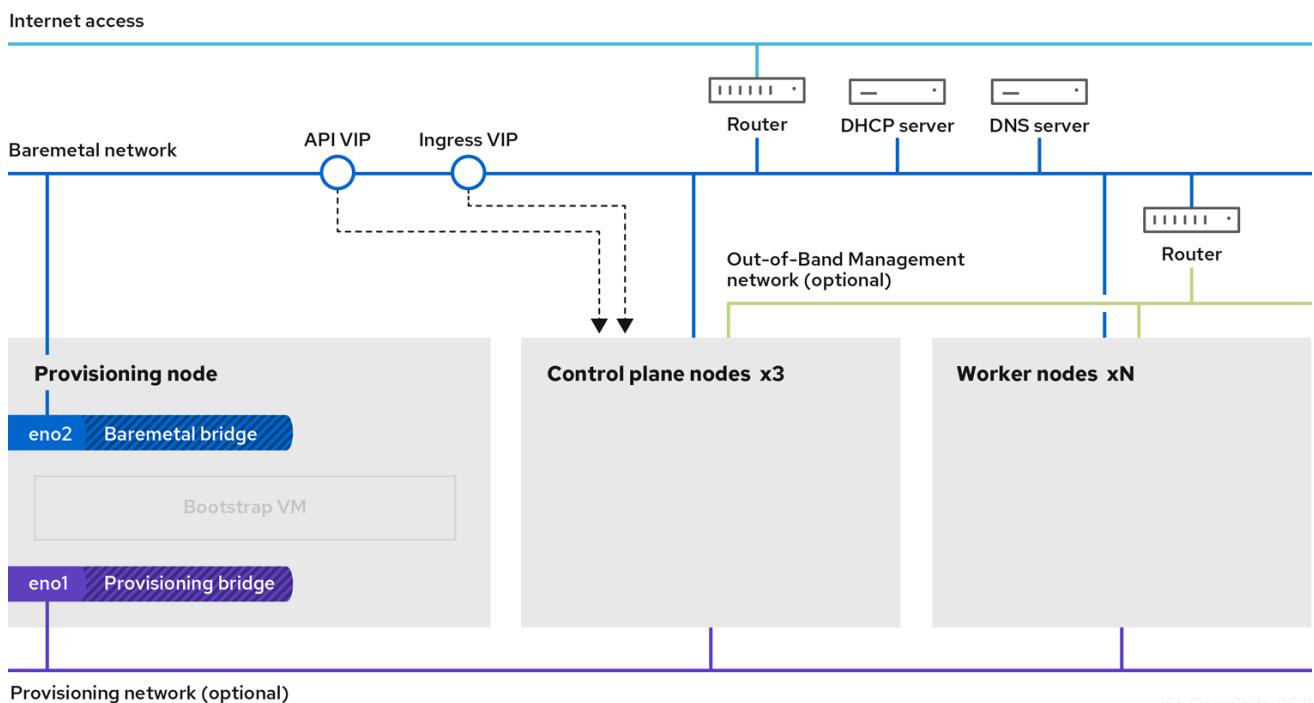
### 3.3.13.3. Configuring network components to run on the control plane

You can configure networking components to run exclusively on the control plane nodes. By default, OpenShift Container Platform allows any node in the machine config pool to host the **ingressVIP** virtual IP address. However, some environments deploy compute nodes in separate subnets from the control plane nodes, which requires configuring the **ingressVIP** virtual IP address to run on the control plane nodes.



#### IMPORTANT

When deploying remote nodes in separate subnets, you must place the **ingressVIP** virtual IP address exclusively with the control plane nodes.



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## Procedure

1. Change to the directory storing the **install-config.yaml** file:

```
$ cd ~/clusterconfigs
```

2. Switch to the **manifests** subdirectory:

```
$ cd manifests
```

3. Create a file named **cluster-network-avoid-workers-99-config.yaml**:

```
$ touch cluster-network-avoid-workers-99-config.yaml
```

4. Open the **cluster-network-avoid-workers-99-config.yaml** file in an editor and enter a custom resource (CR) that describes the Operator configuration:

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  name: 50-worker-fix-ipi-rwn
  labels:
    machineconfiguration.openshift.io/role: worker
spec:
  config:
    ignition:
      version: 3.2.0
    storage:
      files:
        - path: /etc/kubernetes/manifests/keepalived.yaml
```

```
mode: 0644
contents:
  source: data:,
```

This manifest places the **ingressVIP** virtual IP address on the control plane nodes. Additionally, this manifest deploys the following processes on the control plane nodes only:

- **openshift-ingress-operator**
- **keepalived**

5. Save the **cluster-network-avoid-workers-99-config.yaml** file.
6. Create a **manifests/cluster-ingress-default-ingresscontroller.yaml** file:

```
apiVersion: operator.openshift.io/v1
kind: IngressController
metadata:
  name: default
  namespace: openshift-ingress-operator
spec:
  nodePlacement:
    nodeSelector:
      matchLabels:
        node-role.kubernetes.io/master: ""
```

7. Consider backing up the **manifests** directory. The installer deletes the **manifests/** directory when creating the cluster.
8. Modify the **cluster-scheduler-02-config.yml** manifest to make the control plane nodes schedulable by setting the **mastersSchedulable** field to **true**. Control plane nodes are not schedulable by default. For example:

```
$ sed -i "s;mastersSchedulable: false;mastersSchedulable: true;g"
clusterconfigs/manifests/cluster-scheduler-02-config.yaml
```



#### NOTE

If control plane nodes are not schedulable after completing this procedure, deploying the cluster will fail.

#### 3.3.13.4. Deploying routers on compute nodes

During installation, the installation program deploys router pods on compute nodes. By default, the installation program installs two router pods. If a deployed cluster requires additional routers to handle external traffic loads destined for services within the OpenShift Container Platform cluster, you can create a **yaml** file to set an appropriate number of router replicas.



#### IMPORTANT

Deploying a cluster with only one compute node is not supported. While modifying the router replicas will address issues with the **degraded** state when deploying with one compute node, the cluster loses high availability for the ingress API, which is not suitable for production environments.

**NOTE**

By default, the installation program deploys two routers. If the cluster has no compute nodes, the installation program deploys the two routers on the control plane nodes by default.

**Procedure**

1. Create a **router-replicas.yaml** file:

```
apiVersion: operator.openshift.io/v1
kind: IngressController
metadata:
  name: default
  namespace: openshift-ingress-operator
spec:
  replicas: <num-of-router-pods>
  endpointPublishingStrategy:
    type: HostNetwork
  nodePlacement:
    nodeSelector:
      matchLabels:
        node-role.kubernetes.io/worker: ""
```

**NOTE**

Replace **<num-of-router-pods>** with an appropriate value. If working with just one compute node, set **replicas:** to **1**. If working with more than 3 compute nodes, you can increase **replicas:** from the default value **2** as appropriate.

2. Save and copy the **router-replicas.yaml** file to the **clusterconfigs/openshift** directory:

```
$ cp ~/router-replicas.yaml clusterconfigs/openshift/99_router-replicas.yaml
```

**3.3.13.5. Configuring the BIOS**

The following procedure configures the BIOS during the installation process.

**Procedure**

1. Create the manifests.
2. Modify the **BareMetalHost** resource file corresponding to the node:

```
$ vim clusterconfigs/openshift/99_openshift-cluster-api_hosts-* yaml
```

3. Add the BIOS configuration to the **spec** section of the **BareMetalHost** resource:

```
spec:
  firmware:
    simultaneousMultithreadingEnabled: true
    sriovEnabled: true
    virtualizationEnabled: true
```

**NOTE**

Red Hat supports three BIOS configurations. Only servers with BMC type **irmc** are supported. Other types of servers are currently not supported.

4. Create the cluster.

**Additional resources**

- [Configuration using the Bare Metal Operator](#)

**3.3.13.6. Configuring the RAID**

The following procedure configures a redundant array of independent disks (RAID) using baseboard management controllers (BMCs) during the installation process.

**NOTE**

If you want to configure a hardware RAID for the node, verify that the node has a supported RAID controller. OpenShift Container Platform 4.18 does not support software RAID.

**Table 3.14. Hardware RAID support by vendor**

Vendor	BMC and protocol	Firmware version	RAID levels
Fujitsu	iRMC	N/A	0, 1, 5, 6, and 10
Dell	iDRAC with Redfish	Version 6.10.30.20 or later	0, 1, and 5

**Procedure**

1. Create the manifests.
2. Modify the **BareMetalHost** resource corresponding to the node:

```
$ vim clusterconfigs/openshift/99_openshift-cluster-api_hosts-*.yaml
```

**NOTE**

The following example uses a hardware RAID configuration because OpenShift Container Platform 4.18 does not support software RAID.

- a. If you added a specific RAID configuration to the **spec** section, this causes the node to delete the original RAID configuration in the **preparing** phase and perform a specified configuration on the RAID. For example:

```
spec:
  raid:
    hardwareRAIDVolumes:
```

```

- level: "0" ①
  name: "sda"
  numberOfPhysicalDisks: 1
  rotational: true
  sizeGibibytes: 0

```

- ① **level** is a required field, and the others are optional fields.

- If you added an empty RAID configuration to the **spec** section, the empty configuration causes the node to delete the original RAID configuration during the **preparing** phase, but does not perform a new configuration. For example:

```

spec:
  raid:
    hardwareRAIDVolumes: []

```

- If you do not add a **raid** field in the **spec** section, the original RAID configuration is not deleted, and no new configuration will be performed.

- Create the cluster.

### 3.3.13.7. Configuring storage on nodes

You can make changes to operating systems on OpenShift Container Platform nodes by creating **MachineConfig** objects that are managed by the Machine Config Operator (MCO).

The **MachineConfig** specification includes an ignition config for configuring the machines at first boot. This config object can be used to modify files, systemd services, and other operating system features running on OpenShift Container Platform machines.

#### Procedure

Use the ignition config to configure storage on nodes. The following **MachineSet** manifest example demonstrates how to add a partition to a device on a primary node. In this example, apply the manifest before installation to have a partition named **recovery** with a size of 16 GiB on the primary node.

- Create a **custom-partitions.yaml** file and include a **MachineConfig** object that contains your partition layout:

```

apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: primary
  name: 10_primary_storage_config
spec:
  config:
    ignition:
      version: 3.2.0
    storage:
      disks:
        - device: </dev/xxN>
      partitions:
        - label: recovery
          startMiB: 32768

```

```

sizeMiB: 16384
filesystems:
- device: /dev/disk/by-partlabel/recovery
  label: recovery
  format: xfs

```

- Save and copy the **custom-partitions.yaml** file to the **clusterconfigs/openshift** directory:

```
$ cp ~/<MachineConfig_manifest> ~/clusterconfigs/openshift
```

## Additional resources

- [Configuration using the Bare Metal Operator](#)
- [Partition naming scheme](#)

### 3.3.14. Creating a disconnected registry

In some cases, you might want to install an OpenShift Container Platform cluster using a local copy of the installation registry. This could be for enhancing network efficiency because the cluster nodes are on a network that does not have access to the internet.

A local, or mirrored, copy of the registry requires the following:

- A certificate for the registry node. This can be a self-signed certificate.
- A web server that a container on a system will serve.
- An updated pull secret that contains the certificate and local repository information.



#### NOTE

Creating a disconnected registry on a registry node is optional. If you need to create a disconnected registry on a registry node, you must complete all of the following subsections.

## Prerequisites

- If you have already prepared a mirror registry for [Mirroring images for a disconnected installation](#), you can skip directly to [Modify the install-config.yaml file to use the disconnected registry](#).

### 3.3.14.1. Preparing the registry node to host the mirrored registry

The following steps must be completed prior to hosting a mirrored registry on bare metal.

## Procedure

- Open the firewall port on the registry node:

```
$ sudo firewall-cmd --add-port=5000/tcp --zone=libvirt --permanent
```

```
$ sudo firewall-cmd --add-port=5000/tcp --zone=public --permanent
```

```
$ sudo firewall-cmd --reload
```

2. Install the required packages for the registry node:

```
$ sudo yum -y install python3 podman httpd httpd-tools jq
```

3. Create the directory structure where the repository information will be held:

```
$ sudo mkdir -p /opt/registry/{auth,certs,data}
```

### 3.3.14.2. Mirroring the OpenShift Container Platform image repository for a disconnected registry

Complete the following steps to mirror the OpenShift Container Platform image repository for a disconnected registry.

#### Prerequisites

- Your mirror host has access to the internet.
- You configured a mirror registry to use in your restricted network and can access the certificate and credentials that you configured.
- You downloaded the [pull secret from Red Hat OpenShift Cluster Manager](#) and modified it to include authentication to your mirror repository.

#### Procedure

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

- a. Export the release version:

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

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

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

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

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

- c. Export the local repository name:

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

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

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

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

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

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

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

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

- f. Export the release mirror:

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

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

- g. Export the type of architecture for your cluster:

```
$ ARCHITECTURE=<cluster_architecture> ①
```

① Specify the architecture of the cluster, such as **x86\_64**, **aarch64**, **s390x**, or **ppc64le**.

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

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

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

### 3. Mirror the version images to the mirror registry:

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

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

ii. Review the images and configuration manifests to mirror:

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

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

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

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

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

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

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

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

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

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

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



#### NOTE

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

4. To create the installation program that is based on the content that you mirrored, extract it and pin it to the release:
    - If your mirror host does not have internet access, run the following command:
- ```
$ oc adm release extract -a ${LOCAL_SECRET_JSON} --command=openshift-
baremetal-install "${LOCAL_REGISTRY}/${LOCAL_REPOSITORY}:${OCP_RELEASE}"
```
- If the local container registry is connected to the mirror host, run the following command:

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



## IMPORTANT

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

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

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

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

```
$ openshift-baremetal-install
```

### 3.3.14.3. Modify the `install-config.yaml` file to use the disconnected registry

On the provisioner node, the **install-config.yaml** file should use the newly created pull-secret from the **pull-secret-update.txt** file. The **install-config.yaml** file must also contain the disconnected registry node's certificate and registry information.

#### Procedure

- Add the disconnected registry node's certificate to the **install-config.yaml** file:

```
$ echo "additionalTrustBundle: |" >> install-config.yaml
```

The certificate should follow the **"additionalTrustBundle: |"** line and be properly indented, usually by two spaces.

```
$ sed -e 's/^/ /' /opt/registry/certs/domain.crt >> install-config.yaml
```

- Add the mirror information for the registry to the **install-config.yaml** file:

```
$ echo "imageContentSources:" >> install-config.yaml
```

```
$ echo "- mirrors:" >> install-config.yaml
```

```
$ echo " - registry.example.com:5000/ocp4/openshift4" >> install-config.yaml
```

Replace **registry.example.com** with the registry's fully qualified domain name.

```
$ echo " source: quay.io/openshift-release-dev/ocp-release" >> install-config.yaml
```

```
$ echo "- mirrors:" >> install-config.yaml
```

```
$ echo " - registry.example.com:5000/ocp4/openshift4" >> install-config.yaml
```

Replace **registry.example.com** with the registry's fully qualified domain name.

```
$ echo " source: quay.io/openshift-release-dev/ocp-v4.0-art-dev" >> install-config.yaml
```

### 3.3.15. Validation checklist for installation

- OpenShift Container Platform installer has been retrieved.
- OpenShift Container Platform installer has been extracted.
- Required parameters for the **install-config.yaml** have been configured.
- The **hosts** parameter for the **install-config.yaml** has been configured.
- The **bmc** parameter for the **install-config.yaml** has been configured.
- Conventions for the values configured in the **bmc address** field have been applied.
- Created the OpenShift Container Platform manifests.
- (Optional) Deployed routers on compute nodes.
- (Optional) Created a disconnected registry.
- (Optional) Validate disconnected registry settings if in use.

## 3.4. INSTALLING A CLUSTER

### 3.4.1. Cleaning up previous installations

In case of an earlier failed deployment, remove the artifacts from the failed attempt before trying to deploy OpenShift Container Platform again.

#### Procedure

- Power off all bare-metal nodes before installing the OpenShift Container Platform cluster by using the following command:

```
$ ipmitool -I lanplus -U <user> -P <password> -H <management_server_ip> power off
```

- Remove all old bootstrap resources if any remain from an earlier deployment attempt by using the following script:

```
for i in $(sudo virsh list | tail -n +3 | grep bootstrap | awk {'print $2'});
do
    sudo virsh destroy $i;
    sudo virsh undefine $i;
    sudo virsh vol-delete $i --pool $i;
    sudo virsh vol-delete $i.ign --pool $i;
```

```
    sudo virsh pool-destroy $i;
    sudo virsh pool-undefine $i;
done
```

3. Delete the artifacts that the earlier installation generated by using the following command:

```
$ cd ; /bin/rm -rf auth/ bootstrap.ign master.ign worker.ign metadata.json \
.openshift_install.log .openshift_install_state.json
```

4. Re-create the OpenShift Container Platform manifests by using the following command:

```
$ ./openshift-baremetal-install --dir ~/clusterconfigs create manifests
```

### 3.4.2. Deploying the cluster via the OpenShift Container Platform installer

Run the OpenShift Container Platform installer:

```
$ ./openshift-baremetal-install --dir ~/clusterconfigs --log-level debug create cluster
```

### 3.4.3. Following the progress of the installation

During the deployment process, you can check the installation's overall status by issuing the **tail** command to the **.openshift\_install.log** log file in the install directory folder:

```
$ tail -f /path/to/install-dir/.openshift_install.log
```

### 3.4.4. Verifying static IP address configuration

If the DHCP reservation for a cluster node specifies an infinite lease, after the installer successfully provisions the node, the dispatcher script checks the node's network configuration. If the script determines that the network configuration contains an infinite DHCP lease, it creates a new connection using the IP address of the DHCP lease as a static IP address.



#### NOTE

The dispatcher script might run on successfully provisioned nodes while the provisioning of other nodes in the cluster is ongoing.

Verify the network configuration is working properly.

#### Procedure

1. Check the network interface configuration on the node.
2. Turn off the DHCP server and reboot the OpenShift Container Platform node and ensure that the network configuration works properly.

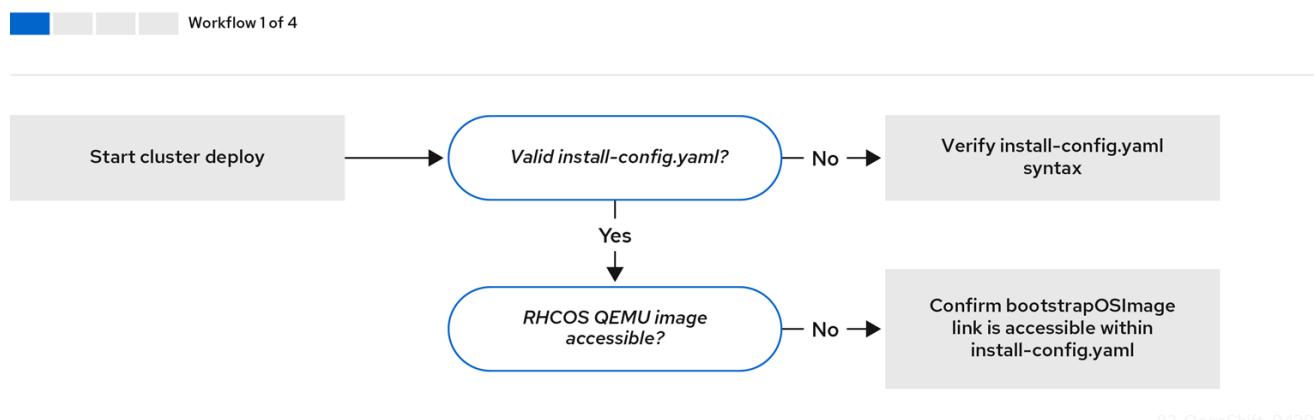
### 3.4.5. Additional resources

- Understanding update channels and releases

## 3.5. TROUBLESHOOTING THE INSTALLATION

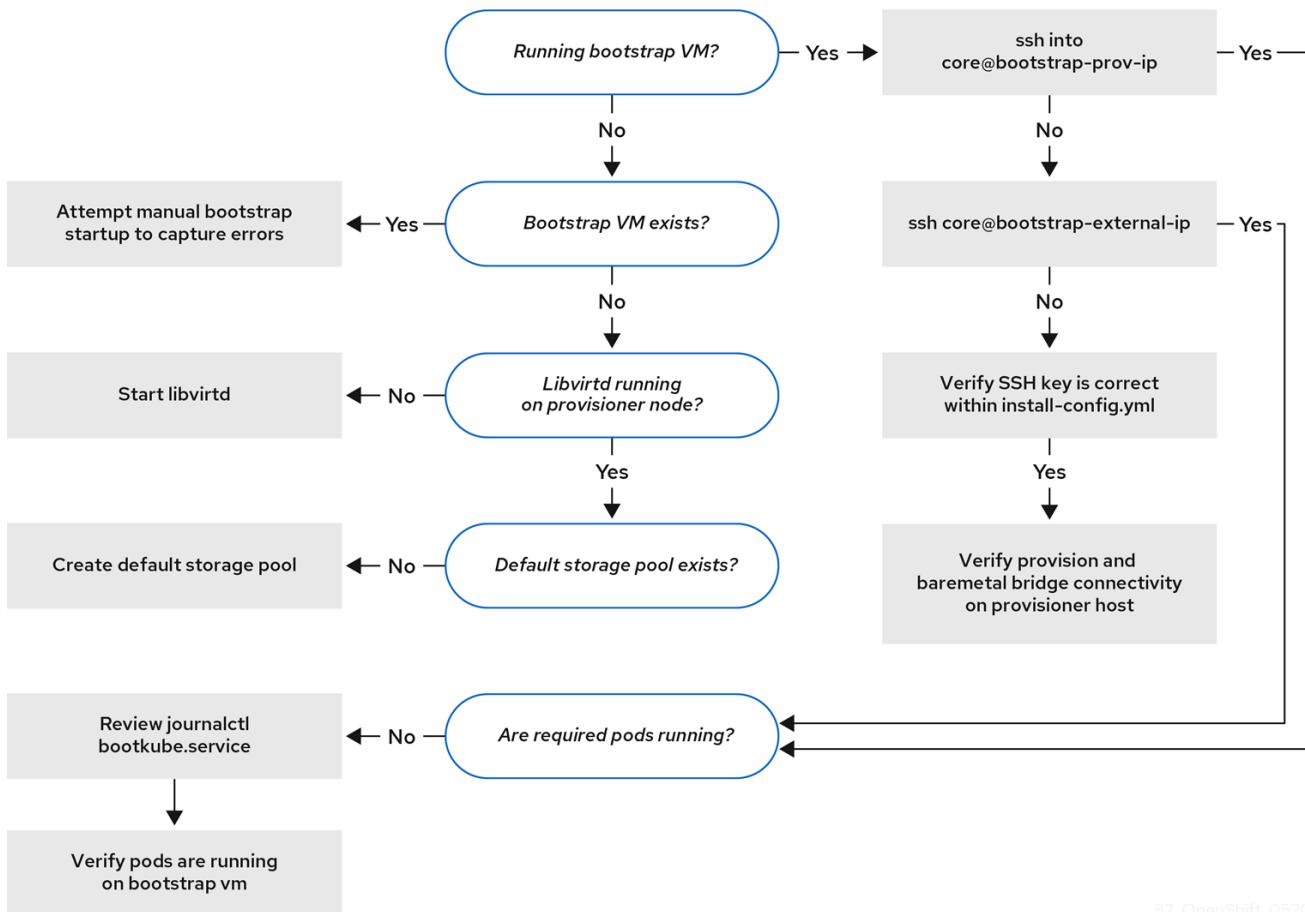
### 3.5.1. Troubleshooting the installation program workflow

Before troubleshooting the installation environment, it is critical to understand the overall flow of the installer-provisioned installation on bare metal. The following diagrams illustrate a troubleshooting flow with a step-by-step breakdown for the environment.



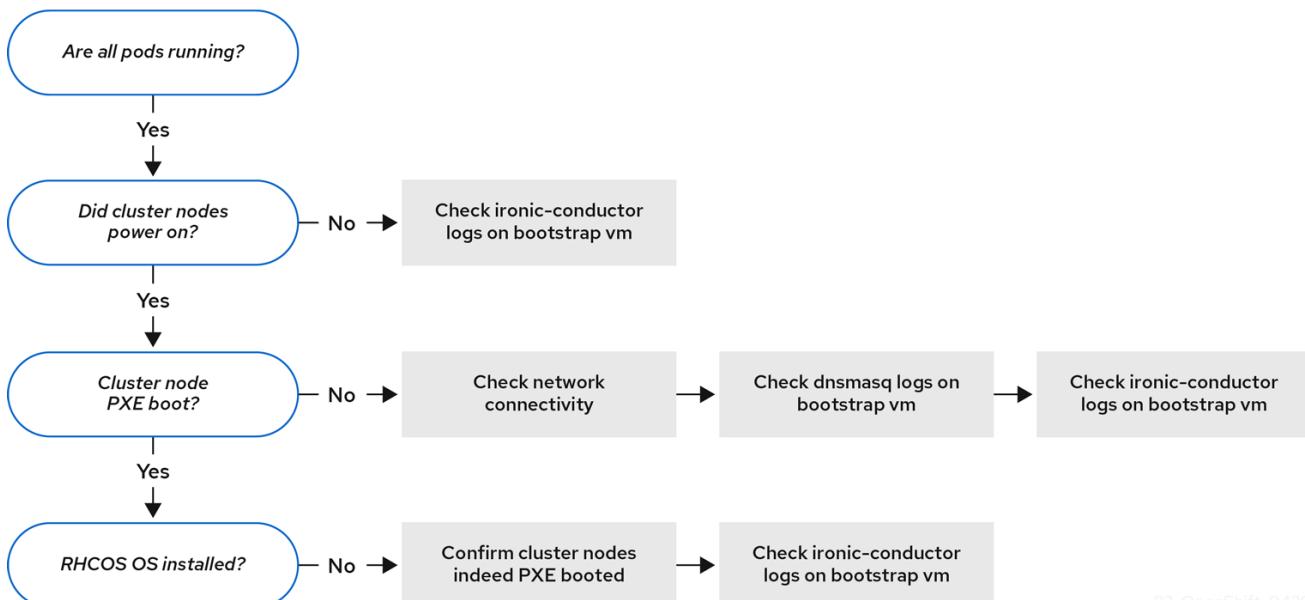
82\_OpenShift\_0420

Workflow 1 of 4 illustrates a troubleshooting workflow when the `install-config.yaml` file has errors or the Red Hat Enterprise Linux CoreOS (RHCOS) images are inaccessible. See [Troubleshooting `install-config.yaml`](#) for troubleshooting suggestions.


█ Workflow 2 of 4


82\_OpenShift\_0520

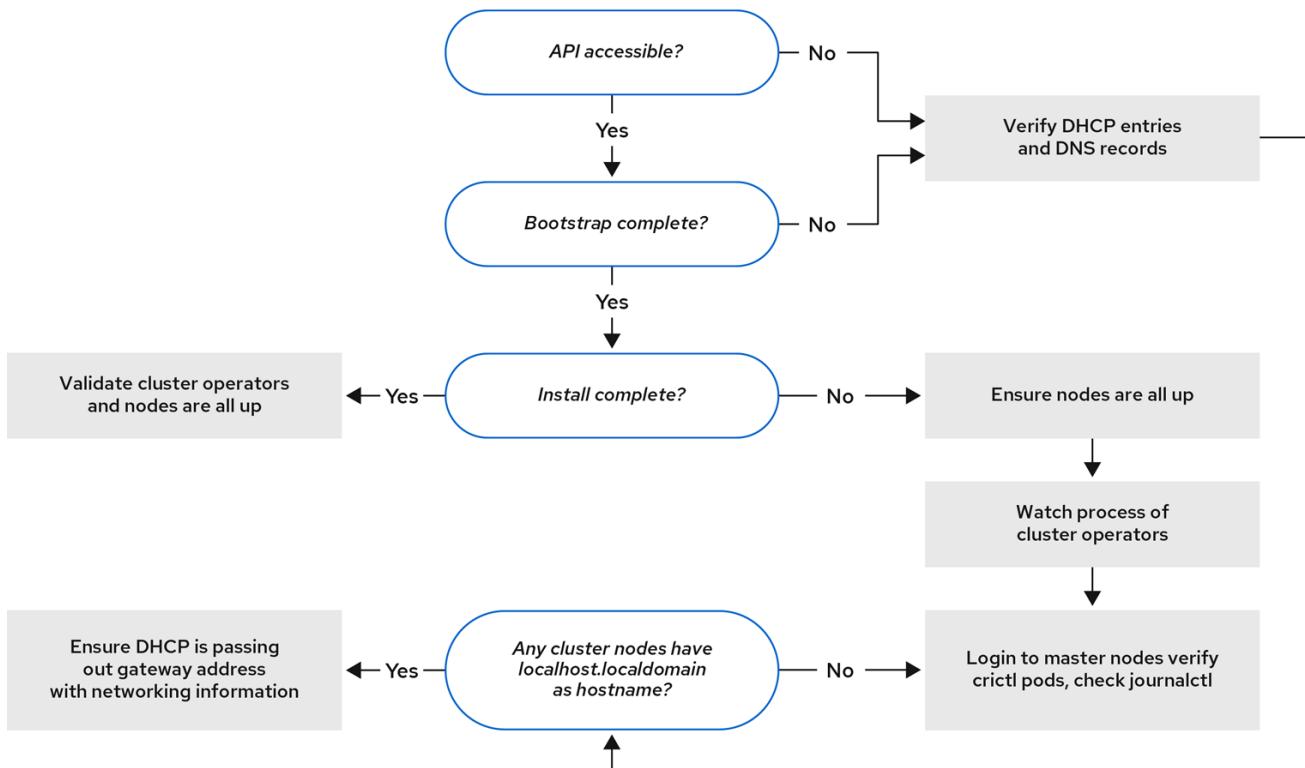
Workflow 2 of 4 illustrates a troubleshooting workflow for [bootstrap VM issues](#), [bootstrap VMs that cannot boot up the cluster nodes](#), and [inspecting logs](#). When installing an OpenShift Container Platform cluster without the **provisioning** network, this workflow does not apply.


█ Workflow 3 of 4


82\_OpenShift\_0420

*Workflow 3 of 4* illustrates a troubleshooting workflow for [cluster nodes that will not PXE boot](#). If installing using Redfish virtual media, each node must meet minimum firmware requirements for the installation program to deploy the node. See **Firmware requirements for installing with virtual media** in the **Prerequisites** section for additional details.

Workflow 4 of 4



82\_OpenShift\_0420

*Workflow 4 of 4* illustrates a troubleshooting workflow from [a non-accessible API](#) to a [validated installation](#).

### 3.5.2. Troubleshooting `install-config.yaml`

The **install-config.yaml** configuration file represents all of the nodes that are part of the OpenShift Container Platform cluster. The file contains the necessary options consisting of but not limited to **apiVersion**, **baseDomain**, **imageContentSources** and virtual IP addresses. If errors occur early in the deployment of the OpenShift Container Platform cluster, the errors are likely in the **install-config.yaml** configuration file.

#### Procedure

1. Use the guidelines in [YAML-tips](#).
2. Verify the YAML syntax is correct using [syntax-check](#).
3. Verify the Red Hat Enterprise Linux CoreOS (RHCOS) QEMU images are properly defined and accessible via the URL provided in the **install-config.yaml**. For example:

```
$ curl -s -o /dev/null -I -w "%{http_code}\n" http://webserver.example.com:8080/rhcos-44.81.202004250133-0-qemu.<architecture>.qcow2.gz?
sha256=7d884b46ee54fe87bbc3893bf2aa99af3b2d31f2e19ab5529c60636fb0f1ce7
```

If the output is **200**, there is a valid response from the webserver storing the bootstrap VM image.

### 3.5.3. Troubleshooting bootstrap VM issues

The OpenShift Container Platform installation program spawns a bootstrap node virtual machine, which handles provisioning the OpenShift Container Platform cluster nodes.

#### Procedure

1. About 10 to 15 minutes after triggering the installation program, check to ensure the bootstrap VM is operational using the **virsh** command:

```
$ sudo virsh list
```

| Id | Name                      | State   |
|----|---------------------------|---------|
| 12 | openshift-xf6fq-bootstrap | running |



#### NOTE

The name of the bootstrap VM is always the cluster name followed by a random set of characters and ending in the word "bootstrap."

2. If the bootstrap VM is not running after 10-15 minutes, verify **libvирtd** is running on the system by executing the following command:

```
$ systemctl status libvирtd
```

- libvирtd.service - Virtualization daemon
   
Loaded: loaded (/usr/lib/systemd/system/libvирtd.service; enabled; vendor preset: enabled)
   
Active: active (running) since Tue 2020-03-03 21:21:07 UTC; 3 weeks 5 days ago
   
Docs: man:libvирtd(8)
   
https://libvирt.org
   
Main PID: 9850 (libvирtd)
   
Tasks: 20 (limit: 32768)
   
Memory: 74.8M
   
CGroup: /system.slice/libvирtd.service
 └─ 9850 /usr/sbin/libvирtd

If the bootstrap VM is operational, log in to it.

3. Use the **virsh console** command to find the IP address of the bootstrap VM:

```
$ sudo virsh console example.com
```

```
Connected to domain example.com
Escape character is ^]
```

```
Red Hat Enterprise Linux CoreOS 43.81.202001142154.0 (Ootpa) 4.3
SSH host key: SHA256:BRWJktXZgQQRY5zjuAV0IKZ4WM7i4TiUyMVanqu9Pqg (ED25519)
SSH host key: SHA256:7+iKGA7VtG5szmk2jB5gl/5EZ+SNCJ3a2g23o0lnlio (ECDSA)
SSH host key: SHA256:DH5VWhvhvagOTaLsYiVNse9ca+ZSW/30OOMed8rlGOc (RSA)
ens3: fd35:919d:4042:2:c7ed:9a9f:a9ec:7
ens4: 172.22.0.2 fe80::1d05:e52e:be5d:263f
localhost login:
```



### IMPORTANT

When deploying an OpenShift Container Platform cluster without the **provisioning** network, you must use a public IP address and not a private IP address like **172.22.0.2**.

- After you obtain the IP address, log in to the bootstrap VM using the **ssh** command:



### NOTE

In the console output of the previous step, you can use the IPv6 IP address provided by **ens3** or the IPv4 IP provided by **ens4**.

```
$ ssh core@172.22.0.2
```

If you are not successful logging in to the bootstrap VM, you have likely encountered one of the following scenarios:

- You cannot reach the **172.22.0.0/24** network. Verify the network connectivity between the provisioner and the **provisioning** network bridge. This issue might occur if you are using a **provisioning** network.
- You cannot reach the bootstrap VM through the public network. When attempting to SSH via **baremetal** network, verify connectivity on the **provisioner** host specifically around the **baremetal** network bridge.
- You encountered **Permission denied (publickey,password,keyboard-interactive)**. When attempting to access the bootstrap VM, a **Permission denied** error might occur. Verify that the SSH key for the user attempting to log in to the VM is set within the **install-config.yaml** file.

#### 3.5.3.1. Bootstrap VM cannot boot up the cluster nodes

During the deployment, it is possible for the bootstrap VM to fail to boot the cluster nodes, which prevents the VM from provisioning the nodes with the RHCOS image. This scenario can arise due to:

- A problem with the **install-config.yaml** file.
- Issues with out-of-band network access when using the baremetal network.

To verify the issue, there are three containers related to **ironic**:

- ironic**
- ironic-inspector**

## Procedure

1. Log in to the bootstrap VM:

```
$ ssh core@172.22.0.2
```

2. To check the container logs, execute the following:

```
[core@localhost ~]$ sudo podman logs -f <container_name>
```

Replace **<container\_name>** with one of **ironic** or **ironic-inspector**. If you encounter an issue where the control plane nodes are not booting up from PXE, check the **ironic** pod. The **ironic** pod contains information about the attempt to boot the cluster nodes, because it attempts to log in to the node over IPMI.

## Potential reason

The cluster nodes might be in the **ON** state when deployment started.

## Solution

Power off the OpenShift Container Platform cluster nodes before you begin the installation over IPMI:

```
$ ipmitool -I lanplus -U root -P <password> -H <out_of_band_ip> power off
```

### 3.5.3.2. Inspecting logs

When experiencing issues downloading or accessing the RHCOS images, first verify that the URL is correct in the **install-config.yaml** configuration file.

#### Example of internal webserver hosting RHCOS images

```
bootstrapOSImage: http://<ip:port>/rhcos-43.81.202001142154.0-qemu.<architecture>.qcow2.gz?
sha256=9d999f55ff1d44f7ed7c106508e5deecd04dc3c06095d34d36bf1cd127837e0c
clusterOSImage: http://<ip:port>/rhcos-43.81.202001142154.0-openstack.<architecture>.qcow2.gz?
sha256=a1bda656fa0892f7b936fdc6b6a6086bddaed5dafacedcd7a1e811abb78fe3b0
```

The **coreos-downloader** container downloads resources from a webserver or from the external [quay.io](#) registry, whichever the **install-config.yaml** configuration file specifies. Verify that the **coreos-downloader** container is up and running and inspect its logs as needed.

## Procedure

1. Log in to the bootstrap VM:

```
$ ssh core@172.22.0.2
```

2. Check the status of the **coreos-downloader** container within the bootstrap VM by running the following command:

```
[core@localhost ~]$ sudo podman logs -f coreos-downloader
```

If the bootstrap VM cannot access the URL to the images, use the **curl** command to verify that the VM can access the images.

3. To inspect the **bootkube** logs that indicate if all the containers launched during the deployment phase, execute the following:

```
[core@localhost ~]$ journalctl -xe
```

```
[core@localhost ~]$ journalctl -b -f -u bootkube.service
```

4. Verify all the pods, including **dnsmasq**, **mariadb**, **httpd**, and **ironic**, are running:

```
[core@localhost ~]$ sudo podman ps
```

5. If there are issues with the pods, check the logs of the containers with issues. To check the logs of the **ironic** service, run the following command:

```
[core@localhost ~]$ sudo podman logs ironic
```

### 3.5.4. Investigating an unavailable Kubernetes API

When the Kubernetes API is unavailable, check the control plane nodes to ensure that they are running the correct components. Also, check the hostname resolution.

#### Procedure

1. Ensure that **etcd** is running on each of the control plane nodes by running the following command:

```
$ sudo crictl logs $(sudo crictl ps --pod=$(sudo crictl pods --name=etcd-member --quiet) --quiet)
```

2. If the previous command fails, ensure that Kubelet created the **etcd** pods by running the following command:

```
$ sudo crictl pods --name=etcd-member
```

If there are no pods, investigate **etcd**.

3. Check the cluster nodes to ensure they have a fully qualified domain name, and not just **localhost.localdomain**, by using the following command:

```
$ hostname
```

If a hostname is not set, set the correct hostname. For example:

```
$ sudo hostnamectl set-hostname <hostname>
```

4. Ensure that each node has the correct name resolution in the DNS server using the **dig** command:

```
$ dig api.<cluster_name>.example.com
```

```
; <>> DiG 9.11.4-P2-RedHat-9.11.4-26.P2.el8 <>> api.<cluster_name>.example.com
;; global options: +cmd
```

```

;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 37551
;; flags: qr aa rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 1, ADDITIONAL: 2

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 4096
; COOKIE: 866929d2f8e8563582af23f05ec44203d313e50948d43f60 (good)
;; QUESTION SECTION:
;api.<cluster_name>.example.com. IN A

;; ANSWER SECTION:
api.<cluster_name>.example.com. 10800 IN A 10.19.13.86

;; AUTHORITY SECTION:
<cluster_name>.example.com. 10800 IN NS <cluster_name>.example.com.

;; ADDITIONAL SECTION:
<cluster_name>.example.com. 10800 IN A 10.19.14.247

;; Query time: 0 msec
;; SERVER: 10.19.14.247#53(10.19.14.247)
;; WHEN: Tue May 19 20:30:59 UTC 2020
;; MSG SIZE rcvd: 140

```

The output in the foregoing example indicates that the appropriate IP address for the **api**.  
**<cluster\_name>.example.com** VIP is **10.19.13.86**. This IP address should reside on the **baremetal** network.

### 3.5.5. Troubleshooting a failure to initialize the cluster

The installation program uses the Cluster Version Operator to create all the components of an OpenShift Container Platform cluster. When the installation program fails to initialize the cluster, you can retrieve the most important information from the **ClusterVersion** and **ClusterOperator** objects.

#### Procedure

1. Inspect the **ClusterVersion** object by running the following command:

```
$ oc --kubeconfig=${INSTALL_DIR}/auth/kubeconfig get clusterversion -o yaml
```

#### Example output

```

apiVersion: config.openshift.io/v1
kind: ClusterVersion
metadata:
  creationTimestamp: 2019-02-27T22:24:21Z
  generation: 1
  name: version
  resourceVersion: "19927"
  selfLink: /apis/config.openshift.io/v1/clusterversions/version
  uid: 6e0f4cf8-3ade-11e9-9034-0a923b47ded4
spec:
  channel: stable-4.1
  clusterID: 5ec312f9-f729-429d-a454-61d4906896ca
  status:

```

```

availableUpdates: null
conditions:
- lastTransitionTime: 2019-02-27T22:50:30Z
  message: Done applying 4.1.1
  status: "True"
  type: Available
- lastTransitionTime: 2019-02-27T22:50:30Z
  status: "False"
  type: Failing
- lastTransitionTime: 2019-02-27T22:50:30Z
  message: Cluster version is 4.1.1
  status: "False"
  type: Progressing
- lastTransitionTime: 2019-02-27T22:24:31Z
  message: 'Unable to retrieve available updates: unknown version 4.1.1
  reason: RemoteFailed
  status: "False"
  type: RetrievedUpdates
desired:
  image: registry.svc.ci.openshift.org/openshift/origin-
release@sha256:91e6f754975963e7db1a9958075eb609ad226968623939d262d1cf45e9dbc3
9a
  version: 4.1.1
history:
- completionTime: 2019-02-27T22:50:30Z
  image: registry.svc.ci.openshift.org/openshift/origin-
release@sha256:91e6f754975963e7db1a9958075eb609ad226968623939d262d1cf45e9dbc3
9a
  startedTime: 2019-02-27T22:24:31Z
  state: Completed
  version: 4.1.1
  observedGeneration: 1
  versionHash: Wa7as_ik1qE=

```

- View the conditions by running the following command:

```
$ oc --kubeconfig=${INSTALL_DIR}/auth/kubeconfig get clusterversion version \
-o=jsonpath='{range .status.conditions[*]}{.type}{" "}{.status}{" "}{.message}{"\n"}{end}'
```

Some of most important conditions include **Failing**, **Available** and **Progressing**.

### Example output

```

Available True Done applying 4.1.1
Failing False
Progressing False Cluster version is 4.0.0-0.alpha-2019-02-26-194020
RetrievedUpdates False Unable to retrieve available updates: unknown version 4.1.1

```

- Inspect the **ClusterOperator** object by running the following command:

```
$ oc --kubeconfig=${INSTALL_DIR}/auth/kubeconfig get clusteroperator
```

The command returns the status of the cluster Operators.

### Example output

| NAME                                | VERSION | AVAILABLE | PROGRESSING | FAILING | SINCE |
|-------------------------------------|---------|-----------|-------------|---------|-------|
| cluster-baremetal-operator          |         | True      | False       | False   | 17m   |
| cluster-autoscaler                  |         | True      | False       | False   | 17m   |
| cluster-storage-operator            |         | True      | False       | False   | 10m   |
| console                             |         | True      | False       | False   | 7m21s |
| dns                                 |         | True      | False       | False   | 31m   |
| image-registry                      |         | True      | False       | False   | 9m58s |
| ingress                             |         | True      | False       | False   | 10m   |
| kube-apiserver                      |         | True      | False       | False   | 28m   |
| kube-controller-manager             |         | True      | False       | False   | 21m   |
| kube-scheduler                      |         | True      | False       | False   | 25m   |
| machine-api                         |         | True      | False       | False   | 17m   |
| machine-config                      |         | True      | False       | False   | 17m   |
| marketplace-operator                |         | True      | False       | False   | 10m   |
| monitoring                          |         | True      | False       | False   | 8m23s |
| network                             |         | True      | False       | False   | 13m   |
| node-tuning                         |         | True      | False       | False   | 11m   |
| openshift-apiserver                 |         | True      | False       | False   | 15m   |
| openshift-authentication            |         | True      | False       | False   | 20m   |
| openshift-cloud-credential-operator |         | True      | False       | False   | 18m   |
| openshift-controller-manager        |         | True      | False       | False   | 10m   |
| openshift-samples                   |         | True      | False       | False   | 8m42s |
| operator-lifecycle-manager          |         | True      | False       | False   | 17m   |
| service-ca                          |         | True      | False       | False   | 30m   |

4. Inspect individual cluster Operators by running the following command:

\$ oc --kubeconfig=\${INSTALL\_DIR}/auth/kubeconfig get clusteroperator <operator> -oyaml

1

- 1 Replace <operator> with the name of a cluster Operator. This command is useful for identifying why an cluster Operator has not achieved the **Available** state or is in the **Failed** state.

### Example output

```
apiVersion: config.openshift.io/v1
kind: ClusterOperator
metadata:
  creationTimestamp: 2019-02-27T22:47:04Z
  generation: 1
  name: monitoring
  resourceVersion: "24677"
  selfLink: /apis/config.openshift.io/v1/clusteroperators/monitoring
  uid: 9a6a5ef9-3ae1-11e9-bad4-0a97b6ba9358
spec: {}
status:
  conditions:
    - lastTransitionTime: 2019-02-27T22:49:10Z
      message: Successfully rolled out the stack.
      status: "True"
      type: Available
    - lastTransitionTime: 2019-02-27T22:49:10Z
      status: "False"
```

```

type: Progressing
- lastTransitionTime: 2019-02-27T22:49:10Z
status: "False"
type: Failing
extension: null
relatedObjects: null
version: ""

```

- To get the cluster Operator's status condition, run the following command:

```
$ oc --kubeconfig=${INSTALL_DIR}/auth/kubeconfig get clusteroperator <operator> \
-o=jsonpath='{range .status.conditions[*]}{.type}" "}{.status}" "}{.message}" "\n"}{end}'
```

Replace **<operator>** with the name of one of the operators above.

#### Example output

```

Available True Successfully rolled out the stack
Progressing False
Failing False

```

- To retrieve the list of objects owned by the cluster Operator, execute the following command:

```
oc --kubeconfig=${INSTALL_DIR}/auth/kubeconfig get clusteroperator kube-apiserver \
-o=jsonpath='{.status.relatedObjects}'
```

#### Example output

```

[map[resource:kubeapiservers group:operator.openshift.io name:cluster] map[group:
name:openshift-config resource:namespaces] map[group: name:openshift-config-managed
resource:namespaces] map[group: name:openshift-kube-apiserver-operator
resource:namespaces] map[group: name:openshift-kube-apiserver resource:namespaces]]

```

### 3.5.6. Troubleshooting a failure to fetch the console URL

The installation program retrieves the URL for the OpenShift Container Platform console by using **[route][route-object]** within the **openshift-console** namespace. If the installation program fails to retrieve the URL for the console, use the following procedure.

#### Procedure

- Check if the console router is in the **Available** or **Failing** state by running the following command:

```
$ oc --kubeconfig=${INSTALL_DIR}/auth/kubeconfig get clusteroperator console -oyaml
```

```

apiVersion: config.openshift.io/v1
kind: ClusterOperator
metadata:
  creationTimestamp: 2019-02-27T22:46:57Z
  generation: 1
  name: console
  resourceVersion: "19682"

```

```

selfLink: /apis/config.openshift.io/v1/clusteroperators/console
uid: 960364aa-3ae1-11e9-bad4-0a97b6ba9358
spec: {}
status:
  conditions:
    - lastTransitionTime: 2019-02-27T22:46:58Z
      status: "False"
      type: Failing
    - lastTransitionTime: 2019-02-27T22:50:12Z
      status: "False"
      type: Progressing
    - lastTransitionTime: 2019-02-27T22:50:12Z
      status: "True"
      type: Available
    - lastTransitionTime: 2019-02-27T22:46:57Z
      status: "True"
      type: Upgradeable
  extension: null
  relatedObjects:
    - group: operator.openshift.io
      name: cluster
      resource: consoles
    - group: config.openshift.io
      name: cluster
      resource: consoles
    - group: oauth.openshift.io
      name: console
      resource: oauthclients
    - group: ""
      name: openshift-console-operator
      resource: namespaces
    - group: ""
      name: openshift-console
      resource: namespaces
  versions: null

```

2. Manually retrieve the console URL by executing the following command:

```
$ oc --kubeconfig=${INSTALL_DIR}/auth/kubeconfig get route console -n openshift-console \
-o=jsonpath='{.spec.host}' console-openshift-console.apps.adahiya-1.devcluster.openshift.com
```

### 3.5.7. Troubleshooting a failure to add the ingress certificate to kubeconfig

The installation program adds the default ingress certificate to the list of trusted client certificate authorities in  **\${INSTALL\_DIR}/auth/kubeconfig**. If the installation program fails to add the ingress certificate to the **kubeconfig** file, you can retrieve the certificate from the cluster and add it.

#### Procedure

1. Retrieve the certificate from the cluster using the following command:

```
$ oc --kubeconfig=${INSTALL_DIR}/auth/kubeconfig get configmaps default-ingress-cert \
-n openshift-config-managed -o=jsonpath='{.data.ca-bundle\.crt}'
```

```

-----BEGIN CERTIFICATE-----
MIIC/TCCAeWgAwIBAgIBATANBgkqhkiG9w0BAQsFADuMSwwKgYDVQQDCNjbHVz
dGVyLWluZ3Jlc3Mtb3BlcmF0b3JAMTU1MTMwNzU4OTAEfW0xOTAyMjcyMjQ2Mjha
Fw0yMTAyMjYyMjQ2MjlaMC4xLDAqBgvNBAMMI2NsdXN0ZXItaW5ncmVzcy1vcGVy
YXRvckAxNTUxMzA3NTg5MIIBljANBqkqhkiG9w0BAQEFAOCAQ8AMIIBCgKCAQEA
uCA4fQ+2YXoXSUL4h/mcvJfrgpBfKBW5hfB8NcgXeCYiQPnCKblH1sEQnI3VC5Pk
2OfNCF3PUlfm4i8CHC95a7nCkRjmNg1gVrWCvS/oLgnO0BvszSiRLxIpuo3C4S
EVqqvxValHcbdAXWgZLQoYZXV7RMz8yZjI5CfhDaaltyBFj3GtIjkXgUwp/5sUfI
LDXW8MM6AXfuG+kweLdLCMm3g8WLLfLBLvVBKB+4IhIH7lI0buOz04RKhnYN+Ebw
tcvFi55vvuUCWMnGhWHGEQ8sWm/wLnNIowsUz7S1/sW8nj87GFHzgkaVM9EOnoNI
gKhMBK9ltNzjrP6dgiKBCQIDAQABoyYwJDAOBgvNVHQ8BAf8EBAMCAqQwEgYDVR0T
AQH/BAgwBgEB/wIBADANBgkqhkiG9w0BAQsFAAOCAQEAq+vi0sFKudaZ9aUQMMha
CeWx9CZvZBblnAWT/61UdpZKpFi4eJ2d33IGcfKwHOi2NP/ISQBebfG0iNLVVPz
vwLbSG1i9R9GLdAbnHpPT9UG6fLaDloKpnKiBfGENfxeiq5vTln2bAgivxrVlyiq
+MdDXFAWb6V4u2xh6RChI7akNsS3oU9PZ9YOs5e8vJp2YAEphht05X0swA+X8V8T
C278FFifpo0h3Q0Dbv8Rfn4UpBEtN4KkLeS+JeT+0o2XOsFZp7Uhr9yFlodRsnNo
H/Uwmab28ocNrGNiEVaVH6eTTQeeZuOdoQzUbCIElpVmkrNGY0M42K0PvOQ/e7+y
AQ==

-----END CERTIFICATE-----

```

- Add the certificate to the **client-certificate-authority-data** field in the `$(INSTALL_DIR)/auth/kubeconfig` file.

### 3.5.8. Troubleshooting SSH access to cluster nodes

For added security, you cannot SSH into the cluster from outside the cluster by default. However, you can access control plane and worker nodes from the provisioner node. If you cannot SSH into the cluster nodes from the provisioner node, the nodes might be waiting on the bootstrap VM. The control plane nodes retrieve their boot configuration from the bootstrap VM, and they cannot boot successfully if they do not retrieve the boot configuration.

#### Procedure

- If you have physical access to the nodes, check their console output to determine if they have successfully booted. If the nodes are still retrieving their boot configuration, there might be problems with the bootstrap VM .
- Ensure you have configured the **sshKey: '<ssh\_pub\_key>'** setting in the `install-config.yaml` file, where `<ssh_pub_key>` is the public key of the **kni** user on the provisioner node.

### 3.5.9. Cluster nodes will not PXE boot

When OpenShift Container Platform cluster nodes will not PXE boot, execute the following checks on the cluster nodes that will not PXE boot. This procedure does not apply when installing an OpenShift Container Platform cluster without the **provisioning** network.

#### Procedure

- Check the network connectivity to the **provisioning** network.
- Ensure PXE is enabled on the NIC for the **provisioning** network and PXE is disabled for all other NICs.
- Verify that the `install-config.yaml` configuration file includes the **rootDeviceHints** parameter and boot MAC address for the NIC connected to the **provisioning** network. For example:

## control plane node settings

```
bootMACAddress: 24:6E:96:1B:96:90 # MAC of bootable provisioning NIC
```

## Worker node settings

```
bootMACAddress: 24:6E:96:1B:96:90 # MAC of bootable provisioning NIC
```

### 3.5.10. Installing creates no worker nodes

The installation program does not provision worker nodes directly. Instead, the Machine API Operator scales nodes up and down on supported platforms. If worker nodes are not created after 15 to 20 minutes, depending on the speed of the cluster’s internet connection, investigate the Machine API Operator.

#### Procedure

- Check the Machine API Operator by running the following command:

```
$ oc --kubeconfig=${INSTALL_DIR}/auth/kubeconfig \
--namespace=openshift-machine-api get deployments
```

If  **\${INSTALL\_DIR}**  is not set in your environment, replace the value with the name of the installation directory.

#### Example output

| NAME                        | READY | UP-TO-DATE | AVAILABLE | AGE |
|-----------------------------|-------|------------|-----------|-----|
| cluster-autoscaler-operator | 1/1   | 1          | 1         | 86m |
| cluster-baremetal-operator  | 1/1   | 1          | 1         | 86m |
| machine-api-controllers     | 1/1   | 1          | 1         | 85m |
| machine-api-operator        | 1/1   | 1          | 1         | 86m |

- Check the machine controller logs by running the following command:

```
$ oc --kubeconfig=${INSTALL_DIR}/auth/kubeconfig \
--namespace=openshift-machine-api logs deployments/machine-api-controllers \
--container=machine-controller
```

### 3.5.11. Troubleshooting the Cluster Network Operator

The Cluster Network Operator is responsible for deploying the networking components. It runs early in the installation process, after the control plane nodes have come up but before the installation program removes the bootstrap control plane. Issues with this Operator might indicate installation program issues.

#### Procedure

- Ensure the network configuration exists by running the following command:

```
$ oc get network -o yaml cluster
```

If it does not exist, the installation program did not create it. To find out why, run the following command:

```
$ openshift-install create manifests
```

Review the manifests to determine why the installation program did not create the network configuration.

2. Ensure the network is running by entering the following command:

```
$ oc get po -n openshift-network-operator
```

### 3.5.12. Unable to discover new bare metal hosts using the BMC

In some cases, the installation program will not be able to discover the new bare metal hosts and issue an error, because it cannot mount the remote virtual media share.

For example:

```
ProvisioningError 51s metal3-baremetal-controller Image provisioning failed: Deploy step
deploy.deploy failed with BadRequestError: HTTP POST
https://<bmc_address>/redfish/v1/Managers/iDRAC.Embedded.1/VirtualMedia/CD/Actions/VirtualMedia.
InsertMedia
returned code 400.
Base.1.8.GeneralError: A general error has occurred. See ExtendedInfo for more information
Extended information: [
{
  "Message": "Unable to mount remote share https://<ironic_address>/redfish/boot-<uuid>.iso.",
  "MessageArgs": [
    "https://<ironic_address>/redfish/boot-<uuid>.iso"
  ],
  "MessageArgs@odata.count": 1,
  "MessageId": "IDRAC.2.5.RAC0720",
  "RelatedProperties": [
    "#/Image"
  ],
  "RelatedProperties@odata.count": 1,
  "Resolution": "Retry the operation.",
  "Severity": "Informational"
}
].
```

In this situation, if you are using virtual media with an unknown certificate authority, you can configure your baseboard management controller (BMC) remote file share settings to trust an unknown certificate authority to avoid this error.



#### NOTE

This resolution was tested on OpenShift Container Platform 4.11 with Dell iDRAC 9 and firmware version 5.10.50.

### 3.5.13. Troubleshooting worker nodes that cannot join the cluster

Installer-provisioned clusters deploy with a DNS server that includes a DNS entry for the **api-int**.

**<cluster\_name>.<base\_domain>** URL. If the nodes within the cluster use an external or upstream DNS server to resolve the **api-int.<cluster\_name>.<base\_domain>** URL and there is no such entry, worker nodes might fail to join the cluster. Ensure that all nodes in the cluster can resolve the domain name.

### Procedure

1. Add a DNS A/AAAA or CNAME record to internally identify the API load balancer. For example, when using dnsmasq, modify the **dnsmasq.conf** configuration file:

```
$ sudo nano /etc/dnsmasq.conf  
  
address=/api-int.<cluster_name>.<base_domain>/<IP_address>  
address=/api-int.mycluster.example.com/192.168.1.10  
address=/api-int.mycluster.example.com/2001:0db8:85a3:0000:0000:8a2e:0370:7334
```

2. Add a DNS PTR record to internally identify the API load balancer. For example, when using dnsmasq, modify the **dnsmasq.conf** configuration file:

```
$ sudo nano /etc/dnsmasq.conf  
  
ptr-record=<IP_address>.in-addr.arpa,api-int.<cluster_name>.<base_domain>  
ptr-record=10.1.168.192.in-addr.arpa,api-int.mycluster.example.com
```

3. Restart the DNS server. For example, when using dnsmasq, execute the following command:

```
$ sudo systemctl restart dnsmasq
```

These records must be resolvable from all the nodes within the cluster.

### 3.5.14. Cleaning up previous installations

In case of an earlier failed deployment, remove the artifacts from the failed attempt before trying to deploy OpenShift Container Platform again.

### Procedure

1. Power off all bare-metal nodes before installing the OpenShift Container Platform cluster by using the following command:

```
$ ipmitool -I lanplus -U <user> -P <password> -H <management_server_ip> power off
```

2. Remove all old bootstrap resources if any remain from an earlier deployment attempt by using the following script:

```
for i in $(sudo virsh list | tail -n +3 | grep bootstrap | awk {'print $2'});  
do  
    sudo virsh destroy $i;  
    sudo virsh undefine $i;  
    sudo virsh vol-delete $i --pool $i;  
    sudo virsh vol-delete $i.ign --pool $i;
```

```
sudo virsh pool-destroy $i;
sudo virsh pool-undefine $i;
done
```

- Delete the artifacts that the earlier installation generated by using the following command:

```
$ cd ; /bin/rm -rf auth/ bootstrap.ign master.ign worker.ign metadata.json \
.openshift_install.log .openshift_install_state.json
```

- Re-create the OpenShift Container Platform manifests by using the following command:

```
$ ./openshift-baremetal-install --dir ~/clusterconfigs create manifests
```

### 3.5.15. Issues with creating the registry

When creating a disconnected registry, you might encounter a "User Not Authorized" error when attempting to mirror the registry. This error might occur if you fail to append the new authentication to the existing **pull-secret.txt** file.

#### Procedure

- Check to ensure authentication is successful:

```
$ /usr/local/bin/oc adm release mirror \
-a pull-secret-update.json
--from=$UPSTREAM_REPO \
--to-release-image=$LOCAL_REG/$LOCAL_REPO:${VERSION} \
--to=$LOCAL_REG/$LOCAL_REPO
```

#### NOTE

Example output of the variables used to mirror the install images:

```
UPSTREAM_REPO=${RELEASE_IMAGE}
LOCAL_REG=<registry_FQDN>:<registry_port>
LOCAL_REPO='ocp4/openshift4'
```

The values of **RELEASE\_IMAGE** and **VERSION** were set during the **Retrieving OpenShift Installer** step of the **Setting up the environment for an OpenShift installation** section.

- After mirroring the registry, confirm that you can access it in your disconnected environment:

```
$ curl -k -u <user>:<password> https://registry.example.com:<registry_port>/v2/_catalog
{"repositories":["<Repo_Name>"]}
```

### 3.5.16. Miscellaneous issues

#### 3.5.16.1. Addressing the runtime network not ready error

After the deployment of a cluster you might receive the following error:

```
`runtime network not ready: NetworkReady=false reason:NetworkPluginNotReady message:Network
plugin returns error: Missing CNI default network`
```

The Cluster Network Operator is responsible for deploying the networking components in response to a special object created by the installation program. It runs very early in the installation process, after the control plane (master) nodes have come up, but before the bootstrap control plane has been torn down. It can be indicative of more subtle installation program issues, such as long delays in bringing up control plane (master) nodes or issues with **apiserver** communication.

## Procedure

1. Inspect the pods in the **openshift-network-operator** namespace:

```
$ oc get all -n openshift-network-operator
NAME                  READY STATUS    RESTARTS AGE
pod/network-operator-69dfd7b577-bg89v 0/1 ContainerCreating 0m 149m
```

2. On the **provisioner** node, determine that the network configuration exists:

```
$ kubectl get network.config.openshift.io cluster -oyaml
apiVersion: config.openshift.io/v1
kind: Network
metadata:
  name: cluster
spec:
  serviceNetwork:
  - 172.30.0.0/16
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  networkType: OVNKubernetes
```

If it does not exist, the installation program did not create it. To determine why the installation program did not create it, execute the following:

```
$ openshift-install create manifests
```

3. Check that the **network-operator** is running:

```
$ kubectl -n openshift-network-operator get pods
```

4. Retrieve the logs:

```
$ kubectl -n openshift-network-operator logs -l "name=network-operator"
```

On high availability clusters with three or more control plane nodes, the Operator will perform leader election and all other Operators will sleep. For additional details, see [Troubleshooting](#).

### 3.5.16.2. Addressing the "No disk found with matching rootDeviceHints" error message

After you deploy a cluster, you might receive the following error message:

No disk found with matching rootDeviceHints

To address the **No disk found with matching rootDeviceHints** error message, a temporary workaround is to change the **rootDeviceHints** to **minSizeGigabytes: 300**.

After you change the **rootDeviceHints** settings, boot the CoreOS and then verify the disk information by using the following command:

```
$ udevadm info /dev/sda
```

If you are using DL360 Gen 10 servers, be aware that they have an SD-card slot that might be assigned the **/dev/sda** device name. If no SD card is present in the server, it can cause conflicts. Ensure that the SD card slot is disabled in the server's BIOS settings.

If the **minSizeGigabytes** workaround is not fulfilling the requirements, you might need to revert **rootDeviceHints** back to **/dev/sda**. This change allows ironic images to boot successfully.

An alternative approach to fixing this problem is by using the serial ID of the disk. However, be aware that finding the serial ID can be challenging and might make the configuration file less readable. If you choose this path, ensure that you gather the serial ID using the previously documented command and incorporate it into your configuration.

### 3.5.16.3. Cluster nodes not getting the correct IPv6 address over DHCP

If the cluster nodes are not getting the correct IPv6 address over DHCP, check the following:

1. Ensure the reserved IPv6 addresses reside outside the DHCP range.
2. In the IP address reservation on the DHCP server, ensure the reservation specifies the correct DHCP Unique Identifier (DUID). For example:

```
# This is a dnsmasq dhcp reservation, 'id:00:03:00:01' is the client id and '18:db:f2:8c:d5:9f' is
the MAC Address for the NIC
id:00:03:00:01:18:db:f2:8c:d5:9f,openshift-master-1,[2620:52:0:1302::6]
```

3. Ensure that route announcements are working.
4. Ensure that the DHCP server is listening on the required interfaces serving the IP address ranges.

### 3.5.16.4. Cluster nodes not getting the correct hostname over DHCP

During IPv6 deployment, cluster nodes must get their hostname over DHCP. Sometimes the **NetworkManager** does not assign the hostname immediately. A control plane (master) node might report an error such as:

Failed Units: 2  
 NetworkManager-wait-online.service  
 nodeip-configuration.service

This error indicates that the cluster node likely booted without first receiving a hostname from the DHCP server, which causes **kubelet** to boot with a **localhost.localdomain** hostname. To address the error, force the node to renew the hostname.

## Procedure

1. Retrieve the **hostname**:

```
[core@master-X ~]$ hostname
```

If the hostname is **localhost**, proceed with the following steps.



### NOTE

Where **X** is the control plane node number.

2. Force the cluster node to renew the DHCP lease:

```
[core@master-X ~]$ sudo nmcli con up "<bare_metal_nic>"
```

Replace **<bare\_metal\_nic>** with the wired connection corresponding to the **baremetal** network.

3. Check **hostname** again:

```
[core@master-X ~]$ hostname
```

4. If the hostname is still **localhost.localdomain**, restart **NetworkManager**:

```
[core@master-X ~]$ sudo systemctl restart NetworkManager
```

5. If the hostname is still **localhost.localdomain**, wait a few minutes and check again. If the hostname remains **localhost.localdomain**, repeat the previous steps.

6. Restart the **nodeip-configuration** service:

```
[core@master-X ~]$ sudo systemctl restart nodeip-configuration.service
```

This service will reconfigure the **kubelet** service with the correct hostname references.

7. Reload the unit files definition since the kubelet changed in the previous step:

```
[core@master-X ~]$ sudo systemctl daemon-reload
```

8. Restart the **kubelet** service:

```
[core@master-X ~]$ sudo systemctl restart kubelet.service
```

9. Ensure **kubelet** booted with the correct hostname:

```
[core@master-X ~]$ sudo journalctl -fu kubelet.service
```

If the cluster node is not getting the correct hostname over DHCP after the cluster is up and running, such as during a reboot, the cluster will have a pending **csr**. **Do not** approve a **csr**, or other issues might arise.

### Addressing a **csr**

- Get CSRs on the cluster:

```
$ oc get csr
```

- Verify if a pending **csr** contains **Subject Name: localhost.localdomain**:

```
$ oc get csr <pending_csr> -o jsonpath='{.spec.request}' | base64 --decode | openssl req -noout -text
```

- Remove any **csr** that contains **Subject Name: localhost.localdomain**:

```
$ oc delete csr <wrong_csr>
```

#### 3.5.16.5. Routes do not reach endpoints

During the installation process, it is possible to encounter a Virtual Router Redundancy Protocol (VRRP) conflict. This conflict might occur if a previously used OpenShift Container Platform node that was once part of a cluster deployment using a specific cluster name is still running but not part of the current OpenShift Container Platform cluster deployment using that same cluster name. For example, a cluster was deployed using the cluster name **openshift**, deploying three control plane (master) nodes and three worker nodes. Later, a separate install uses the same cluster name **openshift**, but this redeployment only installed three control plane (master) nodes, leaving the three worker nodes from a previous deployment in an **ON** state. This might cause a Virtual Router Identifier (VRID) conflict and a VRRP conflict.

- Get the route:

```
$ oc get route oauth-openshift
```

- Check the service endpoint:

```
$ oc get svc oauth-openshift
```

| NAME            | TYPE      | CLUSTER-IP    | EXTERNAL-IP | PORT(S) | AGE |
|-----------------|-----------|---------------|-------------|---------|-----|
| oauth-openshift | ClusterIP | 172.30.19.162 | <none>      | 443/TCP | 59m |

- Attempt to reach the service from a control plane (master) node:

```
[core@master0 ~]$ curl -k https://172.30.19.162
```

```
{
  "kind": "Status",
  "apiVersion": "v1",
  "metadata": {
  },
  "status": "Failure",
```

```

"message": "forbidden: User \"system:anonymous\" cannot get path \"\",
"reason": "Forbidden",
"details": {
},
"code": 403

```

- Identify the **authentication-operator** errors from the **provisioner** node:

```
$ oc logs deployment/authentication-operator -n openshift-authentication-operator
```

```

Event(v1.ObjectReference{Kind:"Deployment", Namespace:"openshift-authentication-
operator", Name:"authentication-operator", UID:"225c5bd5-b368-439b-9155-5fd3c0459d98",
APIVersion:"apps/v1", ResourceVersion:"", FieldPath:""}): type: 'Normal' reason:
'OperatorStatusChanged' Status for clusteroperator/authentication changed: Degraded
message changed from "IngressStateEndpointsDegraded: All 2 endpoints for oauth-server
are reporting"

```

## Solution

- Ensure that the cluster name for every deployment is unique, ensuring no conflict.
- Turn off all the rogue nodes which are not part of the cluster deployment that are using the same cluster name. Otherwise, the authentication pod of the OpenShift Container Platform cluster might never start successfully.

### 3.5.16.6. Failed Ignition during Firstboot

During the Firstboot, the Ignition configuration may fail.

#### Procedure

- Connect to the node where the Ignition configuration failed:

```

Failed Units: 1
machine-config-daemon-firstboot.service

```

- Restart the **machine-config-daemon-firstboot** service:

```
[core@worker-X ~]$ sudo systemctl restart machine-config-daemon-firstboot.service
```

### 3.5.16.7. NTP out of sync

The deployment of OpenShift Container Platform clusters depends on NTP synchronized clocks among the cluster nodes. Without synchronized clocks, the deployment may fail due to clock drift if the time difference is greater than two seconds.

#### Procedure

- Check for differences in the **AGE** of the cluster nodes. For example:

```
$ oc get nodes
```

| NAME                       | STATUS | ROLES  | AGE  | VERSION |
|----------------------------|--------|--------|------|---------|
| master-0.cloud.example.com | Ready  | master | 145m | v1.31.3 |
| master-1.cloud.example.com | Ready  | master | 135m | v1.31.3 |
| master-2.cloud.example.com | Ready  | master | 145m | v1.31.3 |
| worker-2.cloud.example.com | Ready  | worker | 100m | v1.31.3 |

2. Check for inconsistent timing delays due to clock drift. For example:

```
$ oc get bmh -n openshift-machine-api
master-1 error registering master-1 ipmi://<out_of_band_ip>
$ sudo timedatectl
Local time: Tue 2020-03-10 18:20:02 UTC
Universal time: Tue 2020-03-10 18:20:02 UTC
RTC time: Tue 2020-03-10 18:36:53
Time zone: UTC (UTC, +0000)
System clock synchronized: no
NTP service: active
RTC in local TZ: no
```

### Addressing clock drift in existing clusters

1. Create a Butane config file including the contents of the **chrony.conf** file to be delivered to the nodes. In the following example, create **99-master-chrony.bu** to add the file to the control plane nodes. You can modify the file for worker nodes or repeat this procedure for the worker role.



#### NOTE

See "Creating machine configs with Butane" for information about Butane.

```
variant: openshift
version: 4.18.0
metadata:
  name: 99-master-chrony
  labels:
    machineconfiguration.openshift.io/role: master
storage:
  files:
    - path: /etc/chrony.conf
      mode: 0644
      overwrite: true
      contents:
        inline: |
          server <NTP_server> iburst ①
          stratumweight 0
          driftfile /var/lib/chrony/drift
          rtcsync
          makestep 10 3
          bindcmdaddress 127.0.0.1
```

```
bindcmdaddress ::1
keyfile /etc/chrony.keys
commandkey 1
generatecommandkey
noclientlog
logchange 0.5
logdir /var/log/chrony
```

- 1** Replace <NTP\_server> with the IP address of the NTP server.
2. Use Butane to generate a **MachineConfig** object file, **99-master-chrony.yaml**, containing the configuration to be delivered to the nodes:

```
$ butane 99-master-chrony.bu -o 99-master-chrony.yaml
```

3. Apply the **MachineConfig** object file:

```
$ oc apply -f 99-master-chrony.yaml
```

4. Ensure the **System clock synchronized** value is **yes**:

```
$ sudo timedatectl
```

```
Local time: Tue 2020-03-10 19:10:02 UTC
Universal time: Tue 2020-03-10 19:10:02 UTC
RTC time: Tue 2020-03-10 19:36:53
Time zone: UTC (UTC, +0000)
System clock synchronized: yes
    NTP service: active
    RTC in local TZ: no
```

To setup clock synchronization prior to deployment, generate the manifest files and add this file to the **openshift** directory. For example:

```
$ cp chrony-masters.yaml ~/clusterconfigs/openshift/99_masters-chrony-configuration.yaml
```

Then, continue to create the cluster.

### 3.5.17. Reviewing the installation

After installation, ensure the installation program deployed the nodes and pods successfully.

#### Procedure

1. When the OpenShift Container Platform cluster nodes are installed appropriately, the following **Ready** state is seen within the **STATUS** column:

```
$ oc get nodes
```

| NAME                 | STATUS | ROLES         | AGE | VERSION |
|----------------------|--------|---------------|-----|---------|
| master-0.example.com | Ready  | master,worker | 4h  | v1.31.3 |
| master-1.example.com | Ready  | master,worker | 4h  | v1.31.3 |

```
master-2.example.com Ready master,worker 4h v1.31.3
```

2. Confirm the installation program deployed all pods successfully. The following command removes any pods that are still running or have completed as part of the output.

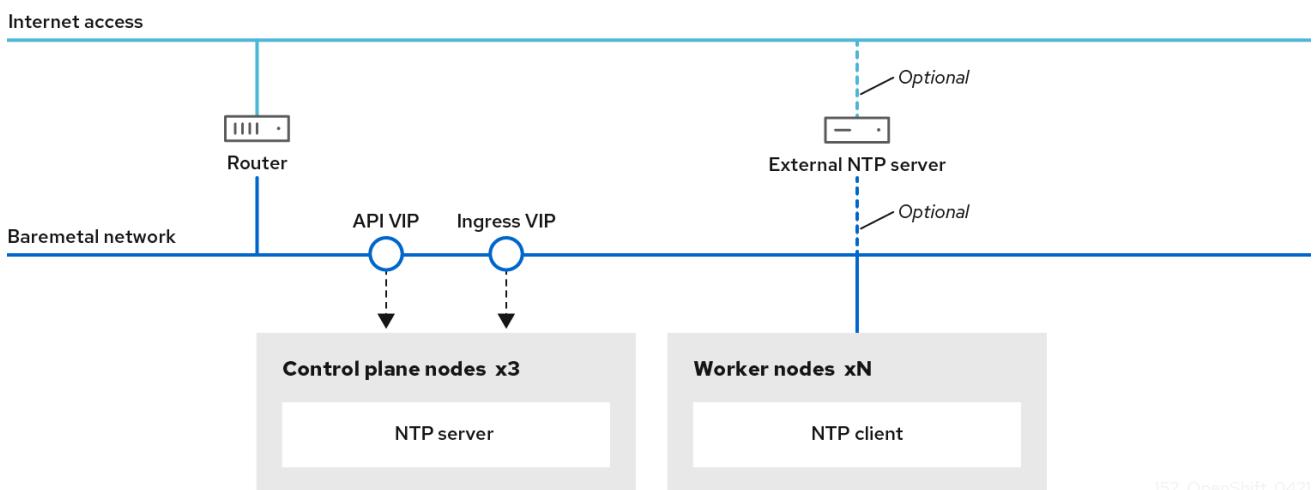
```
$ oc get pods --all-namespaces | grep -iv running | grep -iv complete
```

## 3.6. INSTALLER-PROVISIONED POSTINSTALLATION CONFIGURATION

After successfully deploying an installer-provisioned cluster, consider the following postinstallation procedures.

### 3.6.1. Configuring NTP for disconnected clusters

OpenShift Container Platform installs the **chrony** Network Time Protocol (NTP) service on the cluster nodes. Use the following procedure to configure NTP servers on the control plane nodes and configure compute nodes as NTP clients of the control plane nodes after a successful deployment.



OpenShift Container Platform nodes must agree on a date and time to run properly. When compute nodes retrieve the date and time from the NTP servers on the control plane nodes, it enables the installation and operation of clusters that are not connected to a routable network and thereby do not have access to a higher stratum NTP server.

#### Procedure

1. Install Butane on your installation host by using the following command:

```
$ sudo dnf -y install butane
```

2. Create a Butane config, **99-master-chrony-conf-override.bu**, including the contents of the **chrony.conf** file for the control plane nodes.



#### NOTE

See "Creating machine configs with Butane" for information about Butane.

## Butane config example

```

variant: openshift
version: 4.18.0
metadata:
  name: 99-master-chrony-conf-override
  labels:
    machineconfiguration.openshift.io/role: master
storage:
files:
  - path: /etc/chrony.conf
    mode: 0644
    overwrite: true
    contents:
      inline: |
        # Use public servers from the pool.ntp.org project.
        # Please consider joining the pool (https://www.pool.ntp.org/join.html).

        # The Machine Config Operator manages this file
server openshift-master-0.<cluster-name>.<domain> iburst ①
server openshift-master-1.<cluster-name>.<domain> iburst
server openshift-master-2.<cluster-name>.<domain> iburst

stratumweight 0
driftfile /var/lib/chrony/drift
rtcsync
makestep 10 3
bindcmdaddress 127.0.0.1
bindcmdaddress ::1
keyfile /etc/chrony.keys
commandkey 1
generatecommandkey
noclientlog
logchange 0.5
logdir /var/log/chrony

# Configure the control plane nodes to serve as local NTP servers
# for all compute nodes, even if they are not in sync with an
# upstream NTP server.

# Allow NTP client access from the local network.
allow all
# Serve time even if not synchronized to a time source.
local stratum 3 orphan

```

- ① You must replace **<cluster-name>** with the name of the cluster and replace **<domain>** with the fully qualified domain name.

3. Use Butane to generate a **MachineConfig** object file, **99-master-chrony-conf-override.yaml**, containing the configuration to be delivered to the control plane nodes:

```
$ butane 99-master-chrony-conf-override.bu -o 99-master-chrony-conf-override.yaml
```

4. Create a Butane config, **99-worker-chrony-conf-override.bu**, including the contents of the **chrony.conf** file for the compute nodes that references the NTP servers on the control plane nodes.

### Butane config example

```

variant: openshift
version: 4.18.0
metadata:
  name: 99-worker-chrony-conf-override
  labels:
    machineconfiguration.openshift.io/role: worker
storage:
  files:
    - path: /etc/chrony.conf
      mode: 0644
      overwrite: true
      contents:
        inline: |
          # The Machine Config Operator manages this file.
          server openshift-master-0.<cluster-name>.<domain> iburst ①
          server openshift-master-1.<cluster-name>.<domain> iburst
          server openshift-master-2.<cluster-name>.<domain> iburst

          stratumweight 0
          driftfile /var/lib/chrony/drift
          rtcsync
          makestep 10 3
          bindcmdaddress 127.0.0.1
          bindcmdaddress ::1
          keyfile /etc/chrony.keys
          commandkey 1
          generatecommandkey
          noclientlog
          logchange 0.5
          logdir /var/log/chrony

```

- ① You must replace **<cluster-name>** with the name of the cluster and replace **<domain>** with the fully qualified domain name.

5. Use Butane to generate a **MachineConfig** object file, **99-worker-chrony-conf-override.yaml**, containing the configuration to be delivered to the worker nodes:

```
$ butane 99-worker-chrony-conf-override.bu -o 99-worker-chrony-conf-override.yaml
```

6. Apply the **99-master-chrony-conf-override.yaml** policy to the control plane nodes.

```
$ oc apply -f 99-worker-chrony-conf-override.yaml
```

### Example output

```
machineconfig.machineconfiguration.openshift.io/99-worker-chrony-conf-override created
```

7. Apply the **99-worker-chrony-conf-override.yaml** policy to the compute nodes.

```
$ oc apply -f 99-worker-chrony-conf-override.yaml
```

#### Example output

```
machineconfig.machineconfiguration.openshift.io/99-worker-chrony-conf-override created
```

8. Check the status of the applied NTP settings.

```
$ oc describe machineconfigpool
```

### 3.6.2. Enabling a provisioning network after installation

The assisted installer and installer-provisioned installation for bare metal clusters provide the ability to deploy a cluster without a **provisioning** network. This capability is for scenarios such as proof-of-concept clusters or deploying exclusively with Redfish virtual media when each node's baseboard management controller is routable via the **baremetal** network.

You can enable a **provisioning** network after installation using the Cluster Baremetal Operator (CBO).

#### Prerequisites

- A dedicated physical network must exist, connected to all worker and control plane nodes.
- You must isolate the native, untagged physical network.
- The network cannot have a DHCP server when the **provisioningNetwork** configuration setting is set to **Managed**.
- You can omit the **provisioningInterface** setting in OpenShift Container Platform 4.10 to use the **bootMACAddress** configuration setting.

#### Procedure

1. When setting the **provisioningInterface** setting, first identify the provisioning interface name for the cluster nodes. For example, **eth0** or **eno1**.
2. Enable the Preboot eXecution Environment (PXE) on the **provisioning** network interface of the cluster nodes.
3. Retrieve the current state of the **provisioning** network and save it to a provisioning custom resource (CR) file:

```
$ oc get provisioning -o yaml > enable-provisioning-nw.yaml
```

4. Modify the provisioning CR file:

```
$ vim ~/enable-provisioning-nw.yaml
```

Scroll down to the **provisioningNetwork** configuration setting and change it from **Disabled** to **Managed**. Then, add the **provisioningIP**, **provisioningNetworkCIDR**, **provisioningDHCPRange**, **provisioningInterface**, and **watchAllNameSpaces** configuration

settings after the **provisioningNetwork** setting. Provide appropriate values for each setting.

```
apiVersion: v1
items:
- apiVersion: metal3.io/v1alpha1
  kind: Provisioning
  metadata:
    name: provisioning-configuration
  spec:
    provisioningNetwork: ①
    provisioningIP: ②
    provisioningNetworkCIDR: ③
    provisioningDHCPRange: ④
    provisioningInterface: ⑤
    watchAllNameSpaces: ⑥
```

- ① The **provisioningNetwork** is one of **Managed**, **Unmanaged**, or **Disabled**. When set to **Managed**, Metal3 manages the provisioning network and the CBO deploys the Metal3 pod with a configured DHCP server. When set to **Unmanaged**, the system administrator configures the DHCP server manually.
- ② The **provisioningIP** is the static IP address that the DHCP server and ironic use to provision the network. This static IP address must be within the **provisioning** subnet, and outside of the DHCP range. If you configure this setting, it must have a valid IP address even if the **provisioning** network is **Disabled**. The static IP address is bound to the metal3 pod. If the metal3 pod fails and moves to another server, the static IP address also moves to the new server.
- ③ The Classless Inter-Domain Routing (CIDR) address. If you configure this setting, it must have a valid CIDR address even if the **provisioning** network is **Disabled**. For example: **192.168.0.1/24**.
- ④ The DHCP range. This setting is only applicable to a **Managed** provisioning network. Omit this configuration setting if the **provisioning** network is **Disabled**. For example: **192.168.0.64, 192.168.0.253**.
- ⑤ The NIC name for the **provisioning** interface on cluster nodes. The **provisioningInterface** setting is only applicable to **Managed** and **Unmanaged** provisioning networks. Omit the **provisioningInterface** configuration setting if the **provisioning** network is **Disabled**. Omit the **provisioningInterface** configuration setting to use the **bootMACAddress** configuration setting instead.
- ⑥ Set this setting to **true** if you want metal3 to watch namespaces other than the default **openshift-machine-api** namespace. The default value is **false**.

5. Save the changes to the provisioning CR file.

6. Apply the provisioning CR file to the cluster:

```
$ oc apply -f enable-provisioning-nw.yaml
```

### 3.6.3. Creating a manifest object that includes a customized br-ex bridge

As an alternative to using the **configure-ovs.sh** shell script to set a **br-ex** bridge on a bare-metal platform, you can create a **NodeNetworkConfigurationPolicy** custom resource (CR) that includes an NMState configuration file. The NMState configuration file creates a customized **br-ex** bridge network configuration on each node in your cluster.

This feature supports the following tasks:

- Modifying the maximum transmission unit (MTU) for your cluster.
- Modifying attributes of a different bond interface, such as Mllmon (Media Independent Interface Monitor), bonding mode, or Quality of Service (QoS).
- Updating DNS values.

Consider the following use cases for creating a manifest object that includes a customized **br-ex** bridge:

- You want to make postinstallation changes to the bridge, such as changing the Open vSwitch (OVS) or OVN-Kubernetes **br-ex** bridge network. The **configure-ovs.sh** shell script does not support making postinstallation changes to the bridge.
- You want to deploy the bridge on a different interface than the interface available on a host or server IP address.
- You want to make advanced configurations to the bridge that are not possible with the **configure-ovs.sh** shell script. Using the script for these configurations might result in the bridge failing to connect multiple network interfaces and facilitating data forwarding between the interfaces.

## Prerequisites

- You set a customized **br-ex** by using the alternative method to **configure-ovs**.
- You installed the Kubernetes NMState Operator.

## Procedure

- Create a **NodeNetworkConfigurationPolicy** (NNCP) CR and define a customized **br-ex** bridge network configuration. Depending on your needs, ensure that you set a masquerade IP for either the **ipv4.address.ip**, **ipv6.address.ip**, or both parameters. A masquerade IP address must match an in-use IP address block.



### IMPORTANT

As a post-installation task, you can configure most parameters for a customized **br-ex** bridge that you defined in an existing NNCP CR, except for the IP address.

### Example of an NNCP CR that sets IPv6 and IPv4 masquerade IP addresses

```
apiVersion: nmstate.io/v1
kind: NodeNetworkConfigurationPolicy
metadata:
  name: worker-0-br-ex 1
spec:
  nodeSelector:
    kubernetes.io/hostname: worker-0
```

```

desiredState:
interfaces:
- name: enp2s0 2
  type: ethernet 3
  state: up 4
  ipv4:
    enabled: false 5
  ipv6:
    enabled: false
- name: br-ex
  type: ovs-bridge
  state: up
  ipv4:
    enabled: false
    dhcp: false
  ipv6:
    enabled: false
    dhcp: false
bridge:
  options:
    mcast-snooping-enable: true
  port:
    - name: enp2s0 6
    - name: br-ex
- name: br-ex
  type: ovs-interface
  state: up
  copy-mac-from: enp2s0
  ipv4:
    enabled: true
    dhcp: true
    address:
      - ip: "169.254.169.2"
        prefix-length: 29
  ipv6:
    enabled: false
    dhcp: false
    address:
      - ip: "fd69::2"
        prefix-length: 125

```

- 1** Name of the policy.
- 2** Name of the interface.
- 3** The type of ethernet.
- 4** The requested state for the interface after creation.
- 5** Disables IPv4 and IPv6 in this example.
- 6** The node NIC to which the bridge is attached.

### 3.6.4. Services for a user-managed load balancer

You can configure an OpenShift Container Platform cluster to use a user-managed load balancer in place of the default load balancer.



## IMPORTANT

Configuring a user-managed load balancer depends on your vendor's load balancer.

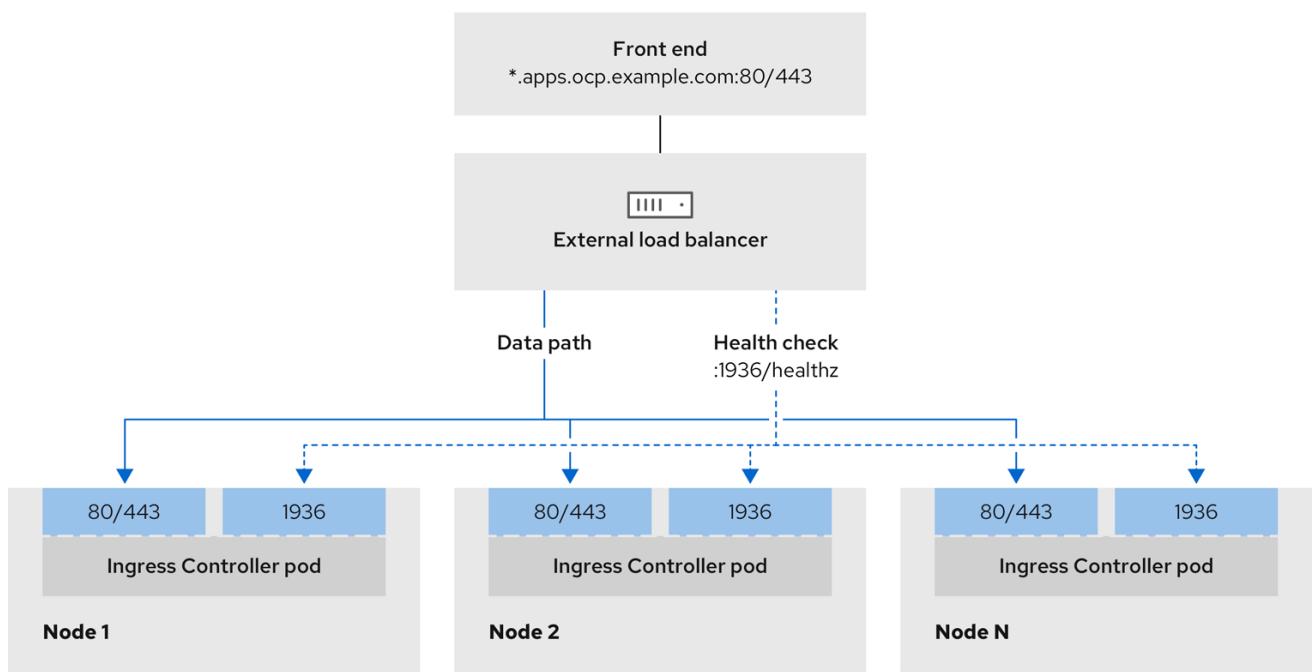
The information and examples in this section are for guideline purposes only. Consult the vendor documentation for more specific information about the vendor's load balancer.

Red Hat supports the following services for a user-managed load balancer:

- Ingress Controller
- OpenShift API
- OpenShift MachineConfig API

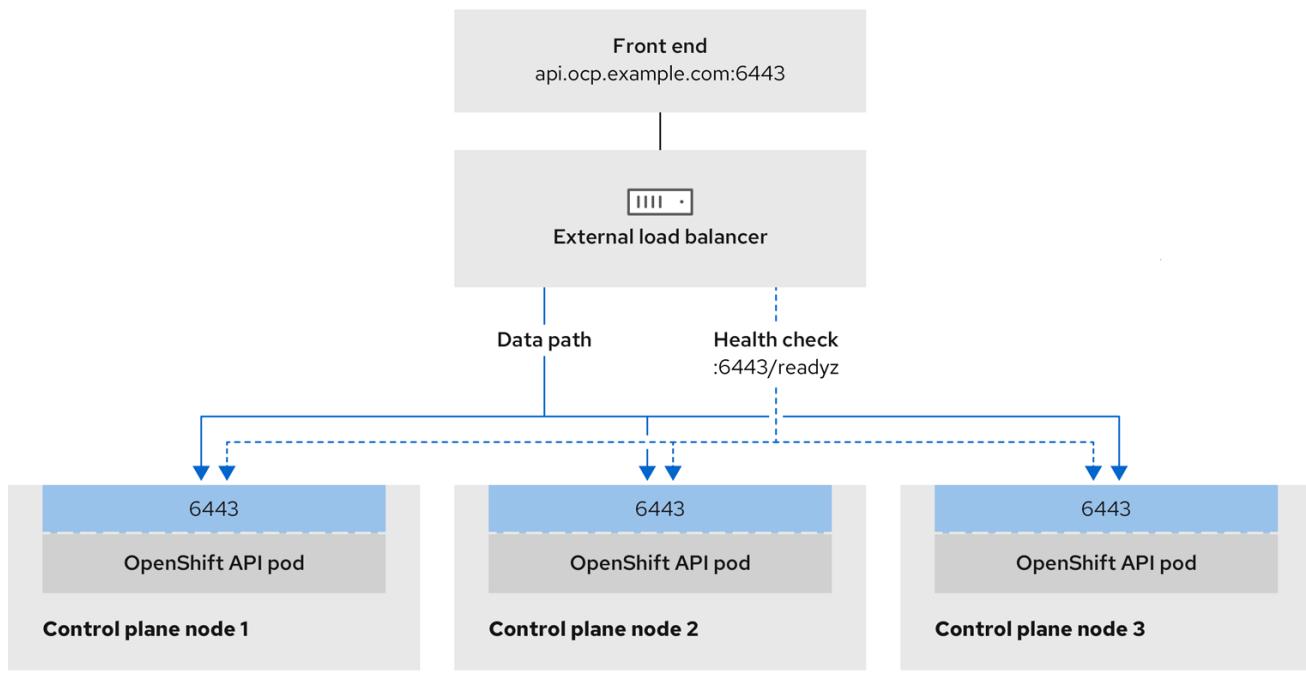
You can choose whether you want to configure one or all of these services for a user-managed load balancer. Configuring only the Ingress Controller service is a common configuration option. To better understand each service, view the following diagrams:

**Figure 3.4. Example network workflow that shows an Ingress Controller operating in an OpenShift Container Platform environment**



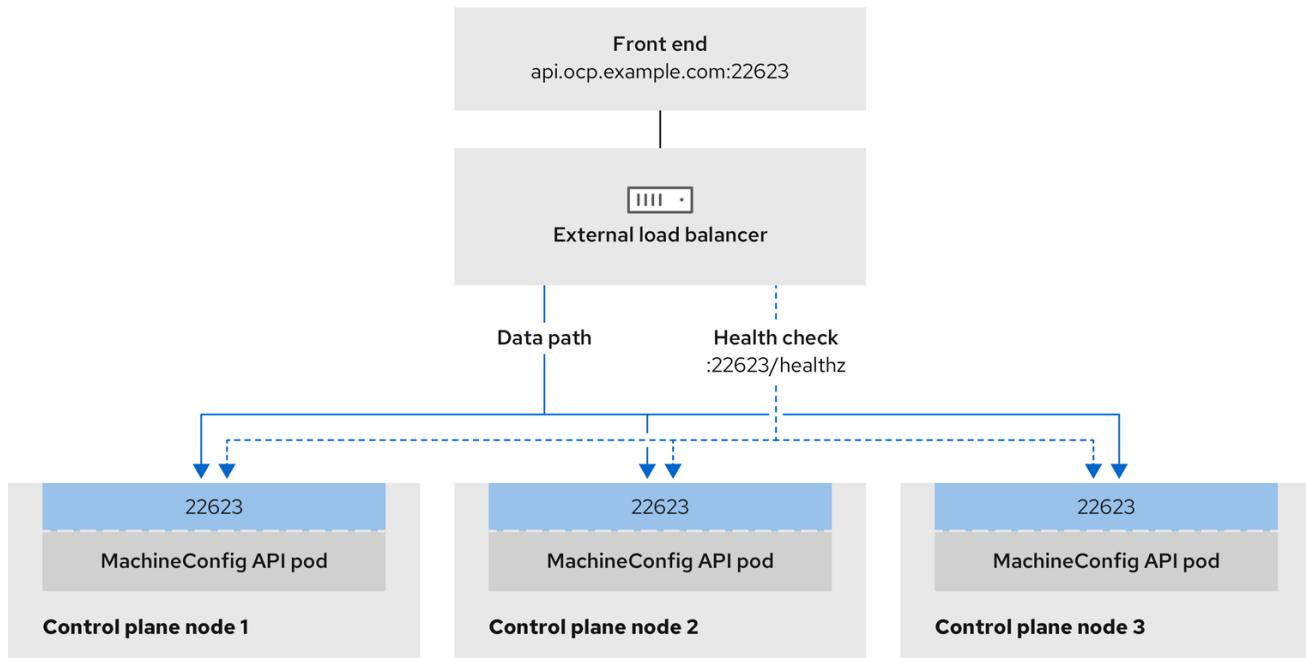
496\_OpenShift\_1222

**Figure 3.5. Example network workflow that shows an OpenShift API operating in an OpenShift Container Platform environment**



496\_OpenShift\_I223

**Figure 3.6. Example network workflow that shows an OpenShift MachineConfig API operating in an OpenShift Container Platform environment**



496\_OpenShift\_I223

The following configuration options are supported for user-managed load balancers:

- Use a node selector to map the Ingress Controller to a specific set of nodes. You must assign a static IP address to each node in this set, or configure each node to receive the same IP address from the Dynamic Host Configuration Protocol (DHCP). Infrastructure nodes commonly receive this type of configuration.

- Target all IP addresses on a subnet. This configuration can reduce maintenance overhead, because you can create and destroy nodes within those networks without reconfiguring the load balancer targets. If you deploy your ingress pods by using a machine set on a smaller network, such as a /27 or /28, you can simplify your load balancer targets.

## TIP

You can list all IP addresses that exist in a network by checking the machine config pool's resources.

Before you configure a user-managed load balancer for your OpenShift Container Platform cluster, consider the following information:

- For a front-end IP address, you can use the same IP address for the front-end IP address, the Ingress Controller's load balancer, and API load balancer. Check the vendor's documentation for this capability.
- For a back-end IP address, ensure that an IP address for an OpenShift Container Platform control plane node does not change during the lifetime of the user-managed load balancer. You can achieve this by completing one of the following actions:
  - Assign a static IP address to each control plane node.
  - Configure each node to receive the same IP address from the DHCP every time the node requests a DHCP lease. Depending on the vendor, the DHCP lease might be in the form of an IP reservation or a static DHCP assignment.
- Manually define each node that runs the Ingress Controller in the user-managed load balancer for the Ingress Controller back-end service. For example, if the Ingress Controller moves to an undefined node, a connection outage can occur.

### 3.6.4.1. Configuring a user-managed load balancer

You can configure an OpenShift Container Platform cluster to use a user-managed load balancer in place of the default load balancer.



## IMPORTANT

Before you configure a user-managed load balancer, ensure that you read the "Services for a user-managed load balancer" section.

Read the following prerequisites that apply to the service that you want to configure for your user-managed load balancer.



## NOTE

MetalLB, which runs on a cluster, functions as a user-managed load balancer.

### OpenShift API prerequisites

- You defined a front-end IP address.
- TCP ports 6443 and 22623 are exposed on the front-end IP address of your load balancer. Check the following items:

- Port 6443 provides access to the OpenShift API service.
- Port 22623 can provide ignition startup configurations to nodes.
- The front-end IP address and port 6443 are reachable by all users of your system with a location external to your OpenShift Container Platform cluster.
- The front-end IP address and port 22623 are reachable only by OpenShift Container Platform nodes.
- The load balancer backend can communicate with OpenShift Container Platform control plane nodes on port 6443 and 22623.

### Ingress Controller prerequisites

- You defined a front-end IP address.
- TCP ports 443 and 80 are exposed on the front-end IP address of your load balancer.
- The front-end IP address, port 80 and port 443 are be reachable by all users of your system with a location external to your OpenShift Container Platform cluster.
- The front-end IP address, port 80 and port 443 are reachable to all nodes that operate in your OpenShift Container Platform cluster.
- The load balancer backend can communicate with OpenShift Container Platform nodes that run the Ingress Controller on ports 80, 443, and 1936.

### Prerequisite for health check URL specifications

You can configure most load balancers by setting health check URLs that determine if a service is available or unavailable. OpenShift Container Platform provides these health checks for the OpenShift API, Machine Configuration API, and Ingress Controller backend services.

The following examples show health check specifications for the previously listed backend services:

#### Example of a Kubernetes API health check specification

```
Path: HTTPS:6443/readyz
Healthy threshold: 2
Unhealthy threshold: 2
Timeout: 10
Interval: 10
```

#### Example of a Machine Config API health check specification

```
Path: HTTPS:22623/healthz
Healthy threshold: 2
Unhealthy threshold: 2
Timeout: 10
Interval: 10
```

#### Example of an Ingress Controller health check specification

```
Path: HTTP:1936/healthz/ready
```

```
Healthy threshold: 2
Unhealthy threshold: 2
Timeout: 5
Interval: 10
```

## Procedure

- Configure the HAProxy Ingress Controller, so that you can enable access to the cluster from your load balancer on ports 6443, 22623, 443, and 80. Depending on your needs, you can specify the IP address of a single subnet or IP addresses from multiple subnets in your HAProxy configuration.

### Example HAProxy configuration with one listed subnet

```
# ...
listen my-cluster-api-6443
    bind 192.168.1.100:6443
    mode tcp
    balance roundrobin
    option httpchk
    http-check connect
    http-check send meth GET uri /readyz
    http-check expect status 200
    server my-cluster-master-2 192.168.1.101:6443 check inter 10s rise 2 fall 2
    server my-cluster-master-0 192.168.1.102:6443 check inter 10s rise 2 fall 2
    server my-cluster-master-1 192.168.1.103:6443 check inter 10s rise 2 fall 2

listen my-cluster-machine-config-api-22623
    bind 192.168.1.100:22623
    mode tcp
    balance roundrobin
    option httpchk
    http-check connect
    http-check send meth GET uri /healthz
    http-check expect status 200
    server my-cluster-master-2 192.168.1.101:22623 check inter 10s rise 2 fall 2
    server my-cluster-master-0 192.168.1.102:22623 check inter 10s rise 2 fall 2
    server my-cluster-master-1 192.168.1.103:22623 check inter 10s rise 2 fall 2

listen my-cluster-apps-443
    bind 192.168.1.100:443
    mode tcp
    balance roundrobin
    option httpchk
    http-check connect
    http-check send meth GET uri /healthz/ready
    http-check expect status 200
    server my-cluster-worker-0 192.168.1.111:443 check port 1936 inter 10s rise 2 fall 2
    server my-cluster-worker-1 192.168.1.112:443 check port 1936 inter 10s rise 2 fall 2
    server my-cluster-worker-2 192.168.1.113:443 check port 1936 inter 10s rise 2 fall 2

listen my-cluster-apps-80
    bind 192.168.1.100:80
    mode tcp
    balance roundrobin
```

```

option httpchk
http-check connect
http-check send meth GET uri /healthz/ready
http-check expect status 200
server my-cluster-worker-0 192.168.1.111:80 check port 1936 inter 10s rise 2 fall 2
server my-cluster-worker-1 192.168.1.112:80 check port 1936 inter 10s rise 2 fall 2
server my-cluster-worker-2 192.168.1.113:80 check port 1936 inter 10s rise 2 fall 2
# ...

```

### Example HAProxy configuration with multiple listed subnets

```

# ...
listen api-server-6443
bind *:6443
mode tcp
server master-00 192.168.83.89:6443 check inter 1s
server master-01 192.168.84.90:6443 check inter 1s
server master-02 192.168.85.99:6443 check inter 1s
server bootstrap 192.168.80.89:6443 check inter 1s

listen machine-config-server-22623
bind *:22623
mode tcp
server master-00 192.168.83.89:22623 check inter 1s
server master-01 192.168.84.90:22623 check inter 1s
server master-02 192.168.85.99:22623 check inter 1s
server bootstrap 192.168.80.89:22623 check inter 1s

listen ingress-router-80
bind *:80
mode tcp
balance source
server worker-00 192.168.83.100:80 check inter 1s
server worker-01 192.168.83.101:80 check inter 1s

listen ingress-router-443
bind *:443
mode tcp
balance source
server worker-00 192.168.83.100:443 check inter 1s
server worker-01 192.168.83.101:443 check inter 1s

listen ironic-api-6385
bind *:6385
mode tcp
balance source
server master-00 192.168.83.89:6385 check inter 1s
server master-01 192.168.84.90:6385 check inter 1s
server master-02 192.168.85.99:6385 check inter 1s
server bootstrap 192.168.80.89:6385 check inter 1s

listen inspector-api-5050
bind *:5050
mode tcp
balance source
server master-00 192.168.83.89:5050 check inter 1s

```

```
server master-01 192.168.84.90:5050 check inter 1s
server master-02 192.168.85.99:5050 check inter 1s
server bootstrap 192.168.80.89:5050 check inter 1s
# ...
```

2. Use the **curl** CLI command to verify that the user-managed load balancer and its resources are operational:

- Verify that the cluster machine configuration API is accessible to the Kubernetes API server resource, by running the following command and observing the response:

```
$ curl https://<loadbalancer_ip_address>:6443/version --insecure
```

If the configuration is correct, you receive a JSON object in response:

```
{
  "major": "1",
  "minor": "11+",
  "gitVersion": "v1.11.0+ad103ed",
  "gitCommit": "ad103ed",
  "gitTreeState": "clean",
  "buildDate": "2019-01-09T06:44:10Z",
  "goVersion": "go1.10.3",
  "compiler": "gc",
  "platform": "linux/amd64"
}
```

- Verify that the cluster machine configuration API is accessible to the Machine config server resource, by running the following command and observing the output:

```
$ curl -v https://<loadbalancer_ip_address>:22623/healthz --insecure
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 200 OK
Content-Length: 0
```

- Verify that the controller is accessible to the Ingress Controller resource on port 80, by running the following command and observing the output:

```
$ curl -I -L -H "Host: console-openshift-console.apps.<cluster_name>.<base_domain>" http://<load_balancer_front_end_IP_address>
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 302 Found
content-length: 0
location: https://console-openshift-console.apps.ocp4.private.opequon.net/
cache-control: no-cache
```

- Verify that the controller is accessible to the Ingress Controller resource on port 443, by running the following command and observing the output:

```
$ curl -I -L --insecure --resolve console-openshift-console.apps.<cluster_name>.<base_domain>:443:<Load Balancer Front End IP Address> https://console-openshift-console.apps.<cluster_name>.<base_domain>
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 200 OK
referrer-policy: strict-origin-when-cross-origin
set-cookie: csrf-
token=UIYWOyQ62LWjw2h003xtYSKlh1a0Py2hhctw0WmV2YEdhJFyQwWcGBsja261dG
LgaYO0nxzVERhiXt6QepA7g==; Path=/; Secure; SameSite=Lax
x-content-type-options: nosniff
x-dns-prefetch-control: off
x-frame-options: DENY
x-xss-protection: 1; mode=block
date: Wed, 04 Oct 2023 16:29:38 GMT
content-type: text/html; charset=utf-8
set-cookie:
1e2670d92730b515ce3a1bb65da45062=1bf5e9573c9a2760c964ed1659cc1673; path=/
HttpOnly; Secure; SameSite=None
cache-control: private
```

3. Configure the DNS records for your cluster to target the front-end IP addresses of the user-managed load balancer. You must update records to your DNS server for the cluster API and applications over the load balancer.

### Examples of modified DNS records

```
<load_balancer_ip_address> A api.<cluster_name>.<base_domain>
A record pointing to Load Balancer Front End
```

```
<load_balancer_ip_address> A apps.<cluster_name>.<base_domain>
A record pointing to Load Balancer Front End
```



#### IMPORTANT

DNS propagation might take some time for each DNS record to become available. Ensure that each DNS record propagates before validating each record.

4. For your OpenShift Container Platform cluster to use the user-managed load balancer, you must specify the following configuration in your cluster's **install-config.yaml** file:

```
# ...
platform:
  loadBalancer:
    type: UserManaged 1
    apiVIPs:
      - <api_ip> 2
    ingressVIPs:
      - <ingress_ip> 3
# ...
```

- 1 Set **UserManaged** for the **type** parameter to specify a user-managed load balancer for your cluster. The parameter defaults to **OpenShiftManagedDefault**, which denotes the default internal load balancer. For services defined in an **openshift-kni-infra** namespace, a user-managed load balancer can deploy the **coredns** service to pods in your cluster but ignores **keepalived** and **haproxy** services.
- 2 Required parameter when you specify a user-managed load balancer. Specify the user-managed load balancer's public IP address, so that the Kubernetes API can communicate with the user-managed load balancer.
- 3 Required parameter when you specify a user-managed load balancer. Specify the user-managed load balancer's public IP address, so that the user-managed load balancer can manage ingress traffic for your cluster.

## Verification

- 1 Use the **curl** CLI command to verify that the user-managed load balancer and DNS record configuration are operational:
  - a. Verify that you can access the cluster API, by running the following command and observing the output:

```
$ curl https://api.<cluster_name>.<base_domain>:6443/version --insecure
```

If the configuration is correct, you receive a JSON object in response:

```
{
  "major": "1",
  "minor": "11+",
  "gitVersion": "v1.11.0+ad103ed",
  "gitCommit": "ad103ed",
  "gitTreeState": "clean",
  "buildDate": "2019-01-09T06:44:10Z",
  "goVersion": "go1.10.3",
  "compiler": "gc",
  "platform": "linux/amd64"
}
```

- b. Verify that you can access the cluster machine configuration, by running the following command and observing the output:

```
$ curl -v https://api.<cluster_name>.<base_domain>:22623/healthz --insecure
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 200 OK
Content-Length: 0
```

- c. Verify that you can access each cluster application on port, by running the following command and observing the output:

```
$ curl http://console-openshift-console.apps.<cluster_name>.<base_domain> -I -L --
insecure
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 302 Found
content-length: 0
location: https://console-openshift-console.apps.<cluster-name>.<base domain>/
cache-control: no-cacheHTTP/1.1 200 OK
referrer-policy: strict-origin-when-cross-origin
set-cookie: csrf-
token=39HoZgztDnzJkq/JuLJMeoKNXIiVv2YgZc09c3TBOBU4NI6kDXaJH1LdicNhN1UsQ
Wzon4Dor9GWGfopaTEQ==; Path=/; Secure
x-content-type-options: nosniff
x-dns-prefetch-control: off
x-frame-options: DENY
x-xss-protection: 1; mode=block
date: Tue, 17 Nov 2020 08:42:10 GMT
content-type: text/html; charset=utf-8
set-cookie:
1e2670d92730b515ce3a1bb65da45062=9b714eb87e93cf34853e87a92d6894be; path=/;
HttpOnly; Secure; SameSite=None
cache-control: private
```

- d. Verify that you can access each cluster application on port 443, by running the following command and observing the output:

```
$ curl https://console-openshift-console.apps.<cluster_name>.<base_domain> -I -L --
insecure
```

If the configuration is correct, the output from the command shows the following response:

```
HTTP/1.1 200 OK
referrer-policy: strict-origin-when-cross-origin
set-cookie: csrf-
token=UIYWOOyQ62LWjw2h003xtYSKlh1a0Py2hhctw0WmV2YEdhJjFyQwWcGBsja261dG
LgaYO0nxzVERhiXt6QepA7g==; Path=/; Secure; SameSite=Lax
x-content-type-options: nosniff
x-dns-prefetch-control: off
x-frame-options: DENY
x-xss-protection: 1; mode=block
date: Wed, 04 Oct 2023 16:29:38 GMT
content-type: text/html; charset=utf-8
set-cookie:
1e2670d92730b515ce3a1bb65da45062=1bf5e9573c9a2760c964ed1659cc1673; path=/;
HttpOnly; Secure; SameSite=None
cache-control: private
```

### 3.6.5. Configuration using the Bare Metal Operator

When deploying OpenShift Container Platform on bare-metal hosts, there are times when you need to make changes to the host either before or after provisioning. This can include inspecting the host's hardware, firmware, and firmware details. It can also include formatting disks or changing modifiable firmware settings.

You can use the Bare Metal Operator (BMO) to provision, manage, and inspect bare-metal hosts in your cluster. The BMO can complete the following operations:

- Provision bare-metal hosts to the cluster with a specific image.
- Turn a host on or off.
- Inspect hardware details of the host and report them to the bare-metal host.
- Upgrade or downgrade a host’s firmware to a specific version.
- Inspect firmware and configure BIOS settings.
- Clean disk contents for the host before or after provisioning the host.

The BMO uses the following resources to complete these tasks:

- **BareMetalHost**
- **HostFirmwareSettings**
- **FirmwareSchema**
- **HostFirmwareComponents**
- **HostUpdatePolicy**

The BMO maintains an inventory of the physical hosts in the cluster by mapping each bare-metal host to an instance of the **BareMetalHost** custom resource definition. Each **BareMetalHost** resource features hardware, software, and firmware details. The BMO continually inspects the bare-metal hosts in the cluster to ensure each **BareMetalHost** resource accurately details the components of the corresponding host.

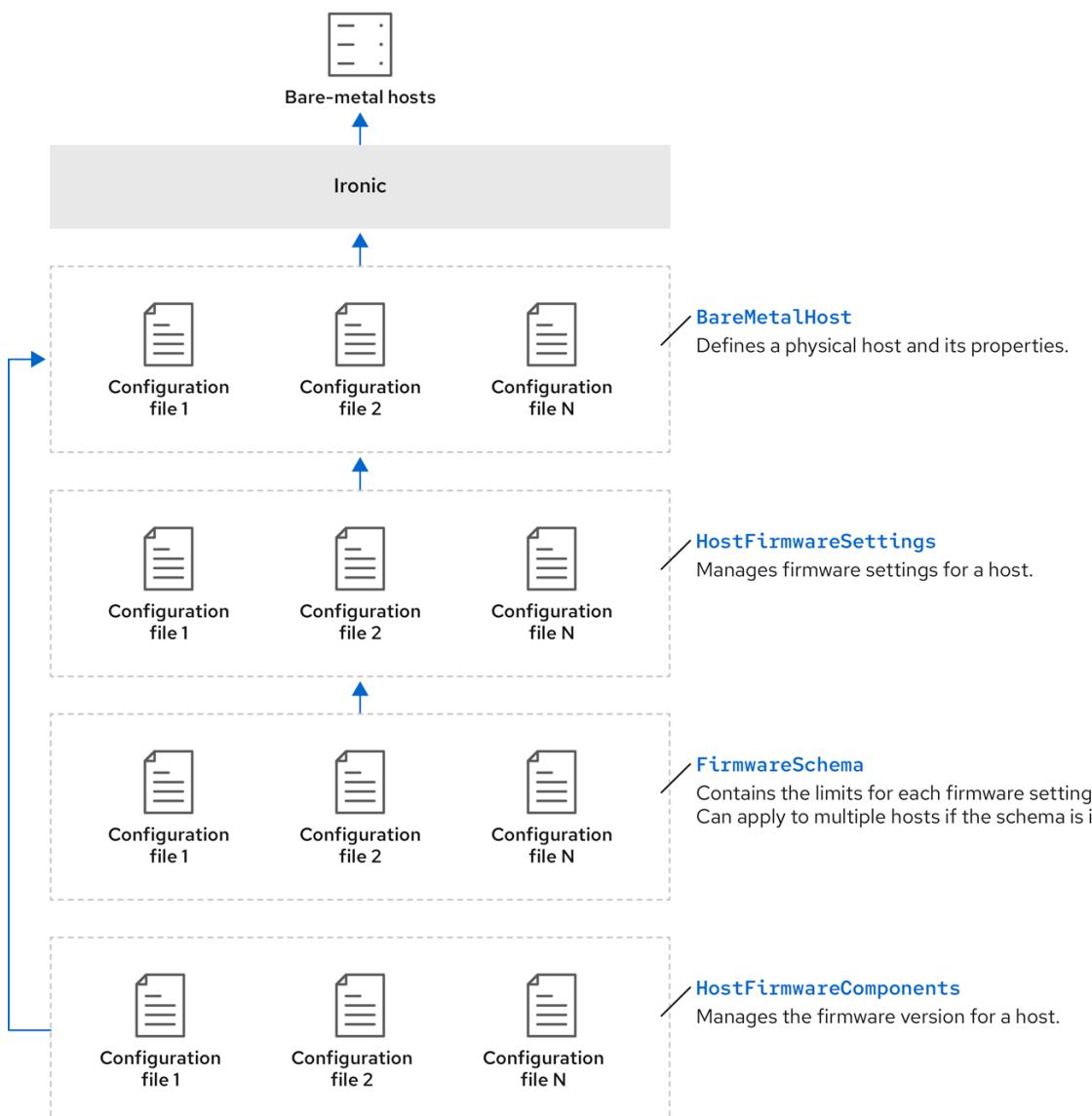
The BMO also uses the **HostFirmwareSettings** resource, the **FirmwareSchema** resource, and the **HostFirmwareComponents** resource to detail firmware specifications and upgrade or downgrade firmware for the bare-metal host.

The BMO interfaces with bare-metal hosts in the cluster by using the Ironic API service. The Ironic service uses the Baseboard Management Controller (BMC) on the host to interface with the machine.

The BMO **HostUpdatePolicy** can enable or disable live updates to the firmware settings, BMC settings, or BIOS settings of a bare-metal host after provisioning the host. By default, the BMO disables live updates.

### 3.6.5.1. Bare Metal Operator architecture

The Bare Metal Operator (BMO) uses the following resources to provision, manage, and inspect bare-metal hosts in your cluster. The following diagram illustrates the architecture of these resources:



715\_OpenShift\_0624

## BareMetalHost

The **BareMetalHost** resource defines a physical host and its properties. When you provision a bare-metal host to the cluster, you must define a **BareMetalHost** resource for that host. For ongoing management of the host, you can inspect the information in the **BareMetalHost** resource or update this information.

The **BareMetalHost** resource features provisioning information such as the following:

- Deployment specifications such as the operating system boot image or the custom RAM disk
- Provisioning state
- Baseboard Management Controller (BMC) address
- Desired power state

The **BareMetalHost** resource features hardware information such as the following:

- Number of CPUs
- MAC address of a NIC

- Size of the host’s storage device
- Current power state

## HostFirmwareSettings

You can use the **HostFirmwareSettings** resource to retrieve and manage the firmware settings for a host. When a host moves to the **Available** state, the Ironic service reads the host’s firmware settings and creates the **HostFirmwareSettings** resource. There is a one-to-one mapping between the **BareMetalHost** resource and the **HostFirmwareSettings** resource.

You can use the **HostFirmwareSettings** resource to inspect the firmware specifications for a host or to update a host’s firmware specifications.



### NOTE

You must adhere to the schema specific to the vendor firmware when you edit the **spec** field of the **HostFirmwareSettings** resource. This schema is defined in the read-only **FirmwareSchema** resource.

## FirmwareSchema

Firmware settings vary among hardware vendors and host models. A **FirmwareSchema** resource is a read-only resource that contains the types and limits for each firmware setting on each host model. The data comes directly from the BMC by using the Ironic service. You can use the **FirmwareSchema** resource to identify valid values that you can specify in the **spec** field of the **HostFirmwareSettings** resource.

A **FirmwareSchema** resource can apply to many **BareMetalHost** resources if the schema is the same.

## HostFirmwareComponents

Metal<sup>3</sup> provides the **HostFirmwareComponents** resource, which describes BIOS and baseboard management controller (BMC) firmware versions. You can upgrade or downgrade the host’s firmware to a specific version by editing the **spec** field of the **HostFirmwareComponents** resource. This is useful when deploying with validated patterns that have been tested against specific firmware versions.

## Additional resources

- [Metal<sup>3</sup> API service for provisioning bare-metal hosts](#)
- [Ironic API service for managing bare-metal infrastructure](#)

## HostUpdatePolicy

The **HostUpdatePolicy** resource can enable or disable live updates to the firmware settings, BMC settings, or BIOS settings of bare-metal hosts. By default, the **HostUpdatePolicy** resource for each bare-metal host restricts updates to hosts during provisioning. You must modify the **HostUpdatePolicy** resource for a host when you want to update the firmware settings, BMC settings, or BIOS settings after provisioning the host.

### 3.6.5.2. About the BareMetalHost resource

Metal<sup>3</sup> introduces the concept of the **BareMetalHost** resource, which defines a physical host and its properties. The **BareMetalHost** resource contains two sections:

1. The **BareMetalHost** spec
2. The **BareMetalHost** status

#### 3.6.5.2.1. The BareMetalHost spec

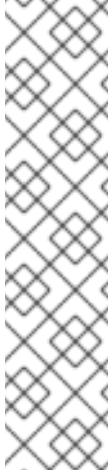
The **spec** section of the **BareMetalHost** resource defines the desired state of the host.

**Table 3.15. BareMetalHost spec**

| Parameters                                                                                          | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|-----------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>automatedCleaningMode</b>                                                                        | An interface to enable or disable automated cleaning during provisioning and de-provisioning. When set to <b>disabled</b> , it skips automated cleaning. When set to <b>metadata</b> , automated cleaning is enabled. The default setting is <b>metadata</b> .                                                                                                                                                                                                                                                     |
| <b>bmc:</b><br><b>address:</b><br><b>credentialsName:</b><br><b>disableCertificateVerification:</b> | The <b>bmc</b> configuration setting contains the connection information for the baseboard management controller (BMC) on the host. The fields are: <ul style="list-style-type: none"> <li>● <b>address</b>: The URL for communicating with the host's BMC controller.</li> <li>● <b>credentialsName</b>: A reference to a secret containing the username and password for the BMC.</li> <li>● <b>disableCertificateVerification</b>: A boolean to skip certificate validation when set to <b>true</b>.</li> </ul> |
| <b>bootMACAddress</b>                                                                               | The MAC address of the NIC used for provisioning the host.                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>bootMode</b>                                                                                     | The boot mode of the host. It defaults to <b>UEFI</b> , but it can also be set to <b>legacy</b> for BIOS boot, or <b>UEFISecureBoot</b> .                                                                                                                                                                                                                                                                                                                                                                          |
| <b>consumerRef</b>                                                                                  | A reference to another resource that is using the host. It could be empty if another resource is not currently using the host. For example, a <b>Machine</b> resource might use the host when the <b>machine-api</b> is using the host.                                                                                                                                                                                                                                                                            |
| <b>description</b>                                                                                  | A human-provided string to help identify the host.                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |

| Parameters                   | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>externallyProvisioned</b> | <p>A boolean indicating whether the host provisioning and deprovisioning are managed externally. When set:</p> <ul style="list-style-type: none"> <li>Power status can still be managed using the online field.</li> <li>Hardware inventory will be monitored, but no provisioning or deprovisioning operations are performed on the host.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>firmware</b>              | <p>Contains information about the BIOS configuration of bare metal hosts. Currently, <b>firmware</b> is only supported by iRMC, iDRAC, iLO4 and iLO5 BMCs. The sub fields are:</p> <ul style="list-style-type: none"> <li><b>simultaneousMultithreadingEnabled</b>: Allows a single physical processor core to appear as several logical processors. Valid settings are <b>true</b> or <b>false</b>.</li> <li><b>sriovEnabled</b>: SR-IOV support enables a hypervisor to create virtual instances of a PCI-express device, potentially increasing performance. Valid settings are <b>true</b> or <b>false</b>.</li> <li><b>virtualizationEnabled</b>: Supports the virtualization of platform hardware. Valid settings are <b>true</b> or <b>false</b>.</li> </ul> |

| Parameters                                                     | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|----------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <pre>image:   url:   checksum:   checksumType:   format:</pre> | <p>The <b>image</b> configuration setting holds the details for the image to be deployed on the host. Ironic requires the image fields. However, when the <b>externallyProvisioned</b> configuration setting is set to <b>true</b> and the external management does not require power control, the fields can be empty. The setting supports the following fields:</p> <ul style="list-style-type: none"> <li>• <b>url</b>: The URL of an image to deploy to the host.</li> <li>• <b>checksum</b>: The actual checksum or a URL to a file containing the checksum for the image at <b>image.url</b>.</li> <li>• <b>checksumType</b>: You can specify checksum algorithms. Currently <b>image.checksumType</b> only supports <b>md5</b>, <b>sha256</b>, and <b>sha512</b>. The default checksum type is <b>md5</b>.</li> <li>• <b>format</b>: This is the disk format of the image. It can be one of <b>raw</b>, <b>qcow2</b>, <b>vdi</b>, <b>vmdk</b>, <b>live-iso</b> or be left unset. Setting it to <b>raw</b> enables raw image streaming in the Ironic agent for that image. Setting it to <b>live-iso</b> enables iso images to live boot without deploying to disk, and it ignores the <b>checksum</b> fields.</li> </ul> |
| <b>networkData</b>                                             | A reference to the secret containing the network configuration data and its namespace, so that it can be attached to the host before the host boots to set up the network.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>online</b>                                                  | A boolean indicating whether the host should be powered on ( <b>true</b> ) or off ( <b>false</b> ). Changing this value will trigger a change in the power state of the physical host.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <pre>raid:   hardwareRAIDVolumes:   softwareRAIDVolumes:</pre> | (Optional) Contains the information about the RAID configuration for bare metal hosts. If not specified, it retains the current configuration.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |

| Parameters | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | NOTE |
|------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
|            |  <p>OpenShift Container Platform 4.18 supports hardware RAID on the installation drive for BMCs, including:</p> <ul style="list-style-type: none"> <li>• Fujitsu iRMC with support for RAID levels 0, 1, 5, 6, and 10</li> <li>• Dell iDRAC using the Redfish API with firmware version 6.10.30.20 or later and RAID levels 0, 1, and 5</li> </ul> <p>OpenShift Container Platform 4.18 does not support software RAID on the installation drive.</p> <p>See the following configuration settings:</p> <ul style="list-style-type: none"> <li>• <b>hardwareRAIDVolumes</b>: Contains the list of logical drives for hardware RAID, and defines the desired volume configuration in the hardware RAID. If you do not specify <b>rootDeviceHints</b>, the first volume is the root volume. The sub-fields are: <ul style="list-style-type: none"> <li>◦ <b>level</b>: The RAID level for the logical drive. The following levels are supported: <b>0,1,2,5,6,1+0,5+0,6+0</b>.</li> <li>◦ <b>name</b>: The name of the volume as a string. It should be unique within the server. If not specified, the volume name will be auto-generated.</li> <li>◦ <b>numberOfPhysicalDisks</b>: The number of physical drives as an integer to use for the logical drive. Defaults to the minimum number of disk drives required for the particular RAID level.</li> <li>◦ <b>physicalDisks</b>: The list of names of physical disk drives as a string. This is an optional field. If specified, the controller field must be specified too.</li> <li>◦ <b>controller</b>: (Optional) The name of the RAID controller as a string to use in the hardware RAID volume.</li> <li>◦ <b>rotational</b>: If set to <b>true</b>, it will only select rotational disk drives. If set to <b>false</b>, it will only select solid-state and NVMe drives. If not set, it selects any drive types, which is the default behavior.</li> <li>◦ <b>sizeGibibytes</b>: The size of the logical drive as an integer to create in GiB. If unspecified or set to <b>0</b>, it will use the maximum capacity of physical drive for the logical drive.</li> </ul> </li> </ul> |      |

| Parameters | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|            | <ul style="list-style-type: none"> <li>● <b>softwareRAIDVolumes</b>: OpenShift Container Platform 4.18 does not support software RAID on the installation drive. This configuration contains the list of logical disks for software RAID. If you do not specify <b>rootDeviceHints</b>, the first volume is the root volume. If you set <b>HardwareRAIDVolumes</b>, this item will be invalid. Software RAIDs will always be deleted. The number of created software RAID devices must be <b>1 or 2</b>. If there is only one software RAID device, it must be <b>RAID-1</b>. If there are two RAID devices, the first device must be <b>RAID-1</b>, while the RAID level for the second device can be <b>0, 1, or 1+0</b>. The first RAID device will be the deployment device, which cannot be a software RAID volume. Enforcing <b>RAID-1</b> reduces the risk of a non-booting node in case of a device failure. The <b>softwareRAIDVolume</b> field defines the desired configuration of the volume in the software RAID. The sub-fields are:           <ul style="list-style-type: none"> <li>○ <b>level</b>: The RAID level for the logical drive. The following levels are supported: <b>0, 1, 1+0</b>.</li> <li>○ <b>physicalDisks</b>: A list of device hints. The number of items should be greater than or equal to <b>2</b>.</li> <li>○ <b>sizeGiabytes</b>: The size of the logical disk drive as an integer to be created in GiB. If unspecified or set to <b>0</b>, it will use the maximum capacity of physical drive for logical drive.</li> </ul> </li> </ul> <p>You can set the <b>hardwareRAIDVolume</b> as an empty slice to clear the hardware RAID configuration. For example:</p> <pre> spec:   raid:     hardwareRAIDVolume: [] </pre> <p>If you receive an error message indicating that the driver does not support RAID, set the <b>raid</b>, <b>hardwareRAIDVolumes</b> or <b>softwareRAIDVolumes</b> to nil. You might need to ensure the host has a RAID controller.</p> |

```

spec:
  raid:
    hardwareRAIDVolume: []

```

If you receive an error message indicating that the driver does not support RAID, set the **raid**, **hardwareRAIDVolumes** or **softwareRAIDVolumes** to nil. You might need to ensure the host has a RAID controller.

| Parameters                                                                                                                                                                                | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <pre>rootDeviceHints:   deviceName:     hctl:     model:     vendor:     serialNumber:     minSizeGigabytes:     wwn:     wwnWithExtension:     wwnVendorExtension:     rotational:</pre> | <p>The <b>rootDeviceHints</b> parameter enables provisioning of the RHCOS image to a particular device. It examines the devices in the order it discovers them, and compares the discovered values with the hint values. It uses the first discovered device that matches the hint value. The configuration can combine multiple hints, but a device must match all hints to get selected. The fields are:</p> <ul style="list-style-type: none"> <li>● <b>deviceName</b>: A string containing a Linux device name like <code>/dev/vda</code>. The hint must match the actual value exactly.</li> <li>● <b>hctl</b>: A string containing a SCSI bus address like <code>0:0:0:0</code>. The hint must match the actual value exactly.</li> <li>● <b>model</b>: A string containing a vendor-specific device identifier. The hint can be a substring of the actual value.</li> <li>● <b>vendor</b>: A string containing the name of the vendor or manufacturer of the device. The hint can be a sub-string of the actual value.</li> <li>● <b>serialNumber</b>: A string containing the device serial number. The hint must match the actual value exactly.</li> <li>● <b>minSizeGigabytes</b>: An integer representing the minimum size of the device in gigabytes.</li> <li>● <b>wwn</b>: A string containing the unique storage identifier. The hint must match the actual value exactly.</li> <li>● <b>wwnWithExtension</b>: A string containing the unique storage identifier with the vendor extension appended. The hint must match the actual value exactly.</li> <li>● <b>wwnVendorExtension</b>: A string containing the unique vendor storage identifier. The hint must match the actual value exactly.</li> <li>● <b>rotational</b>: A boolean indicating whether the device should be a rotating disk (true) or not (false).</li> </ul> |

### 3.6.5.2.2. The BareMetalHost status

The **BareMetalHost** status represents the host's current state, and includes tested credentials, current hardware details, and other information.

Table 3.16. BareMetalHost status

| Parameters                                                                      | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|---------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>goodCredentials</b>                                                          | A reference to the secret and its namespace holding the last set of baseboard management controller (BMC) credentials the system was able to validate as working.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>errorMessage</b>                                                             | Details of the last error reported by the provisioning backend, if any.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>errorType</b>                                                                | <p>Indicates the class of problem that has caused the host to enter an error state. The error types are:</p> <ul style="list-style-type: none"> <li>● <b>provisioned registration error:</b> Occurs when the controller is unable to re-register an already provisioned host.</li> <li>● <b>registration error:</b> Occurs when the controller is unable to connect to the host's baseboard management controller.</li> <li>● <b>inspection error:</b> Occurs when an attempt to obtain hardware details from the host fails.</li> <li>● <b>preparation error:</b> Occurs when cleaning fails.</li> <li>● <b>provisioning error:</b> Occurs when the controller fails to provision or deprovision the host.</li> <li>● <b>power management error:</b> Occurs when the controller is unable to modify the power state of the host.</li> <li>● <b>detach error:</b> Occurs when the controller is unable to detach the host from the provisioner.</li> </ul> |
| <pre>hardware:   cpu   arch:   model:   clockMegahertz:   flags:   count:</pre> | <p>The <b>hardware.cpu</b> field details of the CPU(s) in the system. The fields include:</p> <ul style="list-style-type: none"> <li>● <b>arch:</b> The architecture of the CPU.</li> <li>● <b>model:</b> The CPU model as a string.</li> <li>● <b>clockMegahertz:</b> The speed in MHz of the CPU.</li> <li>● <b>flags:</b> The list of CPU flags. For example, '<b>mmx','sse','sse2','vmx</b>' etc.</li> <li>● <b>count:</b> The number of CPUs available in the system.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |

| Parameters                                                                              | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|-----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| hardware:<br>firmware:                                                                  | Contains BIOS firmware information. For example, the hardware vendor and version.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| hardware:<br>nics:<br>- ip:<br>name:<br>mac:<br>speedGbps:<br>vlans:<br>vlanId:<br>pxe: | <p>The <b>hardware.nics</b> field contains a list of network interfaces for the host. The fields include:</p> <ul style="list-style-type: none"> <li>● <b>ip</b>: The IP address of the NIC, if one was assigned when the discovery agent ran.</li> <li>● <b>name</b>: A string identifying the network device. For example, <b>nic-1</b>.</li> <li>● <b>mac</b>: The MAC address of the NIC.</li> <li>● <b>speedGbps</b>: The speed of the device in Gbps.</li> <li>● <b>vlans</b>: A list holding all the VLANs available for this NIC.</li> <li>● <b>vlanId</b>: The untagged VLAN ID.</li> <li>● <b>pxe</b>: Whether the NIC is able to boot using PXE.</li> </ul> |
| hardware:<br>ramMebibytes:                                                              | The host's amount of memory in Mebibytes (MiB).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| hardware:<br>storage:<br>- name:<br>rotational:<br>sizeBytes:<br>serialNumber:          | <p>The <b>hardware.storage</b> field contains a list of storage devices available to the host. The fields include:</p> <ul style="list-style-type: none"> <li>● <b>name</b>: A string identifying the storage device. For example, <b>disk 1 (boot)</b>.</li> <li>● <b>rotational</b>: Indicates whether the disk is rotational, and returns either <b>true</b> or <b>false</b>.</li> <li>● <b>sizeBytes</b>: The size of the storage device.</li> <li>● <b>serialNumber</b>: The device's serial number.</li> </ul>                                                                                                                                                   |
| hardware:<br>systemVendor:<br>manufacturer:<br>productName:<br>serialNumber:            | Contains information about the host's <b>manufacturer</b> , the <b>productName</b> , and the <b>serialNumber</b> .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

| Parameters                                                                              | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|-----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>lastUpdated</b>                                                                      | The timestamp of the last time the status of the host was updated.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>operationalStatus</b>                                                                | <p>The status of the server. The status is one of the following:</p> <ul style="list-style-type: none"> <li>● <b>OK</b>: Indicates all the details for the host are known, correctly configured, working, and manageable.</li> <li>● <b>discovered</b>: Implies some of the host's details are either not working correctly or missing. For example, the BMC address is known but the login credentials are not.</li> <li>● <b>error</b>: Indicates the system found some sort of irrecoverable error. Refer to the <b>errorMessage</b> field in the status section for more details.</li> <li>● <b>delayed</b>: Indicates that provisioning is delayed to limit simultaneous provisioning of multiple hosts.</li> <li>● <b>detached</b>: Indicates the host is marked <b>unmanaged</b>.</li> </ul>                                                                                                                                                                        |
| <b>poweredOn</b>                                                                        | Boolean indicating whether the host is powered on.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <pre>provisioning:   state:   id:   image:   raid:   firmware:   rootDeviceHints:</pre> | <p>The <b>provisioning</b> field contains values related to deploying an image to the host. The sub-fields include:</p> <ul style="list-style-type: none"> <li>● <b>state</b>: The current state of any ongoing provisioning operation. The states include:       <ul style="list-style-type: none"> <li>○ <b>&lt;empty string&gt;</b>: There is no provisioning happening at the moment.</li> <li>○ <b>unmanaged</b>: There is insufficient information available to register the host.</li> <li>○ <b>registering</b>: The agent is checking the host's BMC details.</li> <li>○ <b>match profile</b>: The agent is comparing the discovered hardware details on the host against known profiles.</li> <li>○ <b>available</b>: The host is available for provisioning. This state was previously known as <b>ready</b>.</li> <li>○ <b>preparing</b>: The existing configuration will be removed, and the new configuration will be set on the host.</li> </ul> </li> </ul> |

| Parameters              | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|-------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                         | <ul style="list-style-type: none"> <li>○ <b>provisioning</b>: The provisioner is writing an image to the host's storage.</li> <li>○ <b>provisioned</b>: The provisioner wrote an image to the host's storage.</li> <li>○ <b>externally provisioned</b>: Metal<sup>3</sup> does not manage the image on the host.</li> <li>○ <b>deprovisioning</b>: The provisioner is wiping the image from the host's storage.</li> <li>○ <b>inspecting</b>: The agent is collecting hardware details for the host.</li> <li>○ <b>deleting</b>: The agent is deleting the from the cluster.</li> <li>● <b>id</b>: The unique identifier for the service in the underlying provisioning tool.</li> <li>● <b>image</b>: The image most recently provisioned to the host.</li> <li>● <b>raid</b>: The list of hardware or software RAID volumes recently set.</li> <li>● <b>firmware</b>: The BIOS configuration for the bare metal server.</li> <li>● <b>rootDeviceHints</b>: The root device selection instructions used for the most recent provisioning operation.</li> </ul> |
| <b>triedCredentials</b> | A reference to the secret and its namespace holding the last set of BMC credentials that were sent to the provisioning backend.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |

### 3.6.5.3. Getting the BareMetalHost resource

The **BareMetalHost** resource contains the properties of a physical host. You must get the **BareMetalHost** resource for a physical host to review its properties.

#### Procedure

1. Get the list of **BareMetalHost** resources:

```
$ oc get bmh -n openshift-machine-api -o yaml
```



#### NOTE

You can use **baremetalhost** as the long form of **bmh** with **oc get** command.

2. Get the list of hosts:

```
$ oc get bmh -n openshift-machine-api
```

3. Get the **BareMetalHost** resource for a specific host:

```
$ oc get bmh <host_name> -n openshift-machine-api -o yaml
```

Where **<host\_name>** is the name of the host.

#### Example output

```
apiVersion: metal3.io/v1alpha1
kind: BareMetalHost
metadata:
  creationTimestamp: "2022-06-16T10:48:33Z"
  finalizers:
    - baremetalhost.metal3.io
  generation: 2
  name: openshift-worker-0
  namespace: openshift-machine-api
  resourceVersion: "30099"
  uid: 1513ae9b-e092-409d-be1b-ad08edeb1271
spec:
  automatedCleaningMode: metadata
  bmc:
    address: redfish://10.46.61.19:443/redfish/v1/Systems/1
    credentialsName: openshift-worker-0-bmc-secret
    disableCertificateVerification: true
  bootMACAddress: 48:df:37:c7:f7:b0
  bootMode: UEFI
  consumerRef:
    apiVersion: machine.openshift.io/v1beta1
    kind: Machine
    name: ocp-edge-958fk-worker-0-nrfcg
    namespace: openshift-machine-api
  customDeploy:
    method: install_coreos
  online: true
  rootDeviceHints:
    deviceName: /dev/disk/by-id/scsi-<serial_number>
  userData:
    name: worker-user-data-managed
    namespace: openshift-machine-api
status:
  errorCount: 0
  errorMessage: ""
  goodCredentials:
    credentials:
      name: openshift-worker-0-bmc-secret
      namespace: openshift-machine-api
    credentialsVersion: "16120"
  hardware:
    cpu:
      arch: x86_64
      clockMegahertz: 2300
      count: 64
      flags:
```

```

- 3dnowprefetch
- abm
- acpi
- adx
- aes
model: Intel(R) Xeon(R) Gold 5218 CPU @ 2.30GHz
firmware:
bios:
date: 10/26/2020
vendor: HPE
version: U30
hostname: openshift-worker-0
nics:
- mac: 48:df:37:c7:f7:b3
model: 0x8086 0x1572
name: ens1f3
ramMebibytes: 262144
storage:
- hctl: "0:0:0:0"
model: VK000960GWTTB
name: /dev/disk/by-id/scsi-<serial_number>
sizeBytes: 960197124096
type: SSD
vendor: ATA
systemVendor:
manufacturer: HPE
productName: ProLiant DL380 Gen10 (868703-B21)
serialNumber: CZ200606M3
lastUpdated: "2022-06-16T11:41:42Z"
operationalStatus: OK
poweredOn: true
provisioning:
ID: 217baa14-cfcf-4196-b764-744e184a3413
bootMode: UEFI
customDeploy:
method: install_coreos
image:
url: ""
raid:
hardwareRAIDVolumes: null
softwareRAIDVolumes: []
rootDeviceHints:
deviceName: /dev/disk/by-id/scsi-<serial_number>
state: provisioned
triedCredentials:
credentials:
name: openshift-worker-0-bmc-secret
namespace: openshift-machine-api
credentialsVersion: "16120"

```

### 3.6.5.4. Editing a BareMetalHost resource

After you deploy an OpenShift Container Platform cluster on bare metal, you might need to edit a node's **BareMetalHost** resource. Consider the following examples:

- You deploy a cluster with the Assisted Installer and need to add or edit the baseboard management controller (BMC) host name or IP address.
- You want to move a node from one cluster to another without deprovisioning it.

## Prerequisites

- Ensure the node is in the **Provisioned**, **ExternallyProvisioned**, or **Available** state.

## Procedure

1. Get the list of nodes:

```
$ oc get bmh -n openshift-machine-api
```

2. Before editing the node's **BareMetalHost** resource, detach the node from Ironic by running the following command:

```
$ oc annotate baremetalhost <node_name> -n openshift-machine-api  
'baremetalhost.metal3.io/detached=true' ①
```

- ① Replace **<node\_name>** with the name of the node.

3. Edit the **BareMetalHost** resource by running the following command:

```
$ oc edit bmh <node_name> -n openshift-machine-api
```

4. Reattach the node to Ironic by running the following command:

```
$ oc annotate baremetalhost <node_name> -n openshift-machine-api  
'baremetalhost.metal3.io/detached'-
```

### 3.6.5.5. Troubleshooting latency when deleting a BareMetalHost resource

When the Bare Metal Operator (BMO) deletes a **BareMetalHost** resource, Ironic deprovisions the bare-metal host with a process called cleaning. When cleaning fails, Ironic retries the cleaning process three times, which is the source of the latency. The cleaning process might not succeed, causing the provisioning status of the bare-metal host to remain in the **deleting** state indefinitely. When this occurs, use the following procedure to disable the cleaning process.



#### WARNING

Do not remove finalizers from the **BareMetalHost** resource.

## Procedure

1. If the cleaning process fails and restarts, wait for it to finish. This might take about 5 minutes.

- If the provisioning status remains in the **deleting** state, disable the cleaning process by modifying the **BareMetalHost** resource and setting the **automatedCleaningMode** field to **disabled**.

See "Editing a BareMetalHost resource" for additional details.

### 3.6.5.6. Attaching a non-bootable ISO to a bare-metal node

You can attach a generic, non-bootable ISO virtual media image to a provisioned node by using the **DataImage** resource. After you apply the resource, the ISO image becomes accessible to the operating system after it has booted. This is useful for configuring a node after provisioning the operating system and before the node boots for the first time.

#### Prerequisites

- The node must use Redfish or drivers derived from it to support this feature.
- The node must be in the **Provisioned** or **ExternallyProvisioned** state.
- The **name** must be the same as the name of the node defined in its **BareMetalHost** resource.
- You have a valid **url** to the ISO image.

#### Procedure

- Create a **DataImage** resource:

```
apiVersion: metal3.io/v1alpha1
kind: DataImage
metadata:
  name: <node_name> 1
spec:
  url: "http://dataimage.example.com/non-bootable.iso" 2
```

- 1** Specify the name of the node as defined in its **BareMetalHost** resource.
- 2** Specify the URL and path to the ISO image.

- Save the **DataImage** resource to a file by running the following command:

```
$ vim <node_name>-dataimage.yaml
```

- Apply the **DataImage** resource by running the following command:

```
$ oc apply -f <node_name>-dataimage.yaml -n <node_namespace> 1
```

- 1** Replace **<node\_namespace>** so that the namespace matches the namespace for the **BareMetalHost** resource. For example, **openshift-machine-api**.

- Reboot the node.

**NOTE**

To reboot the node, attach the **reboot.metal3.io** annotation, or reset set the **online** status in the **BareMetalHost** resource. A forced reboot of the bare-metal node will change the state of the node to **NotReady** for awhile. For example, 5 minutes or more.

- View the **DataImage** resource by running the following command:

```
$ oc get dataimage <node_name> -n openshift-machine-api -o yaml
```

**Example output**

```
apiVersion: v1
items:
- apiVersion: metal3.io/v1alpha1
  kind: DataImage
  metadata:
    annotations:
      kubectl.kubernetes.io/last-applied-configuration: |
        {"apiVersion":"metal3.io/v1alpha1","kind":"DataImage","metadata":{"annotations":{},"name":"bmh-node-1","namespace":"openshift-machine-api"},"spec":{"url":"http://dataimage.example.com/non-bootable.iso"}}
      creationTimestamp: "2024-06-10T12:00:00Z"
    finalizers:
    - dataimage.metal3.io
  generation: 1
  name: bmh-node-1
  namespace: openshift-machine-api
  ownerReferences:
  - apiVersion: metal3.io/v1alpha1
    blockOwnerDeletion: true
    controller: true
    kind: BareMetalHost
    name: bmh-node-1
    uid: 046cdf8e-0e97-485a-8866-e62d20e0f0b3
  resourceVersion: "21695581"
  uid: c5718f50-44b6-4a22-a6b7-71197e4b7b69
  spec:
    url: http://dataimage.example.com/non-bootable.iso
  status:
    attachedImage:
      url: http://dataimage.example.com/non-bootable.iso
    error:
      count: 0
      message: ""
    lastReconciled: "2024-06-10T12:05:00Z"
```

**3.6.5.7. About the HostFirmwareSettings resource**

You can use the **HostFirmwareSettings** resource to retrieve and manage the BIOS settings for a host. When a host moves to the **Available** state, Ironic reads the host's BIOS settings and creates the **HostFirmwareSettings** resource. The resource contains the complete BIOS configuration returned

from the baseboard management controller (BMC). Whereas, the **firmware** field in the **BareMetalHost** resource returns three vendor-independent fields, the **HostFirmwareSettings** resource typically comprises many BIOS settings of vendor-specific fields per host.

The **HostFirmwareSettings** resource contains two sections:

1. The **HostFirmwareSettings** spec.
2. The **HostFirmwareSettings** status.



#### NOTE

Reading and modifying firmware settings is only supported for drivers based on the vendor-independent Redfish protocol, Fujitsu iRMC or HP iLO.

##### 3.6.5.7.1. The HostFirmwareSettings spec

The **spec** section of the **HostFirmwareSettings** resource defines the desired state of the host's BIOS, and it is empty by default. Ironic uses the settings in the **spec.settings** section to update the baseboard management controller (BMC) when the host is in the **Preparing** state. Use the **FirmwareSchema** resource to ensure that you do not send invalid name/value pairs to hosts. See "About the FirmwareSchema resource" for additional details.

#### Example

```
spec:  
  settings:  
    ProcTurboMode: Disabled ①
```

- ① In the foregoing example, the **spec.settings** section contains a name/value pair that will set the **ProcTurboMode** BIOS setting to **Disabled**.



#### NOTE

Integer parameters listed in the **status** section appear as strings. For example, "**1**". When setting integers in the **spec.settings** section, the values should be set as integers without quotes. For example, **1**.

##### 3.6.5.7.2. The HostFirmwareSettings status

The **status** represents the current state of the host's BIOS.

Table 3.17. HostFirmwareSettings

| Parameters                                                                                                        | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|-------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| status:<br>conditions:<br>- lastTransitionTime:<br>message:<br>observedGeneration:<br>reason:<br>status:<br>type: | <p>The <b>conditions</b> field contains a list of state changes. The sub-fields include:</p> <ul style="list-style-type: none"> <li>• <b>lastTransitionTime</b>: The last time the state changed.</li> <li>• <b>message</b>: A description of the state change.</li> <li>• <b>observedGeneration</b>: The current generation of the <b>status</b>. If <b>metadata.generation</b> and this field are not the same, the <b>status.conditions</b> might be out of date.</li> <li>• <b>reason</b>: The reason for the state change.</li> <li>• <b>status</b>: The status of the state change. The status can be <b>True</b>, <b>False</b> or <b>Unknown</b>.</li> <li>• <b>type</b>: The type of state change. The types are <b>Valid</b> and <b>ChangeDetected</b>.</li> </ul> |
| status:<br>schema:<br>name:<br>namespace:<br>lastUpdated:                                                         | <p>The <b>FirmwareSchema</b> for the firmware settings. The fields include:</p> <ul style="list-style-type: none"> <li>• <b>name</b>: The name or unique identifier referencing the schema.</li> <li>• <b>namespace</b>: The namespace where the schema is stored.</li> <li>• <b>lastUpdated</b>: The last time the resource was updated.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                        |
| status:<br>settings:                                                                                              | <p>The <b>settings</b> field contains a list of name/value pairs of a host's current BIOS settings.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

### 3.6.5.8. Getting the HostFirmwareSettings resource

The **HostFirmwareSettings** resource contains the vendor-specific BIOS properties of a physical host. You must get the **HostFirmwareSettings** resource for a physical host to review its BIOS properties.

#### Procedure

1. Get the detailed list of **HostFirmwareSettings** resources by running the following command:

```
$ oc get hfs -n openshift-machine-api -o yaml
```

**NOTE**

You can use **hostfirmwaresettings** as the long form of **hfs** with the **oc get** command.

- Get the list of **HostFirmwareSettings** resources by running the following command:

```
$ oc get hfs -n openshift-machine-api
```

- Get the **HostFirmwareSettings** resource for a particular host by running the following command:

```
$ oc get hfs <host_name> -n openshift-machine-api -o yaml
```

Where **<host\_name>** is the name of the host.

### 3.6.5.9. Editing the HostFirmwareSettings resource of a provisioned host

To make changes to the **HostFirmwareSettings** spec for a provisioned host, perform the following actions:

- Edit the host **HostFirmwareSettings** resource.
- Delete the host from the machine set.
- Scale down the machine set.
- Scale up the machine set to make the changes take effect.

**IMPORTANT**

You can only edit hosts when they are in the **provisioned** state, excluding read-only values. You cannot edit hosts in the **externally provisioned** state.

#### Procedure

- Get the list of **HostFirmwareSettings** resources by running the following command:

```
$ oc get hfs -n openshift-machine-api
```

- Edit the host **HostFirmwareSettings** resource by running the following command:

```
$ oc edit hfs <hostname> -n openshift-machine-api
```

Where **<hostname>** is the name of a provisioned host. The **HostFirmwareSettings** resource will open in the default editor for your terminal.

- Add name and value pairs to the **spec.settings** section by running the following command:

**Example**

```
spec:  
  settings:  
    name: value 1
```

- 1 Use the **FirmwareSchema** resource to identify the available settings for the host. You cannot set values that are read-only.

4. Save the changes and exit the editor.
5. Get the host machine name by running the following command:

```
$ oc get bmh <hostname> -n openshift-machine name
```

Where **<hostname>** is the name of the host. The terminal displays the machine name under the **CONSUMER** field.

6. Annotate the machine to delete it from the machine set by running the following command:

```
$ oc annotate machine <machine_name> machine.openshift.io/delete-machine=true -n openshift-machine-api
```

Where **<machine\_name>** is the name of the machine to delete.

7. Get a list of nodes and count the number of worker nodes by running the following command:

```
$ oc get nodes
```

8. Get the machine set by running the following command:

```
$ oc get machinesets -n openshift-machine-api
```

9. Scale the machine set by running the following command:

```
$ oc scale machineset <machineset_name> -n openshift-machine-api --replicas=<n-1>
```

Where **<machineset\_name>** is the name of the machine set and **<n-1>** is the decremented number of worker nodes.

10. When the host enters the **Available** state, scale up the machine set to make the **HostFirmwareSettings** resource changes take effect by running the following command:

```
$ oc scale machineset <machineset_name> -n openshift-machine-api --replicas=<n>
```

Where **<machineset\_name>** is the name of the machine set and **<n>** is the number of worker nodes.

### 3.6.5.10. Performing a live update to the HostFirmwareSettings resource

You can perform a live update to the **HostFirmwareSettings** resource after it has begun running workloads. Live updates do not trigger deprovisioning and reprovisioning the host.



## IMPORTANT

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

For more information about the support scope of Red Hat Technology Preview features, see [Technology Preview Features Support Scope](#).

### Prerequisites

- The **HostUpdatePolicy** resource must have the **firmwareSettings** parameter set to **onReboot**.

### Procedure

- Update the **HostFirmwareSettings** resource by running the following command:

```
$ oc patch hostfirmwaresettings <hostname> --type merge -p \①
  '{"spec": {"settings": {"<name>": "<value>"}}}' ②
```

- Replace **<hostname>** with the name of the host.
- Replace **<name>** with the name of the setting. Replace **<value>** with the value of the setting. You can set multiple name-value pairs.



## NOTE

Get the **FirmwareSchema** resource to determine which settings the hardware supports and what settings and values you can update. You cannot update read-only values and you cannot update the **FirmwareSchema** resource. You can also use the **oc edit <hostname> hostfirmwaresettings -n openshift-machine-api** command to update the **HostFirmwareSettings** resource.

- Cordon and drain the node by running the following command:

```
$ oc drain <node_name> --force ①
```

- Replace **<node\_name>** with the name of the node.

- Power off the host for a period of 5 minutes by running the following command:

```
$ oc patch bmh <hostname> --type merge -p '{"spec": {"online": false}}'
```

This step ensures that daemonsets or controllers can mark any infrastructure pods that might be running on the host as offline, while the remaining hosts handle incoming requests.

- After 5 minutes, power on the host by running the following command:

```
$ oc patch bmh <hostname> --type merge -p '{"spec": {"online": true}}'
```

The servicing operation commences and the Bare Metal Operator (BMO) sets the **operationalStatus** parameter of the **BareMetalHost** to **servicing**. The BMO updates the **operationalStatus** parameter to **OK** after updating the resource. If an error occurs, the BMO updates the **operationalStatus** parameter to **error** and retries the operation.

- Once Ironic completes the update and the host powers up, uncordon the node by running the following command:

```
$ oc uncordon <node_name>
```

### 3.6.5.11. Verifying the HostFirmware Settings resource is valid

When the user edits the **spec.settings** section to make a change to the **HostFirmwareSetting**(HFS) resource, the Bare Metal Operator (BMO) validates the change against the **FirmwareSchema** resource, which is a read-only resource. If the setting is invalid, the BMO will set the **Type** value of the **status.Condition** setting to **False** and also generate an event and store it in the HFS resource. Use the following procedure to verify that the resource is valid.

#### Procedure

- Get a list of **HostFirmwareSetting** resources:

```
$ oc get hfs -n openshift-machine-api
```

- Verify that the **HostFirmwareSettings** resource for a particular host is valid:

```
$ oc describe hfs <host_name> -n openshift-machine-api
```

Where **<host\_name>** is the name of the host.

#### Example output

Events:

| Type   | Reason           | Age   | From                                   | Message                                                                                 |
|--------|------------------|-------|----------------------------------------|-----------------------------------------------------------------------------------------|
| Normal | ValidationFailed | 2m49s | metal3-hostfirmwaresettings-controller | Invalid BIOS setting: Setting ProcTurboMode is invalid, unknown enumeration value - Foo |



#### IMPORTANT

If the response returns **ValidationFailed**, there is an error in the resource configuration and you must update the values to conform to the **FirmwareSchema** resource.

### 3.6.5.12. About the FirmwareSchema resource

BIOS settings vary among hardware vendors and host models. A **FirmwareSchema** resource is a read-only resource that contains the types and limits for each BIOS setting on each host model. The data comes directly from the BMC through Ironic. The **FirmwareSchema** enables you to identify valid values you can specify in the **spec** field of the **HostFirmwareSettings** resource. The **FirmwareSchema** resource has a unique identifier derived from its settings and limits. Identical host models use the same **FirmwareSchema** identifier. It is likely that multiple instances of **HostFirmwareSettings** use the same **FirmwareSchema**.

Table 3.18. FirmwareSchema specification

| Parameters                                                                                                                                  | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|---------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <pre>&lt;BIOS_setting_name&gt; attribute_type: allowable_values: lower_bound: upper_bound: min_length: max_length: read_only: unique:</pre> | <p>The <b>spec</b> is a simple map consisting of the BIOS setting name and the limits of the setting. The fields include:</p> <ul style="list-style-type: none"> <li>● <b>attribute_type</b>: The type of setting. The supported types are: <ul style="list-style-type: none"> <li>○ <b>Enumeration</b></li> <li>○ <b>Integer</b></li> <li>○ <b>String</b></li> <li>○ <b>Boolean</b></li> </ul> </li> <li>● <b>allowable_values</b>: A list of allowable values when the <b>attribute_type</b> is <b>Enumeration</b>.</li> <li>● <b>lower_bound</b>: The lowest allowed value when <b>attribute_type</b> is <b>Integer</b>.</li> <li>● <b>upper_bound</b>: The highest allowed value when <b>attribute_type</b> is <b>Integer</b>.</li> <li>● <b>min_length</b>: The shortest string length that the value can have when <b>attribute_type</b> is <b>String</b>.</li> <li>● <b>max_length</b>: The longest string length that the value can have when <b>attribute_type</b> is <b>String</b>.</li> <li>● <b>read_only</b>: The setting is read only and cannot be modified.</li> <li>● <b>unique</b>: The setting is specific to this host.</li> </ul> |

### 3.6.5.13. Getting the FirmwareSchema resource

Each host model from each vendor has different BIOS settings. When editing the **HostFirmwareSettings** resource's **spec** section, the name/value pairs you set must conform to that host's firmware schema. To ensure you are setting valid name/value pairs, get the **FirmwareSchema** for the host and review it.

#### Procedure

1. Get the list of **FirmwareSchema** resource instances by running the following command:

```
$ oc get firmwareschema -n openshift-machine-api
```

2. Get a particular **FirmwareSchema** instance by running the following command:

```
$ oc get firmwareschema <instance_name> -n openshift-machine-api -o yaml
```

Where `<instance_name>` is the name of the schema instance stated in the **HostFirmwareSettings** resource (see Table 3).

### 3.6.5.14. About the HostFirmwareComponents resource

Metal<sup>3</sup> provides the **HostFirmwareComponents** resource, which describes BIOS and baseboard management controller (BMC) firmware versions. The **HostFirmwareComponents** resource contains two sections:

1. The **HostFirmwareComponents** spec
2. The **HostFirmwareComponents** status

#### 3.6.5.14.1. HostFirmwareComponents spec

The **spec** section of the **HostFirmwareComponents** resource defines the desired state of the host's BIOS and BMC versions.

**Table 3.19. HostFirmwareComponents spec**

| Parameters                                                                                       | Description                                                                                                                                                                                                                                                                                                                                 |
|--------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>updates:</li> <li>  component:</li> <li>  url:</li> </ul> | <p>The <b>updates</b> configuration setting contains the components to update. The fields are:</p> <ul style="list-style-type: none"> <li>● <b>component</b>: The name of the component. The valid settings are <b>bios</b> or <b>bmc</b>.</li> <li>● <b>url</b>: The URL to the component's firmware specification and version.</li> </ul> |

#### 3.6.5.14.2. HostFirmwareComponents status

The **status** section of the **HostFirmwareComponents** resource returns the current status of the host's BIOS and BMC versions.

**Table 3.20. HostFirmwareComponents status**

| Parameters | Description |
|------------|-------------|
|            |             |

| Parameters                                                                                           | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| components:<br>component:<br>initialVersion:<br>currentVersion:<br>lastVersionFlashed:<br>updatedAt: | <p>The <b>components</b> section contains the status of the components. The fields are:</p> <ul style="list-style-type: none"> <li>• <b>component</b>: The name of the firmware component. It returns <b>bios</b> or <b>bmc</b>.</li> <li>• <b>initialVersion</b>: The initial firmware version of the component. Ironic retrieves this information when creating the <b>BareMetalHost</b> resource. You cannot change it.</li> <li>• <b>currentVersion</b>: The current firmware version of the component. Initially, the value matches the <b>initialVersion</b> value until Ironic updates the firmware on the bare-metal host.</li> <li>• <b>lastVersionFlashed</b>: The last firmware version of the component flashed on the bare-metal host. This field returns <b>null</b> until Ironic updates the firmware.</li> <li>• <b>updatedAt</b>: The timestamp when Ironic updated the bare-metal host's firmware.</li> </ul> |
| updates:<br>component:<br>url:                                                                       | <p>The <b>updates</b> configuration setting contains the updated components. The fields are:</p> <ul style="list-style-type: none"> <li>• <b>component</b>: The name of the component.</li> <li>• <b>url</b>: The URL to the component's firmware specification and version.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |

### 3.6.5.15. Getting the HostFirmwareComponents resource

The **HostFirmwareComponents** resource contains the specific firmware version of the BIOS and baseboard management controller (BMC) of a physical host. You must get the **HostFirmwareComponents** resource for a physical host to review the firmware version and status.

#### Procedure

1. Get the detailed list of **HostFirmwareComponents** resources by running the following command:

```
$ oc get hostfirmwarecomponents -n openshift-machine-api -o yaml
```

2. Get the list of **HostFirmwareComponents** resources by running the following command:

```
$ oc get hostfirmwarecomponents -n openshift-machine-api
```

- Get the **HostFirmwareComponents** resource for a particular host by running the following command:

```
$ oc get hostfirmwarecomponents <host_name> -n openshift-machine-api -o yaml
```

Where **<host\_name>** is the name of the host.

### Example output

```
---
apiVersion: metal3.io/v1alpha1
kind: HostFirmwareComponents
metadata:
  creationTimestamp: 2024-04-25T20:32:06Z"
  generation: 1
  name: ostest-master-2
  namespace: openshift-machine-api
  ownerReferences:
    - apiVersion: metal3.io/v1alpha1
      blockOwnerDeletion: true
      controller: true
      kind: BareMetalHost
      name: ostest-master-2
      uid: 16022566-7850-4dc8-9e7d-f216211d4195
  resourceVersion: "2437"
  uid: 2038d63f-afc0-4413-8ffe-2f8e098d1f6c
spec:
  updates: []
status:
  components:
    - component: bios
      currentVersion: 1.0.0
      initialVersion: 1.0.0
    - component: bmc
      currentVersion: "1.00"
      initialVersion: "1.00"
  conditions:
    - lastTransitionTime: "2024-04-25T20:32:06Z"
      message: ""
      observedGeneration: 1
      reason: OK
      status: "True"
      type: Valid
    - lastTransitionTime: "2024-04-25T20:32:06Z"
      message: ""
      observedGeneration: 1
      reason: OK
      status: "False"
      type: ChangeDetected
  lastUpdated: "2024-04-25T20:32:06Z"
  updates: []
```

#### 3.6.5.16. Editing the HostFirmwareComponents resource of a provisioned host

You can edit the **HostFirmwareComponents** resource of a provisioned host.

## Procedure

- Get the detailed list of **HostFirmwareComponents** resources by running the following command:

```
$ oc get hostfirmwarecomponents -n openshift-machine-api -o yaml
```

- Edit the **HostFirmwareComponents** resource by running the following command:

```
$ oc edit <hostname> hostfirmwarecomponents -n openshift-machine-api ①
```

- Where **<hostname>** is the name of the host. The **HostFirmwareComponents** resource will open in the default editor for your terminal.

- Make the appropriate edits.

### Example output

```
---  
apiVersion: metal3.io/v1alpha1  
kind: HostFirmwareComponents  
metadata:  
  creationTimestamp: 2024-04-25T20:32:06Z"  
  generation: 1  
  name: ostest-master-2  
  namespace: openshift-machine-api  
  ownerReferences:  
    - apiVersion: metal3.io/v1alpha1  
      blockOwnerDeletion: true  
      controller: true  
      kind: BareMetalHost  
      name: ostest-master-2  
      uid: 16022566-7850-4dc8-9e7d-f216211d4195  
  resourceVersion: "2437"  
  uid: 2038d63f-afc0-4413-8ffe-2f8e098d1f6c  
spec:  
  updates:  
    - name: bios ①  
      url: https://myurl.with.firmware.for.bios ②  
    - name: bmc ③  
      url: https://myurl.with.firmware.for.bmc ④  
status:  
  components:  
    - component: bios  
      currentVersion: 1.0.0  
      initialVersion: 1.0.0  
    - component: bmc  
      currentVersion: "1.00"  
      initialVersion: "1.00"  
  conditions:  
    - lastTransitionTime: "2024-04-25T20:32:06Z"  
      message: ""  
      observedGeneration: 1  
      reason: OK
```

```

status: "True"
type: Valid
- lastTransitionTime: "2024-04-25T20:32:06Z"
  message: ""
  observedGeneration: 1
  reason: OK
  status: "False"
  type: ChangeDetected
lastUpdated: "2024-04-25T20:32:06Z"

```

- 1 To set a BIOS version, set the **name** attribute to **bios**.
- 2 To set a BIOS version, set the **url** attribute to the URL for the firmware version of the BIOS.
- 3 To set a BMC version, set the **name** attribute to **bmc**.
- 4 To set a BMC version, set the **url** attribute to the URL for the firmware version of the BMC.

4. Save the changes and exit the editor.

5. Get the host machine name by running the following command:

```
$ oc get bmh <host_name> -n openshift-machine name 1
```

- 1 Where **<host\_name>** is the name of the host. The terminal displays the machine name under the **CONSUMER** field.

6. Annotate the machine to delete it from the machine set by running the following command:

```
$ oc annotate machine <machine_name> machine.openshift.io/delete-machine=true -n
openshift-machine-api 1
```

- 1 Where **<machine\_name>** is the name of the machine to delete.

7. Get a list of nodes and count the number of worker nodes by running the following command:

```
$ oc get nodes
```

8. Get the machine set by running the following command:

```
$ oc get machinesets -n openshift-machine-api
```

9. Scale down the machine set by running the following command:

```
$ oc scale machineset <machineset_name> -n openshift-machine-api --replicas=<n-1> 1
```

- 1 Where **<machineset\_name>** is the name of the machine set and **<n-1>** is the decremented number of worker nodes.

10. When the host enters the **Available** state, scale up the machine set to make the **HostFirmwareComponents** resource changes take effect by running the following command:

```
$ oc scale machineset <machineset_name> -n openshift-machine-api --replicas=<n> ①
```

- 1 Where **<machineset\_name>** is the name of the machine set and **<n>** is the number of worker nodes.

### 3.6.5.17. Performing a live update to the HostFirmwareComponents resource

You can perform a live update to the **HostFirmwareComponents** resource on an already provisioned host. Live updates do not trigger deprovisioning and reprovisioning the host.



#### IMPORTANT

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

For more information about the support scope of Red Hat Technology Preview features, see [Technology Preview Features Support Scope](#).



#### IMPORTANT

Do not perform live updates on production hosts. You can perform live updates to the BIOS for testing purposes. We do not recommend that you perform live updates to the BMC on OpenShift Container Platform 4.18 for test purposes, especially on earlier generation hardware.

#### Prerequisites

- The **HostUpdatePolicy** resource must have the **firmwareUpdates** parameter set to **onReboot**.

#### Procedure

1. Update the **HostFirmwareComponents** resource by running the following command:

```
$ oc patch hostfirmwarecomponents <hostname> --type merge -p \①
  '{"spec": {"updates": [{"component": "<type>", \②
    "url": "<url>"}]}'} \③
```

- 1 Replace **<hostname>** with the name of the host.
- 2 Replace **<type>** with the type of component. Specify **bios** or **bmc**.
- 3 Replace **<url>** with the URL for the component.

**NOTE**

You can also use the **oc edit <hostname> hostfirmwarecomponents -n openshift-machine-api** command to update the resource.

2. Cordon and drain the node by running the following command:

```
$ oc drain <node_name> --force ①
```

① Replace **<node\_name>** with the name of the node.

3. Power off the host for a period of 5 minutes by running the following command:

```
$ oc patch bmh <hostname> --type merge -p '{"spec": {"online": false}}'
```

This step ensures that daemonsets or controllers mark any infrastructure pods that might be running on the node as offline, while the remaining nodes handle incoming requests.

4. After 5 minutes, power on the host by running the following command:

```
$ oc patch bmh <hostname> --type merge -p '{"spec": {"online": true}}'
```

The servicing operation commences and the Bare Metal Operator (BMO) sets the **operationalStatus** parameter of the **BareMetalHost** to **servicing**. The BMO updates the **operationalStatus** parameter to **OK** after updating the resource. If an error occurs, the BMO updates the **operationalStatus** parameter to **error** and retries the operation.

5. Uncordon the node by running the following command:

```
$ oc uncordon <node_name>
```

### 3.6.5.18. About the HostUpdatePolicy resource

You can use the **HostUpdatePolicy** resource to enable or disable applying live updates to the firmware settings, BMC settings, or firmware settings of each bare-metal host. By default, the Operator disables live updates to already provisioned bare-metal hosts by default.

#### The HostUpdatePolicy spec

The **spec** section of the **HostUpdatePolicy** resource provides two settings:

##### **firmwareSettings**

This setting corresponds to the **HostFirmwareSettings** resource.

##### **firmwareUpdates**

This setting corresponds to the **HostFirmwareComponents** resource.

When you set the value to **onPreparing**, you can only update the host during provisioning, which is the default setting. When you set the value to **onReboot**, you can update a provisioned host by applying the resource and rebooting the bare-metal host. Then, follow the procedure for editing the **HostFirmwareSettings** or **HostFirmwareComponents** resource.

#### Example HostUpdatePolicy resource

```

apiVersion: metal3.io/v1alpha1
kind: HostUpdatePolicy
metadata:
  name: <hostname> 1
  namespace: openshift-machine-api
spec:
  firmwareSettings: <setting> 2
  firmwareUpdates: <setting>

```

- 1** The name of the bare-metal host.
- 2** The update policy setting. Specify **onPreparing** to disable live updates. Specify **onReboot** to enable live updates.

### 3.6.5.19. Setting the HostUpdatePolicy resource

By default, the **HostUpdatePolicy** disables live updates. To enable live updates, use the following procedure.



#### IMPORTANT

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

For more information about the support scope of Red Hat Technology Preview features, see [Technology Preview Features Support Scope](#).

#### Procedure

- Create the **HostUpdatePolicy** resource by running the following command:

```
$ vim hup.yaml
```

You can use any text editor you prefer.

#### Example HostUpdatePolicy resource

```

apiVersion: metal3.io/v1alpha1
kind: HostUpdatePolicy
metadata:
  name: <hostname> 1
  namespace: openshift-machine-api
spec:
  firmwareSettings: onReboot
  firmwareUpdates: onReboot

```

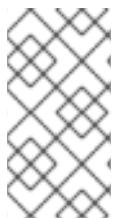
- 1** Replace **<hostname>** with the name of the host.

2. Save the changes to the **hup.yaml** file.
3. Apply the policy by running the following command:

```
$ oc apply -f hup.yaml
```

## 3.7. EXPANDING THE CLUSTER

After deploying an installer-provisioned OpenShift Container Platform cluster, you can use the following procedures to expand the number of worker nodes. Ensure that each prospective worker node meets the prerequisites.



### NOTE

Expanding the cluster using RedFish Virtual Media involves meeting minimum firmware requirements. See [Firmware requirements for installing with virtual media](#) in the [Prerequisites](#) section for additional details when expanding the cluster using RedFish Virtual Media.

### 3.7.1. Preparing the bare metal node

To expand your cluster, you must provide the node with the relevant IP address. This can be done with a static configuration, or with a DHCP (Dynamic Host Configuration protocol) server. When expanding the cluster using a DHCP server, each node must have a DHCP reservation.



### RESERVING IP ADDRESSES SO THEY BECOME STATIC IP ADDRESSES

Some administrators prefer to use static IP addresses so that each node's IP address remains constant in the absence of a DHCP server. To configure static IP addresses with NMState, see "Optional: Configuring host network interfaces in the [install-config.yaml](#) file" in the "Setting up the environment for an OpenShift installation" section for additional details.

Preparing the bare metal node requires executing the following procedure from the provisioner node.

#### Procedure

1. Get the **oc** binary:
 

```
$ curl -s https://mirror.openshift.com/pub/openshift-v4/clients/ocp/$VERSION/openshift-client-linux-$VERSION.tar.gz | tar zxvf - oc
```

```
$ sudo cp oc /usr/local/bin
```
2. Power off the bare metal node by using the baseboard management controller (BMC), and ensure it is off.
3. Retrieve the user name and password of the bare metal node's baseboard management controller. Then, create **base64** strings from the user name and password:
 

```
$ echo -ne "root" | base64
```

```
$ echo -ne "password" | base64
```

4. Create a configuration file for the bare metal node. Depending on whether you are using a static configuration or a DHCP server, use one of the following example **bmh.yaml** files, replacing values in the YAML to match your environment:

```
$ vim bmh.yaml
```

- **Static configuration bmh.yaml:**

```
---
apiVersion: v1 1
kind: Secret
metadata:
  name: openshift-worker-<num>-network-config-secret 2
  namespace: openshift-machine-api
  type: Opaque
  stringData:
    nmstate: | 3
      interfaces: 4
        - name: <nic1_name> 5
          type: ethernet
          state: up
          ipv4:
            address:
              - ip: <ip_address> 6
                prefix-length: 24
                enabled: true
            dns-resolver:
              config:
                server:
                  - <dns_ip_address> 7
            routes:
              config:
                - destination: 0.0.0.0/0
                  next-hop-address: <next_hop_ip_address> 8
                  next-hop-interface: <next_hop_nic1_name> 9
    ---
apiVersion: v1
kind: Secret
metadata:
  name: openshift-worker-<num>-bmc-secret 10
  namespace: openshift-machine-api
  type: Opaque
  data:
    username: <base64_of_uid> 11
    password: <base64_of_pwd> 12
    ---
apiVersion: metal3.io/v1alpha1
kind: BareMetalHost
metadata:
  name: openshift-worker-<num> 13
  namespace: openshift-machine-api
```

```

spec:
  online: True
  bootMACAddress: <nic1_mac_address> ⑯
  bmc:
    address: <protocol>://<bmc_url> ⑰
    credentialsName: openshift-worker-<num>-bmc-secret ⑱
    disableCertificateVerification: True ⑲
    username: <bmc_username> ⑳
    password: <bmc_password> ㉑
  rootDeviceHints:
    deviceName: <root_device_hint> ㉒
  preprovisioningNetworkDataName: openshift-worker-<num>-network-config-secret ㉓

```

- ⑯ To configure the network interface for a newly created node, specify the name of the secret that contains the network configuration. Follow the **nmstate** syntax to define the network configuration for your node. See "Optional: Configuring host network interfaces in the install-config.yaml file" for details on configuring NMState syntax.
- ⑰ ⑱ ⑲ Replace <num> for the worker number of the bare metal node in the **name** fields, the **credentialsName** field, and the **preprovisioningNetworkDataName** field.
- ㉒ Add the NMState YAML syntax to configure the host interfaces.
- ㉓ Optional: If you have configured the network interface with **nmstate**, and you want to disable an interface, set **state: up** with the IP addresses set to **enabled: false** as shown:

```

  ---
  interfaces:
    - name: <nict_name>
      type: ethernet
      state: up
      ipv4:
        enabled: false
      ipv6:
        enabled: false

```

- ④ ⑤ ⑥ ⑦ ⑧ ⑨ Replace <nict\_name>, <ip\_address>, <dns\_ip\_address>, <next\_hop\_ip\_address> and <next\_hop\_nict\_name> with appropriate values.
- ⑩ ⑪ Replace <base64\_of\_uid> and <base64\_of\_pwd> with the base64 string of the user name and password.
- ⑫ Replace <nict\_mac\_address> with the MAC address of the bare metal node's first NIC. See the "BMC addressing" section for additional BMC configuration options.
- ⑬ Replace <protocol> with the BMC protocol, such as IPMI, RedFish, or others. Replace <bmc\_url> with the URL of the bare metal node's baseboard management controller.
- ⑭ To skip certificate validation, set **disableCertificateVerification** to true.
- ⑮ ⑯ Replace <bmc\_username> and <bmc\_password> with the string of the BMC user name and password.

- 20 Optional: Replace `<root_device_hint>` with a device path if you specify a root device hint.
- 21 Optional: If you have configured the network interface for the newly created node, provide the network configuration secret name in the `preprovisioningNetworkDataName` of the BareMetalHost CR.

- DHCP configuration `bmh.yaml`:

```

---
apiVersion: v1
kind: Secret
metadata:
  name: openshift-worker-<num>-bmc-secret 1
  namespace: openshift-machine-api
  type: Opaque
data:
  username: <base64_of_uid> 2
  password: <base64_of_pwd> 3
---
apiVersion: metal3.io/v1alpha1
kind: BareMetalHost
metadata:
  name: openshift-worker-<num> 4
  namespace: openshift-machine-api
spec:
  online: True
  bootMACAddress: <nict1_mac_address> 5
  bmc:
    address: <protocol>://<bmc_url> 6
    credentialsName: openshift-worker-<num>-bmc-secret 7
    disableCertificateVerification: True 8
    username: <bmc_username> 9
    password: <bmc_password> 10
  rootDeviceHints:
    deviceName: <root_device_hint> 11
  preprovisioningNetworkDataName: openshift-worker-<num>-network-config-secret 12

```

1 4 7 Replace `<num>` for the worker number of the bare metal node in the `name` fields, the `credentialsName` field, and the `preprovisioningNetworkDataName` field.

2 3 Replace `<base64_of_uid>` and `<base64_of_pwd>` with the base64 string of the user name and password.

5 Replace `<nict1_mac_address>` with the MAC address of the bare metal node's first NIC. See the "BMC addressing" section for additional BMC configuration options.

6 Replace `<protocol>` with the BMC protocol, such as IPMI, RedFish, or others. Replace `<bmc_url>` with the URL of the bare metal node's baseboard management controller.

8 To skip certificate validation, set `disableCertificateVerification` to true.

9 10 Replace `<bmc_username>` and `<bmc_password>` with the string of the BMC user name and password.

- 11 Optional: Replace `<root_device_hint>` with a device path if you specify a root device hint.
- 12 Optional: If you have configured the network interface for the newly created node, provide the network configuration secret name in the `preprovisioningNetworkDataName` of the BareMetalHost CR.



### NOTE

If the MAC address of an existing bare metal node matches the MAC address of a bare metal host that you are attempting to provision, then the ironic installation will fail. If the host enrollment, inspection, cleaning, or other ironic steps fail, the Bare Metal Operator retries the installation continuously. See "Diagnosing a host duplicate MAC address" for more information.

5. Create the bare metal node:

```
$ oc -n openshift-machine-api create -f bmh.yaml
```

### Example output

```
secret/openshift-worker-<num>-network-config-secret created
secret/openshift-worker-<num>-bmc-secret created
baremetalhost.metal3.io/openshift-worker-<num> created
```

Where `<num>` will be the worker number.

6. Power up and inspect the bare metal node:

```
$ oc -n openshift-machine-api get bmh openshift-worker-<num>
```

Where `<num>` is the worker node number.

### Example output

| NAME                   | STATE     | CONSUMER | ONLINE | ERROR |
|------------------------|-----------|----------|--------|-------|
| openshift-worker-<num> | available |          | true   |       |



### NOTE

To allow the worker node to join the cluster, scale the `machineset` object to the number of the `BareMetalHost` objects. You can scale nodes either manually or automatically. To scale nodes automatically, use the `metal3.io/autoscale-to-hosts` annotation for `machineset`.

## Additional resources

- See [Optional: Configuring host network interfaces in the install-config.yaml file](#) for details on configuring the NMState syntax.
- See [Automatically scaling machines to the number of available bare metal hosts](#) for details on automatically scaling machines.

### 3.7.2. Replacing a bare-metal control plane node

Use the following procedure to replace an installer-provisioned OpenShift Container Platform control plane node.



#### IMPORTANT

If you reuse the **BareMetalHost** object definition from an existing control plane host, do not leave the **externallyProvisioned** field set to **true**.

Existing control plane **BareMetalHost** objects may have the **externallyProvisioned** flag set to **true** if they were provisioned by the OpenShift Container Platform installation program.

#### Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.
- You have taken an etcd backup.



#### IMPORTANT

Take an etcd backup before performing this procedure so that you can restore your cluster if you encounter any issues. For more information about taking an etcd backup, see the *Additional resources* section.

#### Procedure

1. Ensure that the Bare Metal Operator is available:

```
$ oc get clusteroperator baremetal
```

#### Example output

| NAME      | VERSION | AVAILABLE | PROGRESSING | DEGRADED | SINCE | MESSAGE |
|-----------|---------|-----------|-------------|----------|-------|---------|
| baremetal | 4.18    | True      | False       | False    | 3d15h |         |

2. Remove the old **BareMetalHost** and **Machine** objects:

```
$ oc delete bmh -n openshift-machine-api <host_name>
$ oc delete machine -n openshift-machine-api <machine_name>
```

Replace **<host\_name>** with the name of the host and **<machine\_name>** with the name of the machine. The machine name appears under the **CONSUMER** field.

After you remove the **BareMetalHost** and **Machine** objects, then the machine controller automatically deletes the **Node** object.

3. Create the new **BareMetalHost** object and the secret to store the BMC credentials:

```
$ cat <<EOF | oc apply -f -
apiVersion: v1
kind: Secret
metadata:
```

```

name: control-plane-<num>-bmc-secret ①
namespace: openshift-machine-api
data:
  username: <base64_of_uid> ②
  password: <base64_of_pwd> ③
type: Opaque
---
apiVersion: metal3.io/v1alpha1
kind: BareMetalHost
metadata:
  name: control-plane-<num> ④
  namespace: openshift-machine-api
spec:
  automatedCleaningMode: disabled
  bmc:
    address: <protocol>://<bmc_ip> ⑤
    credentialsName: control-plane-<num>-bmc-secret ⑥
  bootMACAddress: <NIC1_mac_address> ⑦
  bootMode: UEFI
  externallyProvisioned: false
  online: true
EOF

```

① ④ ⑥ Replace **<num>** for the control plane number of the bare metal node in the **name** fields and the **credentialsName** field.

- ② Replace **<base64\_of\_uid>** with the **base64** string of the user name.
- ③ Replace **<base64\_of\_pwd>** with the **base64** string of the password.
- ⑤ Replace **<protocol>** with the BMC protocol, such as **redfish**, **redfish-virtualmedia**, **idrac-virtualmedia**, or others. Replace **<bmc\_ip>** with the IP address of the bare metal node's baseboard management controller. For additional BMC configuration options, see "BMC addressing" in the *Additional resources* section.
- ⑦ Replace **<NIC1\_mac\_address>** with the MAC address of the bare metal node's first NIC.

After the inspection is complete, the **BareMetalHost** object is created and available to be provisioned.

#### 4. View available **BareMetalHost** objects:

```
$ oc get bmh -n openshift-machine-api
```

#### Example output

| NAME                        | STATE                  | CONSUMER        | ONLINE | ERROR | AGE   |
|-----------------------------|------------------------|-----------------|--------|-------|-------|
| control-plane-1.example.com | available              | control-plane-1 | true   |       | 1h10m |
| control-plane-2.example.com | externally provisioned | control-plane-2 |        | true  |       |
|                             | 4h53m                  |                 |        |       |       |
| control-plane-3.example.com | externally provisioned | control-plane-3 |        | true  |       |
|                             | 4h53m                  |                 |        |       |       |
| compute-1.example.com       | provisioned            | compute-1-ktmmx |        | true  |       |

|                       |             |  |                 |      |
|-----------------------|-------------|--|-----------------|------|
| 4h53m                 |             |  |                 |      |
| compute-1.example.com | provisioned |  | compute-2-l2zmb | true |
| 4h53m                 |             |  |                 |      |

There are no **MachineSet** objects for control plane nodes, so you must create a **Machine** object instead. You can copy the **providerSpec** from another control plane **Machine** object.

5. Create a **Machine** object:

```
$ cat <<EOF | oc apply -f -
apiVersion: machine.openshift.io/v1beta1
kind: Machine
metadata:
  annotations:
    metal3.io/BareMetalHost: openshift-machine-api/control-plane-<num> ①
  labels:
    machine.openshift.io/cluster-api-cluster: control-plane-<num> ②
    machine.openshift.io/cluster-api-machine-role: master
    machine.openshift.io/cluster-api-machine-type: master
  name: control-plane-<num> ③
  namespace: openshift-machine-api
spec:
  metadata: {}
  providerSpec:
    value:
      apiVersion: baremetal.cluster.k8s.io/v1alpha1
      customDeploy:
        method: install_coreos
      hostSelector: {}
      image:
        checksum: ""
        url: ""
      kind: BareMetalMachineProviderSpec
      metadata:
        creationTimestamp: null
      userData:
        name: master-user-data-managed
EOF
```

① ② ③ Replace **<num>** for the control plane number of the bare metal node in the **name**, **labels** and **annotations** fields.

6. To view the **BareMetalHost** objects, run the following command:

```
$ oc get bmh -A
```

#### Example output

| NAME                        | STATE                  | CONSUMER        | ONLINE | ERROR | AGE   |
|-----------------------------|------------------------|-----------------|--------|-------|-------|
| control-plane-1.example.com | provisioned            | control-plane-1 | true   |       | 2h53m |
| control-plane-2.example.com | externally provisioned | control-plane-2 | true   |       | 5h53m |
| control-plane-3.example.com | externally provisioned | control-plane-3 | true   |       | 5h53m |

|                                |             |                 |      |
|--------------------------------|-------------|-----------------|------|
| compute-1.example.com<br>5h53m | provisioned | compute-1-ktmmx | true |
| compute-2.example.com<br>5h53m | provisioned | compute-2-l2zmb | true |

7. After the RHCOS installation, verify that the **BareMetalHost** is added to the cluster:

```
$ oc get nodes
```

### Example output

| NAME                        | STATUS    | ROLES  | AGE  | VERSION |
|-----------------------------|-----------|--------|------|---------|
| control-plane-1.example.com | available | master | 4m2s | v1.31.3 |
| control-plane-2.example.com | available | master | 141m | v1.31.3 |
| control-plane-3.example.com | available | master | 141m | v1.31.3 |
| compute-1.example.com       | available | worker | 87m  | v1.31.3 |
| compute-2.example.com       | available | worker | 87m  | v1.31.3 |



### NOTE

After replacement of the new control plane node, the etcd pod running in the new node is in **crashloopback** status. See "Replacing an unhealthy etcd member" in the *Additional resources* section for more information.

### Additional resources

- [Replacing an unhealthy etcd member](#)
- [Backing up etcd](#)
- [Configuration using the Bare Metal Operator](#)
- [BMC addressing](#)

### 3.7.3. Preparing to deploy with Virtual Media on the baremetal network

If the **provisioning** network is enabled and you want to expand the cluster using Virtual Media on the **baremetal** network, use the following procedure.

#### Prerequisites

- There is an existing cluster with a **baremetal** network and a **provisioning** network.

#### Procedure

1. Edit the **provisioning** custom resource (CR) to enable deploying with Virtual Media on the **baremetal** network:

```
oc edit provisioning
```

```
apiVersion: metal3.io/v1alpha1
kind: Provisioning
metadata:
```

```

creationTimestamp: "2021-08-05T18:51:50Z"
finalizers:
- provisioning.metal3.io
generation: 8
name: provisioning-configuration
resourceVersion: "551591"
uid: f76e956f-24c6-4361-aa5b-feaf72c5b526
spec:
provisioningDHCPRange: 172.22.0.10,172.22.0.254
provisioningIP: 172.22.0.3
provisioningInterface: enp1s0
provisioningNetwork: Managed
provisioningNetworkCIDR: 172.22.0.0/24
virtualMediaViaExternalNetwork: true ①
status:
generations:
- group: apps
hash: ""
lastGeneration: 7
name: metal3
namespace: openshift-machine-api
resource: deployments
- group: apps
hash: ""
lastGeneration: 1
name: metal3-image-cache
namespace: openshift-machine-api
resource: daemonsets
observedGeneration: 8
readyReplicas: 0

```

① Add **virtualMediaViaExternalNetwork: true** to the **provisioning** CR.

2. If the image URL exists, edit the **machineset** to use the API VIP address. This step only applies to clusters installed in versions 4.9 or earlier.

```

oc edit machineset

apiVersion: machine.openshift.io/v1beta1
kind: MachineSet
metadata:
creationTimestamp: "2021-08-05T18:51:52Z"
generation: 11
labels:
  machine.openshift.io/cluster-api-cluster: ostest-hwmdt
  machine.openshift.io/cluster-api-machine-role: worker
  machine.openshift.io/cluster-api-machine-type: worker
name: ostest-hwmdt-worker-0
namespace: openshift-machine-api
resourceVersion: "551513"
uid: fad1c6e0-b9da-4d4a-8d73-286f78788931
spec:
replicas: 2
selector:

```

```

matchLabels:
  machine.openshift.io/cluster-api-cluster: ostest-hwmdt
  machine.openshift.io/cluster-api-machineset: ostest-hwmdt-worker-0
template:
  metadata:
    labels:
      machine.openshift.io/cluster-api-cluster: ostest-hwmdt
      machine.openshift.io/cluster-api-machine-role: worker
      machine.openshift.io/cluster-api-machine-type: worker
      machine.openshift.io/cluster-api-machineset: ostest-hwmdt-worker-0
spec:
  metadata: {}
  providerSpec:
    value:
      apiVersion: baremetal.cluster.k8s.io/v1alpha1
      hostSelector: {}
      image:
        checksum: http://172.22.0.3:6181/images/rhcos-<version>.<architecture>.qcow2.
<md5sum> ①
      url: http://172.22.0.3:6181/images/rhcos-<version>.<architecture>.qcow2 ②
      kind: BareMetalMachineProviderSpec
      metadata:
        creationTimestamp: null
      userData:
        name: worker-user-data
status:
  availableReplicas: 2
  fullyLabeledReplicas: 2
  observedGeneration: 11
  readyReplicas: 2
  replicas: 2

```

- ① Edit the **checksum** URL to use the API VIP address.
- ② Edit the **url** URL to use the API VIP address.

### 3.7.4. Diagnosing a duplicate MAC address when provisioning a new host in the cluster

If the MAC address of an existing bare-metal node in the cluster matches the MAC address of a bare-metal host you are attempting to add to the cluster, the Bare Metal Operator associates the host with the existing node. If the host enrollment, inspection, cleaning, or other Ironic steps fail, the Bare Metal Operator retries the installation continuously. A registration error is displayed for the failed bare-metal host.

You can diagnose a duplicate MAC address by examining the bare-metal hosts that are running in the **openshift-machine-api** namespace.

#### Prerequisites

- Install an OpenShift Container Platform cluster on bare metal.
- Install the OpenShift Container Platform CLI **oc**.

- Log in as a user with **cluster-admin** privileges.

## Procedure

To determine whether a bare-metal host that fails provisioning has the same MAC address as an existing node, do the following:

1. Get the bare-metal hosts running in the **openshift-machine-api** namespace:

```
$ oc get bmh -n openshift-machine-api
```

### Example output

| NAME               | STATUS | PROVISIONING STATUS    | CONSUMER                       |
|--------------------|--------|------------------------|--------------------------------|
| openshift-master-0 | OK     | externally provisioned | openshift-zpwpq-master-0       |
| openshift-master-1 | OK     | externally provisioned | openshift-zpwpq-master-1       |
| openshift-master-2 | OK     | externally provisioned | openshift-zpwpq-master-2       |
| openshift-worker-0 | OK     | provisioned            | openshift-zpwpq-worker-0-lv84n |
| openshift-worker-1 | OK     | provisioned            | openshift-zpwpq-worker-0-zd8lm |
| openshift-worker-2 | error  | registering            |                                |

2. To see more detailed information about the status of the failing host, run the following command replacing **<bare\_metal\_host\_name>** with the name of the host:

```
$ oc get -n openshift-machine-api bmh <bare_metal_host_name> -o yaml
```

### Example output

```
...
status:
  errorCount: 12
  errorMessage: MAC address b4:96:91:1d:7c:20 conflicts with existing node openshift-worker-1
  errorType: registration error
...
...
```

## 3.7.5. Provisioning the bare metal node

Provisioning the bare metal node requires executing the following procedure from the provisioner node.

## Procedure

1. Ensure the **STATE** is **available** before provisioning the bare metal node.

```
$ oc -n openshift-machine-api get bmh openshift-worker-<num>
```

Where **<num>** is the worker node number.

| NAME             | STATE     | ONLINE | ERROR | AGE |
|------------------|-----------|--------|-------|-----|
| openshift-worker | available | true   |       | 34h |

2. Get a count of the number of worker nodes.

```
$ oc get nodes
```

| NAME                                     | STATUS | ROLES  | AGE | VERSION |
|------------------------------------------|--------|--------|-----|---------|
| openshift-master-1.openshift.example.com | Ready  | master | 30h | v1.31.3 |
| openshift-master-2.openshift.example.com | Ready  | master | 30h | v1.31.3 |
| openshift-master-3.openshift.example.com | Ready  | master | 30h | v1.31.3 |
| openshift-worker-0.openshift.example.com | Ready  | worker | 30h | v1.31.3 |
| openshift-worker-1.openshift.example.com | Ready  | worker | 30h | v1.31.3 |

3. Get the compute machine set.

```
$ oc get machinesets -n openshift-machine-api
```

| NAME                           | DESIRED | CURRENT | READY | AVAILABLE | AGE |
|--------------------------------|---------|---------|-------|-----------|-----|
| ...                            |         |         |       |           |     |
| openshift-worker-0.example.com | 1       | 1       | 1     | 1         | 55m |
| openshift-worker-1.example.com | 1       | 1       | 1     | 1         | 55m |

4. Increase the number of worker nodes by one.

```
$ oc scale --replicas=<num> machineset <machineset> -n openshift-machine-api
```

Replace **<num>** with the new number of worker nodes. Replace **<machineset>** with the name of the compute machine set from the previous step.

5. Check the status of the bare metal node.

```
$ oc -n openshift-machine-api get bmh openshift-worker-<num>
```

Where **<num>** is the worker node number. The STATE changes from **ready** to **provisioning**.

| NAME                   | STATE        | CONSUMER                     | ONLINE | ERROR |
|------------------------|--------------|------------------------------|--------|-------|
| openshift-worker-<num> | provisioning | openshift-worker-<num>-65tjz | true   |       |

The **provisioning** status remains until the OpenShift Container Platform cluster provisions the node. This can take 30 minutes or more. After the node is provisioned, the state will change to **provisioned**.

| NAME                   | STATE       | CONSUMER                     | ONLINE | ERROR |
|------------------------|-------------|------------------------------|--------|-------|
| openshift-worker-<num> | provisioned | openshift-worker-<num>-65tjz | true   |       |

6. After provisioning completes, ensure the bare metal node is ready.

```
$ oc get nodes
```

| NAME                                         | STATUS | ROLES  | AGE   | VERSION |
|----------------------------------------------|--------|--------|-------|---------|
| openshift-master-1.openshift.example.com     | Ready  | master | 30h   | v1.31.3 |
| openshift-master-2.openshift.example.com     | Ready  | master | 30h   | v1.31.3 |
| openshift-master-3.openshift.example.com     | Ready  | master | 30h   | v1.31.3 |
| openshift-worker-0.openshift.example.com     | Ready  | worker | 30h   | v1.31.3 |
| openshift-worker-1.openshift.example.com     | Ready  | worker | 30h   | v1.31.3 |
| openshift-worker-<num>.openshift.example.com | Ready  | worker | 3m27s | v1.31.3 |

You can also check the kubelet.

```
$ ssh openshift-worker-<num>
```

```
[kni@openshift-worker-<num>]$ journalctl -fu kubelet
```