Deploying Installer Provisioned Infrastructure (IPI) of OpenShift on Bare Metal - 4.8

Deployment Integration Team

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Draft documentation

This document is considered a DRAFT:

1. It might not be complete
2. It might be not accurate
3. It might break your environment

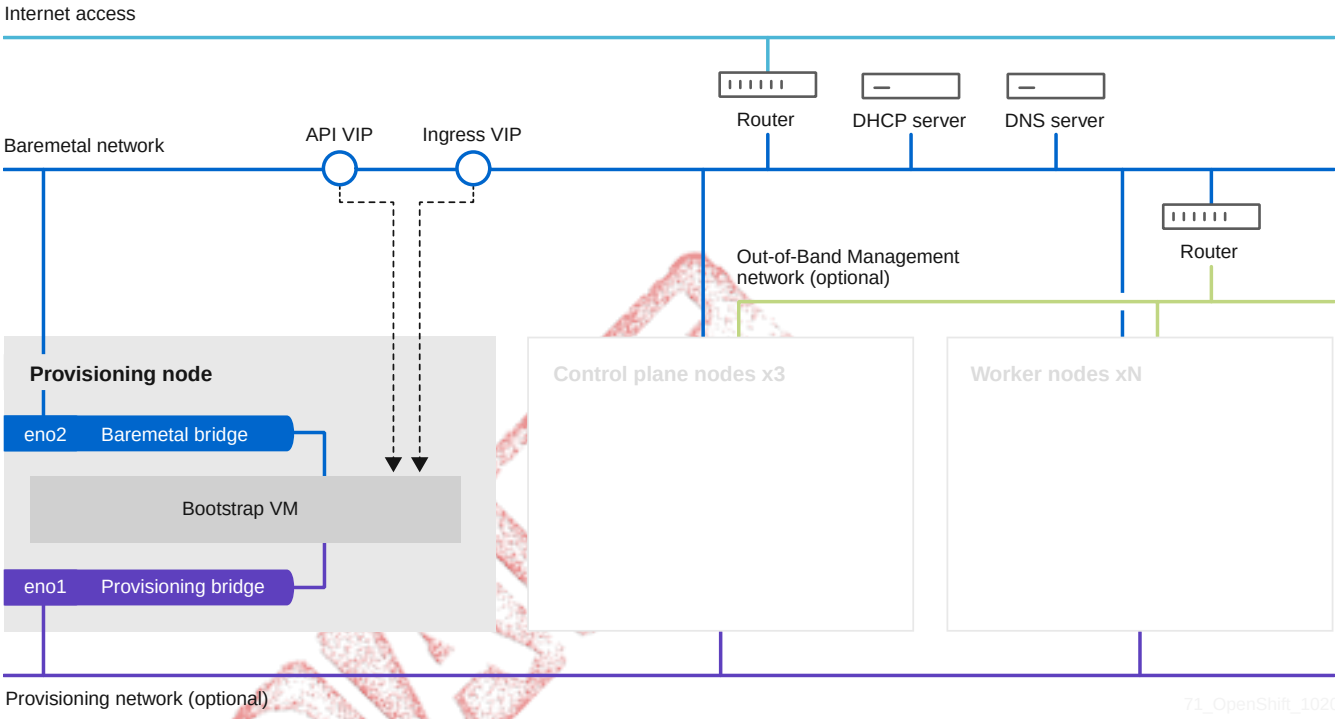
Download the PDF version of this document or visit https://openshift-kni.github.io/baremetal-deploy/

Chapter 1. Overview

The Bare Metal IPI images and code described in this document are for **Developer Preview** purposes and are **not supported** by Red Hat at this time.

Installer-provisioned installation provides support for installing OpenShift Container Platform on bare metal nodes. This guide provides a methodology to achieving a successful installation.

During installer-provisioned installation on bare metal, the installer on the bare metal node labeled as `provisioner` creates a bootstrap virtual machine (VM). The role of the bootstrap VM is to assist in the process of deploying an OpenShift Container Platform cluster. The bootstrap VM connects to the `baremetal` network and to the `provisioning` network, if present, via the network bridges.



When the installation of OpenShift control plane nodes is complete and fully operational, the installer destroys the bootstrap VM automatically and moves the virtual IP addresses (VIPs) to the control plane nodes accordingly.

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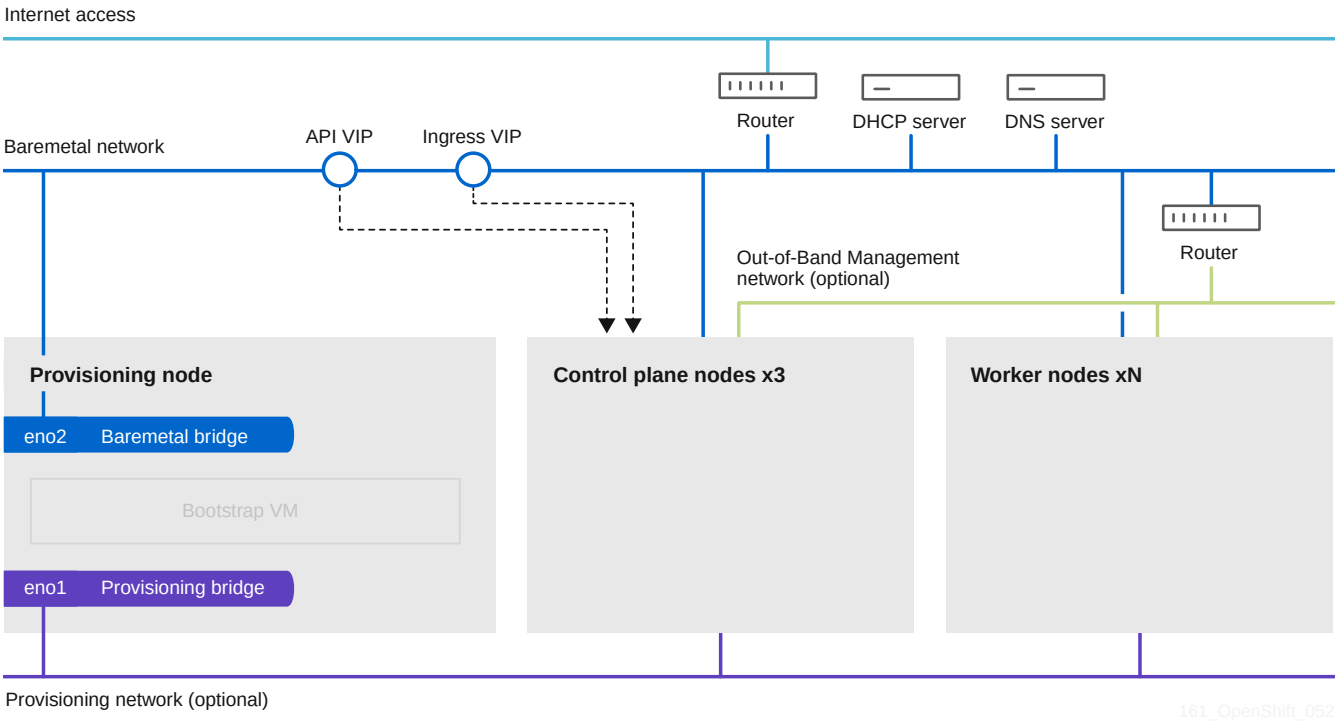
Internet access
Router
DHCP server
DNS server
Baremetal network
API VIP
Ingress VIP
Router
Out-of-Band Management network (optional)
Provisioning node
Control plane nodes x3
Worker nodes xN
eno2
Baremetal bridge
Bootstrap VM
eno1
Provisioning bridge
Provisioning network (optional)

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Chapter 2. Prerequisites

Installer-provisioned installation of OpenShift Container Platform requires:

1. One provisioner node with Red Hat Enterprise Linux (RHEL) 8.x installed.
2. Three control plane nodes.
3. Baseboard Management Controller (BMC) access to each node.
4. At least one network:
    a. One **required** routable network
    b. One **optional** network for provisioning nodes; and,
    c. One **optional** management network.

Before starting an installer-provisioned installation of OpenShift Container Platform, ensure the hardware environment meets the following requirements.

2.1. Node requirements

Installer-provisioned installation involves a number of hardware node requirements:

- **CPU architecture:** All nodes must use `x86_64` CPU architecture.
- **Similar nodes:** Red Hat recommends nodes have an identical configuration per role. That is, Red Hat recommends nodes be the same brand and model with the same CPU, memory and storage configuration.
- **Baseboard Management Controller:** The `provisioner` node must be able to access the baseboard management controller (BMC) of each OpenShift Container Platform cluster node. You may use IPMI, Redfish, or a proprietary protocol.
- **Latest generation:** Nodes must be of the most recent generation. Installer-provisioned installation relies on BMC protocols, which must be compatible across nodes. Additionally, RHEL 8 ships with the most recent drivers for RAID controllers. Ensure that the nodes are recent enough to support RHEL 8 for the `provisioner` node and RHCOS 8 for the control plane and worker nodes.
- **Registry node:** (Optional) If setting up a disconnected mirrored registry, it is recommended the registry reside in its own node.
- **Provisioner node:** Installer-provisioned installation requires one `provisioner` node.
- **Control plane:** Installer-provisioned installation requires three control plane nodes for high availability.
- **Worker nodes:** While not required, a typical production cluster has one or more worker nodes. Smaller clusters are more resource efficient for administrators and developers during development, production, and testing.
- **Network interfaces:** Each node must have at least one 10GB network interface for the routable `baremetal` network. Each node must have one 10GB network interface for a `provisioning` network **when using the `provisioning` network** for deployment. Using the `provisioning`

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network is the default configuration. Network interface names must follow the same naming convention across all nodes. For example, the first NIC name on a node, such as `eth0` or `eno1`, must be the same name on all of the other nodes. The same principle applies to the remaining NICs on each node.

- **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.
- **Secure Boot:** Many production scenarios require nodes with Secure Boot enabled to verify the node only boots with trusted software, such as UEFI firmware drivers, EFI applications and the operating system. You may deploy with secure boot manually or managed.
  1. **Manually:** To deploy a 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 installation uses Redfish virtual media.
  2. **Managed:** To deploy a 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.

Red Hat does not support Secure Boot with self-generated keys.

2.2. Firmware requirements for installing with virtual media

The installer for installer-provisioned OpenShift Container Platform clusters validates the hardware and firmware compatibility with Redfish virtual media. The following table lists supported firmware for installer-provisioned OpenShift Container Platform clusters deployed with Redfish virtual media.

Table 1. Firmware compatibility for Redfish virtual media

Hardware	Model	Management	Firmware Versions
HP	10th Generation	iLO5	N/A
	9th Generation	iLO4	N/A
Dell	14th Generation	iDRAC 9	v4.20.20.20 - 04.40.00.00
	13th Generation	iDRAC 8	v2.75.75.75+

Refer to the hardware documentation for the nodes or contact the hardware vendor for information on updating the firmware.

There are no known firmware limitations for HP servers.

For Dell servers, ensure the OpenShift Container Platform cluster nodes have AutoAttach Enabled through the iDRAC console. The menu path is: **Configuration → Virtual Media → Attach Mode → AutoAttach** . With iDRAC 9 firmware version `04.40.00.00`, the Virtual Console plug-in defaults to `eHTML5`, which causes problems with the **InsertVirtualMedia** workflow. Set the plug-in to `HTML5` to avoid this issue. The menu path is: **Configuration → Virtual console → Plug-in Type → HTML5** .

The installer will not initiate installation on a node if the node firmware is below the foregoing versions when installing with virtual media.

2.3. Network requirements

Installer-provisioned installation of OpenShift Container Platform involves several network requirements by default. First, installer-provisioned installation involves a non-routable `provisioning` network for provisioning the operating system on each bare metal node and a routable `baremetal` network. Since installer-provisioned installation deploys `ironic-dnsmasq`, the networks should have no other DHCP servers running on the same broadcast domain. Network administrators must reserve IP addresses for each node in the OpenShift Container Platform cluster.

Network Time Protocol (NTP)

Each OpenShift Container Platform node in the cluster must have access to an NTP server. OpenShift Container Platform nodes use NTP to synchronize their clocks. For example, cluster nodes use SSL certificates that require validation, which might fail if the date and time between the nodes are not in sync.

Define a consistent clock date and time format in each cluster node's BIOS settings, or installation might fail.

In OpenShift Container Platform 4.8 and later releases, you may 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.

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. When deploying using the `provisioning` network, the first NIC on each node, such as `eth0` or `eno1`, **must** interface with the `provisioning` network.
- `baremetal`: The `baremetal` network is a routable network. When deploying using the `provisioning` network, the second NIC on each node, such as `eth1` or `eno2`, **must** interface with the `baremetal`

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network. When deploying without a `provisioning` network, you can use any NIC on each node to interface with the `baremetal` network.

Each NIC should be on a separate VLAN corresponding to the appropriate network.

Configuring the DNS server

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>.<domain-name>
```

For example:

```
test-cluster.example.com
```

You must also specify an `api.<cluster-name>.<domain>` record in the DNS. In subsequent configuration steps, when you configure network components to run exclusively on the control plane, the internal DNS resolution no longer works. This is an expected outcome.

Failure to create a DNS record for the API precludes worker nodes from joining the cluster.

For assistance in configuring the DNS server, check Appendix section for:

- Creating DNS Records with Bind (Option 1)
- Creating DNS Records with dnsmasq (Option 2)

Reserving IP addresses for nodes with the DHCP server

For the `baremetal` network, a network administrator must reserve a number of IP addresses, including:

1. Two virtual IP addresses.
    - One IP address for the API endpoint
    - One IP address for the wildcard ingress endpoint
2. One IP address for the provisioner node.
3. One IP address for each control plane (master) node.
4. One IP address for each worker node, if applicable.

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Reserving IP addresses so they become static IP addresses

Some administrators prefer to use static IP addresses so that each node's IP address remains constant in the absence of a DHCP server. To use static IP addresses in the OpenShift Container Platform cluster, **reserve the IP addresses with an infinite lease**. During deployment, the installer will reconfigure the NICs from DHCP assigned addresses to static IP addresses. NICs with DHCP leases that are not infinite will remain configured to use DHCP.

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.

The following table provides an exemplary embodiment of fully qualified domain names. The API and Nameserver addresses begin with canonical name extensions. The host names of the control plane and worker nodes are exemplary, so you can use any host naming convention you prefer.

Usage	Host Name	IP
API	*api.<cluster-name>.<domain>*	*<ip>*
Ingress LB (apps)	**.apps.<cluster-name>.<domain>*	*<ip>*
Provisioner node	*provisioner.<cluster-name>.<domain>*	*<ip>*
Master-0	*openshift-master-0.<cluster-name>.<domain>*	*<ip>*
Master-1	*openshift-master-1.<cluster-name>-.<domain>*	*<ip>*
Master-2	*openshift-master-2.<cluster-name>.<domain>*	*<ip>*
Worker-0	*openshift-worker-0.<cluster-name>.<domain>*	*<ip>*
Worker-1	*openshift-worker-1.<cluster-name>.<domain>*	*<ip>*
Worker-n	*openshift-worker-n.<cluster-name>.<domain>*	*<ip>*

For assistance in configuring the DHCP server, check Appendix section for:

- Creating DHCP reservations with dhcpd (Option 1)
- Creating DHCP reservations with dnsmasq (Option 2)

State-driven network configuration requirements (Technology Preview)

OpenShift Container Platform supports additional post-installation state-driven network configuration on the secondary network interfaces of cluster nodes using `kubernetes-nmstate`. For example, system administrators might configure a secondary network interface on cluster nodes after installation for a storage network.

Configuration must occur before scheduling pods.

State-driven network configuration requires installing `kubernetes-nmstate`, and also requires Network Manager running on the cluster nodes. See **OpenShift Virtualization** > **Kubernetes**

NMState (Tech Preview) for additional details.

IPv6 considerations

SLAAC Addressing

If you do not plan to use SLAAC [1] addresses on your OpenShift Container Platform node, then it should be disabled for `baremetal` networks, that means that if your network equipment is configured to send SLAAC addresses when replying to Route Advertisements that behavior should be changed, so it only sends the route and not the SLAAC address.

Install `ndptool` on your system in order to check what your RAs look like:

```
# Turn down/up baremetal iface on a master Node
$ sudo nmcli con down "Wired connection 5" && sudo nmcli con up "Wired connection 5"
Connection 'Wired connection 5' successfully deactivated (D-Bus active path:
/org/freedesktop/NetworkManager/ActiveConnection/1983)
Connection successfully activated (D-Bus active path:
/org/freedesktop/NetworkManager/ActiveConnection/2044)

# ndptool monitor on Helper node
$ sudo ndptool monitor -t ra
NDP payload len 80, from addr: fe80::c0a4:6464:bcb3:d657, iface: baremetal.153
  Type: RA
  Hop limit: 64
  Managed address configuration: yes
  Other configuration: no
  Default router preference: medium
  Router lifetime: 0s
  Reachable time: unspecified
  Retransmit time: unspecified
  Source linkaddr: 1c:40:24:1b:0c:34
  Prefix: 2620:52:0:1303::/64, valid_time: 86400s, preferred_time: 14400s, on_link:
yes, autonomous_addr_conf: no, router_addr: no
  Route: ::/0, lifetime: 0s, preference: low
```

The `ndptool monitor` should report `Managed address configuration: yes`.

Network Ranges and Configurations

Different `baremetal` and `provisioning` networks are required for each environment; each environment will have a different IPv6 range for each one of those networks.

In our configuration we used subinterfaces attached to two different physical interfaces, VLAN tagging was done at O.S. level (this required switch ports configured with `trunk` mode).

Our different IPv6 networks were all routable but usually, the only routable networks are the `baremetal` ones.

Keep in mind that `provisioning` networks cannot be in the same broadcast domain, since services such as DHCP are running.

Route Advertisement

Route Advertisement must be enabled for both networks `baremetal` and `provisioning`.

Route Advertisements

As mentioned previously, both the `baremetal` and the `provisioning` networks must have Route Advertisement enabled. For the `baremetal` network, the `radvd` daemon was used, while the `provisioning` network has RA enabled in the Metal³ dnsmasq, so no configuration is needed.

2.4. Configuring nodes

Configuring nodes when using the `provisioning` network

Each node in the cluster requires the following configuration for proper installation.

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:

NIC	Network	VLAN
NIC1	`provisioning`	<provisioning-vlan>
NIC2	`baremetal`	<baremetal-vlan>

NIC1 is a non-routable network (`provisioning`) that is only used for the installation of the OpenShift Container Platform cluster.

The Red Hat Enterprise Linux (RHEL) 8.x installation process on the provisioner node might vary. To install Red Hat Enterprise Linux (RHEL) 8.x using a local Satellite server or a PXE server, PXE-enable NIC2.

PXE	Boot order
NIC1 PXE-enabled `provisioning` network	1
NIC2 `baremetal` network. PXE-enabled is optional.	2

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	`baremetal`	<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.

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.

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:

1. Boot the node and enter the BIOS menu.
2. Set the node's boot mode to UEFI Enabled.
3. Enable Secure Boot.

Red Hat does not support Secure Boot with self-generated keys.

2.5. Out-of-band management

Nodes will typically have an additional NIC used by the Baseboard Management Controllers (BMCs). These BMCs must be accessible from the `provisioner` node.

Each node must be accessible via out-of-band management. When using an out-of-band management network, the `provisioner` node requires access to the out-of-band management network for a successful OpenShift Container Platform 4 installation.

The out-of-band management setup is out of scope for this document. We recommend setting up a separate management network for out-of-band management. However, using the `provisioning` network or the `baremetal` network are valid options.

2.6. 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

When using the `provisioning` network

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- NIC1 (`provisioning`) MAC address
- NIC2 (`baremetal`) MAC address

When omitting the `provisioning` network

- NICx (`baremetal`) MAC address

2.7. Validation checklist for nodes

When using the `provisioning` network

- ▢ DHCP reservations use infinite leases to deploy the cluster with static IP addresses. (optional)
- ▢ NIC1 VLAN is configured for the `provisioning` network.
- ▢ NIC2 VLAN is configured for the `baremetal` network.
- ▢ NIC1 is PXE-enabled on the provisioner, Control Plane (master), and worker nodes.
- ▢ PXE has been disabled on all other NICs.
- ▢ Control plane and worker nodes are configured.
- ▢ All nodes accessible via out-of-band management.
- ▢ A separate management network has been created. (optional)
- ▢ Required data for installation.

When omitting the `provisioning` network

- ▢ DHCP reservations use infinite leases to deploy the cluster with static IP addresses. (optional)
- ▢ NICx VLAN is configured for the `baremetal` network.
- ▢ Control plane and worker nodes are configured.
- ▢ All nodes accessible via out-of-band management.
- ▢ A separate management network has been created. (optional)
- ▢ Required data for installation.

Summary

After an environment has been prepared according to the documented prerequisites, the installation process is the same as other installer-provisioned platforms.

[1] Stateless Address AutoConfiguration

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Chapter 3. Setting up the environment for an OpenShift installation

3.1. Installing RHEL on the provisioner node

With the networking configuration complete, the next step is to install RHEL 8.X on the provisioner node. The installer uses the provisioner node as the orchestrator while installing the OpenShift Container Platform cluster. For the purposes of this document, installing RHEL on the provisioner node is out of scope. However, options include but are not limited to using a RHEL Satellite server, PXE, or installation media.

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.

```
[root@provisioner ~]# useradd kni
[root@provisioner ~]# passwd kni
[root@provisioner ~]# echo "kni ALL=(root) NOPASSWD:ALL" | tee -a
/etc/sudoers.d/kni
[root@provisioner ~]# chmod 0440 /etc/sudoers.d/kni
```

3. Create an `ssh` key for the new user.

```
[root@provisioner ~]# su - kni -c "ssh-keygen -t rsa -f /home/kni/.ssh/id_rsa -N
''"
```

4. Log in as the new user on the provisioner node.

```
[root@provisioner ~]# su - kni
[kni@provisioner ~]$
```

5. Use Red Hat Subscription Manager to register the provisioner node.

```
[kni@provisioner ~]$ sudo subscription-manager register --username=<user>
--password=<pass> --auto-attach
[kni@provisioner ~]$ sudo subscription-manager repos --enable=rhel-8-for-x86_64-
appstream-rpms --enable=rhel-8-for-x86_64-baseos-rpms
```

For more information about Red Hat Subscription Manager, see Using and Configuring Red Hat Subscription Manager.

6. Install the following packages.

```
[kni@provisioner ~]$ 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.

```
[kni@provisioner ~]$ sudo usermod --append --groups libvirt <user>
```

8. Restart `firewalld` and enable the `http` service.

```
[kni@provisioner ~]$ sudo systemctl start firewalld
[kni@provisioner ~]$ sudo firewall-cmd --zone=public --add-service=http --permanent
[kni@provisioner ~]$ sudo firewall-cmd --add-port=5000/tcp --zone=libvirt
--permanent
[kni@provisioner ~]$ sudo firewall-cmd --add-port=5000/tcp --zone=public
--permanent
[kni@provisioner ~]$ sudo firewall-cmd --reload
```

9. Start and enable the `libvirtd` service.

```
[kni@provisioner ~]$ sudo systemctl start libvirtd
[kni@provisioner ~]$ sudo systemctl enable libvirtd --now
```

10. Create the `default` storage pool and start it.

```
[kni@provisioner ~]$ sudo virsh pool-define-as --name default --type dir --target
/var/lib/libvirt/images
[kni@provisioner ~]$ sudo virsh pool-start default
[kni@provisioner ~]$ sudo virsh pool-autostart default
```

11. Configure networking.

This step can also be run from the web console.

Provisioning Network (IPv4 address)

```
[kni@provisioner ~]$ sudo nohup bash -c """
    nmcli con down "$PROV_CONN"
    nmcli con delete "$PROV_CONN"
    # RHEL 8.1 appends the word "System" in front of the connection, delete in case
it exists
    nmcli con down "System $PROV_CONN"
    nmcli con delete "System $PROV_CONN"
    nmcli connection add ifname provisioning type bridge con-name provisioning
    nmcli con add type bridge-slave ifname "$PROV_CONN" master provisioning
    nmcli connection modify provisioning ipv4.addresses 172.22.0.1/24 ipv4.method
manual
    nmcli con down provisioning
    nmcli con up provisioning"""
```

The `ssh` connection might disconnect after executing this step.

The IPv4 address may be any address as long as it is not routable via the `baremetal` network.

Provisioning Network (IPv6 address)

```
[kni@provisioner ~]$ sudo nohup bash -c """
    nmcli con down "$PROV_CONN"
    nmcli con delete "$PROV_CONN"
    # RHEL 8.1 appends the word "System" in front of the connection, delete in case
it exists
    nmcli con down "System $PROV_CONN"
    nmcli con delete "System $PROV_CONN"
    nmcli connection add ifname provisioning type bridge con-name provisioning
    nmcli con add type bridge-slave ifname "$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"""
```

The `ssh` connection might disconnect after executing this step.

The IPv6 address may be any address as long as it is not routable via the `baremetal` network.

Ensure that UEFI is enabled and UEFI PXE settings are set to the IPv6 protocol when using IPv6 addressing.

12. `ssh` back into the `provisioner` node (if required).

```
# ssh kni@provisioner.<cluster-name>.<domain>
```

13. Verify the connection bridges have been properly created.

```
[kni@provisioner ~]$ nmcli con show
```

```
NAME               UUID                                  TYPE      DEVICE
baremetal          4d5133a5-8351-4bb9-bfd4-3af264801530  bridge    baremetal
provisioning       43942805-017f-4d7d-a2c2-7cb3324482ed  bridge    provisioning
virbr0             d9bca40f-eee1-410b-8879-a2d4bb0465e7  bridge    virbr0
bridge-slave-eno1  76a8ed50-c7e5-4999-b4f6-6d9014dd0812  ethernet  eno1
bridge-slave-eno2  f31c3353-54b7-48de-893a-02d2b34c4736  ethernet  eno2
```

14. Create a `pull-secret.txt` file.

```
[kni@provisioner ~]$ vim pull-secret.txt
```

In a web browser, navigate to Install on Bare Metal with user-provisioned infrastructure, and scroll down to the **Downloads** section. Click **Copy pull secret**. Paste the contents into the `pull-secret.txt` file and save the contents in the `kni` user's home directory.

3.3. Retrieving the OpenShift Container Platform installer (GA Release)

Use the `latest-4.x` version of the installer to deploy the latest generally available version of OpenShift Container Platform:

```
[kni@provisioner ~]$ export VERSION=latest-4.8
export RELEASE_IMAGE=$(curl -s https://mirror.openshift.com/pub/openshift-
v4/clients/ocp/$VERSION/release.txt | grep 'Pull From: quay.io' | awk -F ' ' '{print
$3}')
```

3.4. Extracting the OpenShift Container Platform installer (GA Release)

After retrieving the installer, the next step is to extract it.

Procedure

1. Set the environment variables:

```
[kni@provisioner ~]$ export cmd=openshift-baremetal-install
[kni@provisioner ~]$ export pullsecret_file=~/pull-secret.txt
[kni@provisioner ~]$ export extract_dir=$(pwd)
```

2. Get the `oc` binary:

```
[kni@provisioner ~]$ curl -s https://mirror.openshift.com/pub/openshift-
v4/clients/ocp/$VERSION/openshift-client-linux.tar.gz | tar zxvf - oc
```

3. Extract the installer:

```
[kni@provisioner ~]$ sudo cp oc /usr/local/bin
[kni@provisioner ~]$ oc adm release extract --registry-config "${pullsecret_file}"
--command=$cmd --to "${extract_dir}" ${RELEASE_IMAGE}
[kni@provisioner ~]$ sudo cp openshift-baremetal-install /usr/local/bin
```

3.5. Creating an RHCOS images cache (optional)

To employ image caching, you must download two images: the Red Hat Enterprise Linux CoreOS (RHCOS) image used by the bootstrap VM and the RHCOS image used by the installer to provision the different nodes. Image caching is optional, but especially useful when running the installer on a network with limited bandwidth.

If you are running the installer on a network with limited bandwidth and the RHCOS images download takes more than 15 to 20 minutes, the installer will timeout. Caching images on a web server will help in such scenarios.

Use the following steps to install a container that contains the images.

1. Install `podman`.

```
$ sudo dnf install -y podman
```

2. Open firewall port `8080` to be used for RHCOS image caching.

```
$ sudo firewall-cmd --add-port=8080/tcp --zone=public --permanent
$ sudo firewall-cmd --reload
```

3. Create a directory to store the `bootstraposimage` and `clusterosimage`.

```
$ mkdir /home/kni/rhcos_image_cache
```

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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 rhcos_image_cache/
```

5. Get the commit ID from the installer. The ID determines which images the installer needs to download.

```
$ export COMMIT_ID=$(/usr/local/bin/openshift-baremetal-install version | grep
'^built from commit' | awk '{print $4}')
```

6. Get the URI for the RHCOS image that the installer will deploy on the nodes.

```
$ export RHCOS_OPENSTACK_URI=$(curl -s -S
https://raw.githubusercontent.com/openshift/installer/$COMMIT_ID/data/data/rhcos.js
on  | jq .images.openstack.path | sed 's/"//g')
```

7. Get the URI for the RHCOS image that the installer will deploy on the bootstrap VM.

```
$ export RHCOS_QEMU_URI=$(curl -s -S
https://raw.githubusercontent.com/openshift/installer/$COMMIT_ID/data/data/rhcos.js
on  | jq .images.qemu.path | sed 's/"//g')
```

8. Get the path where the images are published.

```
$ export RHCOS_PATH=$(curl -s -S
https://raw.githubusercontent.com/openshift/installer/$COMMIT_ID/data/data/rhcos.js
on | jq .baseURI | sed 's/"//g')
```

9. Get the SHA hash for the RHCOS image that will be deployed on the bootstrap VM.

```
$ export RHCOS_QEMU_SHA_UNCOMPRESSED=$(curl -s -S
https://raw.githubusercontent.com/openshift/installer/$COMMIT_ID/data/data/rhcos.js
on  | jq -r '.images.qemu["uncompressed-sha256"]')
```

10. Get the SHA hash for the RHCOS image that will be deployed on the nodes.

```
$ export RHCOS_OPENSTACK_SHA_COMPRESSED=$(curl -s -S
https://raw.githubusercontent.com/openshift/installer/$COMMIT_ID/data/data/rhcos.js
on  | jq -r '.images.openstack.sha256')
```

11. Download the images and place them in the `/home/kni/rhcos_image_cache` directory.

```
$ curl -L ${RHCOS_PATH}${RHCOS_QEMU_URI} -o /home/kni/rhcos_image_cache/
${RHCOS_QEMU_URI}
$ curl -L ${RHCOS_PATH}${RHCOS_OPENSTACK_URI} -o /home/kni/rhcos_image_cache/
${RHCOS_OPENSTACK_URI}
```

12. Confirm SELinux type is of `httpd_sys_content_t` for the newly created files.

```
$ ls -Z /home/kni/rhcos_image_cache
```

13. Create the pod.

```
$ podman run -d --name rhcos_image_cache \
-v /home/kni/rhcos_image_cache:/var/www/html \
-p 8080:8080/tcp \
registry.centos.org/centos/httpd-24-centos7:latest
```

14. Generate the `bootstrapOSImage` and `clusterOSImage` configuration.

```
$ export BAREMETAL_IP=$(ip addr show dev baremetal | awk '/inet /{print $2}' | cut
-d"/" -f1
$ export RHCOS_OPENSTACK_SHA256=$(zcat /home/kni/rhcos_image_cache/
${RHCOS_OPENSTACK_URI} | sha256sum | awk '{print $1}')
$ export RHCOS_QEMU_SHA256=$(zcat /home/kni/rhcos_image_cache/${RHCOS_QEMU_URI} |
sha256sum | awk '{print $1}')
$ export CLUSTER_OS_IMAGE="http://${BAREMETAL_IP}:8080/${RHCOS_OPENSTACK_URI
}?sha256=${RHCOS_OPENSTACK_SHA256}"
$ export BOOTSTRAP_OS_IMAGE="http://${BAREMETAL_IP}:8000/${RHCOS_QEMU_URI}
?sha256=${RHCOS_QEMU_SHA256}"
$ echo "${RHCOS_OPENSTACK_SHA256}  ${RHCOS_OPENSTACK_URI}" >
/home/kni/rhcos_image_cache/rhcos-ootpa-latest.qcow2.md5sum
$ echo "    bootstrapOSImage=${BOOTSTRAP_OS_IMAGE}"
$ echo "    clusterOSImage=${CLUSTER_OS_IMAGE}"
```

15. Add the required configuration to the `install-config.yaml` file under `platform.baremetal`.

```
platform:
  baremetal:
    bootstrapOSImage: http://<BAREMETAL_IP>:8080/<RHCOS_QEMU_URI>?sha256
=<RHCOS_QEMU_SHA256>
    clusterOSImage: http://<BAREMETAL_IP>:8080/<RHCOS_OPENSTACK_URI>?sha256
=<RHCOS_OPENSTACK_SHA256>
```

See the **Configuring the install-config.yaml file** section for additional details.

3.6. Configuration files

3.6.1. Configuring the `install-config.yaml` file

The `install-config.yaml` file requires some additional details. Most of the information is teaching the installer and the resulting cluster enough about the available hardware so that it is able to fully manage it.

1. Configure `install-config.yaml`. Change the appropriate variables to match the environment, including `pullSecret` and `sshKey`.

```
apiVersion: v1
basedomain: <domain>
metadata:
  name: <cluster-name>
networking:
  machineCIDR: <public-cidr>
  networkType: OVNKubernetes
compute:
- name: worker
  replicas: 2 ①
controlPlane:
  name: master
  replicas: 3
  platform:
    baremetal: {}
platform:
  baremetal:
    apiVIP: <api-ip>
    ingressVIP: <wildcard-ip>
    provisioningNetworkInterface: <NIC1>
    provisioningNetworkCIDR: <CIDR>
    hosts:
      - name: openshift-master-0
        role: master
        bmc:
          address: ipmi://<out-of-band-ip> ②
          username: <user>
          password: <password>
        bootMACAddress: <NIC1-mac-address>
        hardwareProfile: default
      - name: openshift-master-1
        role: master
        bmc:
          address: ipmi://<out-of-band-ip>
          username: <user>
          password: <password>
        bootMACAddress: <NIC1-mac-address>
        hardwareProfile: default
      - name: openshift-master-2
```

```
        role: master
        bmc:
          address: ipmi://<out-of-band-ip>
          username: <user>
          password: <password>
        bootMACAddress: <NIC1-mac-address>
        hardwareProfile: default
      - name: openshift-worker-0
        role: worker
        bmc:
          address: ipmi://<out-of-band-ip>
          username: <user>
          password: <password>
        bootMACAddress: <NIC1-mac-address>
        hardwareProfile: unknown
      - name: openshift-worker-1
        role: worker
        bmc:
          address: ipmi://<out-of-band-ip>
          username: <user>
          password: <password>
        bootMACAddress: <NIC1-mac-address>
        hardwareProfile: unknown
pullSecret: '<pull_secret>'
sshKey: '<ssh_pub_key>'
```

① Scale the worker machines based on the number of worker nodes that are part of the OpenShift Container Platform cluster.

② Refer to the BMC addressing for more options

2. Create a directory to store cluster configs.

```
[kni@provisioner ~]$ mkdir ~/clusterconfigs
[kni@provisioner ~]$ cp install-config.yaml ~/clusterconfigs
```

3. Ensure all bare metal nodes are powered off prior to installing the OpenShift Container Platform cluster.

```
[kni@provisioner ~]$ ipmitool -I lanplus -U <user> -P <password> -H <management-
server-ip> power off
```

4. Remove old bootstrap resources if any are left over from a previous deployment attempt.

```
for i in $(sudo virsh list | tail -n +3 | grep bootstrap | awk {'print $2'});
do
  sudo virsh destroy $i;
  sudo virsh undefine $i;
  sudo virsh vol-delete $i --pool $i;
  sudo virsh vol-delete $i.ign --pool $i;
  sudo virsh pool-destroy $i;
  sudo virsh pool-undefine $i;
done
```

3.6.2. Setting proxy settings within the `install-config.yaml` file (optional)

To deploy an OpenShift Container Platform cluster using a proxy, make the following changes to the `install-config.yaml` file.

```
apiVersion: v1
baseDomain: <domain>
proxy:
  httpProxy: http://USERNAME:PASSWORD@proxy.example.com:PORT
  httpsProxy: https://USERNAME:PASSWORD@proxy.example.com:PORT
  noProxy: <WILDCARD_OF_DOMAIN>,<PROVISIONING_NETWORK/CIDR>,<BMC_ADDRESS_RANGE/CIDR>
```

See below for an example of `noProxy` with values.

```
noProxy: .example.com,172.22.0.0/24,10.10.0.0/24
```

With a proxy enabled, set the appropriate values of the proxy in the corresponding key/value pair.

Key considerations:

- If the proxy does not have an HTTPS proxy, change the value of `httpsProxy` from `https://` to `http://`.
- If using a provisioning network, include it in the `noProxy` setting, otherwise the installer will fail.
- Set all of the proxy settings as environment variables within the provisioner node. For example, `HTTP_PROXY`, `HTTPS_PROXY`, and `NO_PROXY`.

3.6.3. Modifying the `install-config.yaml` file for no `provisioning` network (optional)

To deploy an OpenShift Container Platform cluster without a `provisioning` network, make the following changes to the `install-config.yaml` file.

```
platform:
  baremetal:
    apiVIP: <apiVIP>
    ingressVIP: <ingress/wildcard VIP>
    provisioningNetwork: "Disabled"
```

3.6.4. Modifying the `install-config.yaml` file for dual-stack network (optional)

To deploy an OpenShift Container Platform cluster with dual-stack, make the following changes to the `install-config.yaml` file.

```
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
```

In the above snippet, the values for the networks must match the ones for your own environment and that IPv4 details must go **before** IPv6 ones, having the `machineNetwork` two entries and same for the `clusterNetwork` and `serviceNetwork`.

We also need to deploy an additional manifest for enabling the FeatureGate with the following contents:

```
apiVersion: config.openshift.io/v1
kind: FeatureGate
metadata:
  name: cluster
spec:
  featureSet: IPv6DualStackNoUpgrade
```

3.6.5. Configuring managed Secure Boot in the `install-config.yaml` file (optional)

To enable managed Secure Boot, add the `bootMode` configuration setting to each node.

Example

```
hosts:
  - name: openshift-master-0
    role: master
    bmc:
      address: ipmi://<out-of-band-ip>
      username: <user>
      password: <password>
    bootMACAddress: <NIC1-mac-address>
    hardwareProfile: default
    bootMode: UEFISecureBoot ①
```

① The `bootMode` setting is `legacy` by default. Change it to `UEFISecureBoot` to enable managed Secure Boot.

See **Node requirements** to ensure the nodes can support managed Secure Boot. If not, you can enable Secure Boot manually, which requires Redfish virtual media.

3.6.6. Additional `install-config` parameters

See the following tables for the required parameters, the `hosts` parameter, and the `bmc` parameter for the `install-config.yaml` file.

Table 2. Required parameters

Parameters	Default	Description
`baseDomain`		The domain name for the cluster. For example, `example.com`.
`bootMode`	`legacy`	The boot mode for a node. Options are `legacy`, `UEFI` and `UEFISecureBoot`.
`sshKey`		The `sshKey` configuration setting contains the key in the `~/.ssh/id_rsa.pub` file required to access the control plane nodes and worker nodes. Typically, this key is from the `provisioner` node.
`pullSecret`		The `pullSecret` configuration setting contains a copy of the pull secret downloaded from the Install OpenShift on Bare Metal page when preparing the provisioner node.

Parameters	Default	Description
`metadata:` `  name:`		The name to be given to the OpenShift Container Platform cluster. For example, `openshift`.
`networking:` `  machineCIDR:`		The public CIDR (Classless Inter-Domain Routing) of the external network. For example, `10.0.0.0/24` or `2620:52:0:1302::/64` .
`compute:` `  - name: worker`		The OpenShift Container Platform cluster requires a name be provided for worker (or compute) nodes even if there are zero nodes.
`compute:` `  replicas: 2`		Replicas sets the number of worker (or compute) nodes in the OpenShift Container Platform cluster.
`controlPlane:` `  name: master`		The OpenShift Container Platform cluster requires a name for control plane (master) nodes.
`controlPlane:` `  replicas: 3`		Replicas sets the number of control plane (master) nodes included as part of the OpenShift Container Platform cluster.
`provisioningNetworkInterface`		The name of the network interface on control plane nodes connected to the provisioning network.
`defaultMachinePlatform`		The default configuration used for machine pools without a platform configuration.
`apiVIP`	`api.<clustername.clusterdomain>`	The VIP to use for internal API communication. This setting must either be provided or pre-configured in the DNS so that the default name resolves correctly.

Parameters	Default	Description
disableCertificateVerification	False	redfish and redfish-virtualmedia need this parameter to manage BMC addresses. The value should be True when using a self-signed certificate for BMC addresses.
ingressVIP	test.apps.<clustername.clusterdomain>	The VIP to use for ingress traffic.

Table 3. Optional Parameters

Parameters	Default	Description
provisioningDHCPRange	172.22.0.10,172.22.0.100	Defines the IP range for nodes on the provisioning network.
provisioningNetworkCIDR	172.22.0.0/24	The CIDR for the network to use for provisioning. This option is required when not using the default address range on the provisioning network.
clusterProvisioningIP	The third IP address of the provisioningNetworkCIDR.	The IP address within the cluster where the provisioning services run. Defaults to the third IP address of the provisioning subnet. For example, 172.22.0.3.
bootstrapProvisioningIP	The second IP address of the provisioningNetworkCIDR.	The IP address on the bootstrap VM where the provisioning services run while the installer is deploying the control plane (master) nodes. Defaults to the second IP address of the provisioning subnet. For example, 172.22.0.2 or 2620:52:0:1307::2 .
externalBridge	baremetal	The name of the baremetal bridge of the hypervisor attached to the baremetal network.
provisioningBridge	provisioning	The name of the provisioning bridge on the provisioner host attached to the provisioning network.
defaultMachinePlatform		The default configuration used for machine pools without a platform configuration.
bootstrapOSImage		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: <code><a href="https://mirror.openshift.com/rhcos-<version>-qemu.qcow2.gz?sha256=<uncompressed_sha256>" class="bare">https://mirror.openshift.com/rhcos-<version>-qemu.qcow2.gz?sha256=<uncompressed_sha256></a>;</code> or <code>http://[2620:52:0:1307::1]/rhcos-<version>-qemu.x86_64.qcow2.gz?sha256=<uncompressed_sha256></code> .

Parameters	Default	Description
clusterOSImage		A URL to override the default operating system for cluster nodes. The URL must include a SHA-256 hash of the image. For example, <code><a href="https://mirror.openshift.com/images/rhcos-<version>-openstack.qcow2.gz?sha256=<compressed_sha256&gt" class="bare">https://mirror.openshift.com/images/rhcos-<version>-openstack.qcow2.gz?sha256=<compressed_sha256&gt</a>;</code>.
provisioningNetwork		Set this parameter to Disabled to disable the requirement for a provisioning network. User may only do virtual media based provisioning, or bring up the cluster using assisted installation. If using power management, BMC's must be accessible from the machine networks. User must provide two IP addresses on the external network that are used for the provisioning services. Set this parameter to Managed, which is the default, to fully manage the provisioning network, including DHCP, TFTP, and so on. Set this parameter to Unmanaged to still enable the provisioning network but take care of manual configuration of DHCP. Virtual media provisioning is recommended but PXE is still available if required.
httpProxy		Set this parameter to the appropriate HTTP proxy used within your environment.
httpsProxy		Set this parameter to the appropriate HTTPS proxy used within your environment.
noProxy		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.

Name	Default	Description
name		The name of the BareMetalHost resource to associate with the details. For example, openshift-master-0.
role		The role of the bare metal node. Either master or worker.

`bmc`		Connection details for the baseboard management controller. See the BMC addressing section for additional details.
`bootMACAddress`		The MAC address of the NIC the host will use to boot on the `provisioning` network.

3.6.7. BMC addressing

Most vendors support BMC addressing with the Intelligent Platform Management Interface or 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 or SDDC. Redfish is human readable and machine capable, and leverages common Internet and web services standards to expose information directly to the modern tool chain. If your hardware does not support Redfish network boot, use IPMI.

IPMI

Hosts using IPMI use the `ipmi://<out-of-band-ip>:<port>` address format, which defaults to port `623` if not specified. The following example demonstrates an IPMI configuration within the `install-config.yaml` file.

```
platform:
  baremetal:
    hosts:
      - name: openshift-master-0
        role: master
        bmc:
          address: ipmi://<out-of-band-ip>
          username: <user>
          password: <password>
```

Redfish network boot

To enable Redfish, use `redfish://` or `redfish+http://` to disable TLS. The installer requires both the host name 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
```

BMC addressing for Dell

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: <host name>
        role: <master | worker>
        bmc:
          address: <address>
          username: <user>
          password: <password>
```

For Dell hardware, Red Hat supports Redfish virtual media, Redfish network boot, and IPMI.

Table 4. BMC address formats for Dell hardware

Protocol	Address Format
Redfish virtual media	idrac-virtualmedia://<out-of-band-ip>/redfish/v1/Systems/System.Embedded.1
Redfish network boot	redfish://<out-of-band-ip>/redfish/v1/Systems/System.Embedded.1
IPMI	ipmi://<out-of-band-ip>

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

For Redfish virtual media on Dell servers, use idrac-virtualmedia:// in the address setting. Using redfish-virtualmedia:// will NOT work.

The following example demonstrates using iDRAC virtual media within the install-config.yaml file.

```
platform:
  baremetal:
    hosts:
      - name: openshift-master-0
        role: master
        bmc:
          address: idrac-virtualmedia://<out-of-band-
ip>/redfish/v1/Systems/System.Embedded.1
          username: <user>
          password: <password>
```

While it is recommended to have a certificate of authority for the out-of-band management addresses, you must include disableCertificateVerification: True in the bmc configuration if using self-signed certificates. The following example demonstrates a Redfish configuration using the disableCertificateVerification: True configuration parameter within the install-config.yaml file.

```
platform:
  baremetal:
    hosts:
      - name: openshift-master-0
        role: master
        bmc:
          address: idrac-virtualmedia://<out-of-band-
ip>/redfish/v1/Systems/System.Embedded.1
          username: <user>
          password: <password>
          disableCertificateVerification: True
```

Currently Redfish is only supported on Dell with iDRAC firmware versions `4.20.20.20` through `04.40.00.00` for IPI on bare metal deployments. There is a known issue with version `04.40.00.00`. With iDRAC 9 firmware version `04.40.00.00`, the Virtual Console plug-in defaults to `eHTML5`, which causes problems with the **InsertVirtualMedia** workflow. Set the plug-in to `HTML5` to avoid this issue. The menu path is: **Configuration** → **Virtual console** → **Plug-in Type** → **HTML5** .

Ensure the OpenShift Container Platform cluster nodes have AutoAttach Enabled through the iDRAC console. The menu path is: **Configuration** → **Virtual Media** → **Attach Mode** → **AutoAttach** .

Use `idrac-virtualmedia://` as the protocol for Redfish virtual media. Using `redfish-virtualmedia://` will NOT work on Dell hardware, because the `idrac-virtualmedia://` protocol corresponds to the `idrac` hardware type and the Redfish protocol in Ironic. Dell's `idrac-virtualmedia://` protocol uses the Redfish standard with Dell's OEM extensions. Ironic also supports the `idrac` type with the WSMAN protocol. So you must specify `idrac-virtualmedia://` to avoid unexpected behavior when electing to use Redfish with virtual media on Dell hardware.

Redfish network boot for Dell

To enable Redfish, use `redfish://` or `redfish+http://` to disable TLS. The installer requires both the host name or the IP address and the path to the system ID. The following example demonstrates a Redfish configuration within the `install-config.yaml` file.

```
platform:
  baremetal:
    hosts:
      - name: openshift-master-0
        role: master
        bmc:
          address: redfish://<out-of-band-ip>/redfish/v1/Systems/System.Embedded.1
          username: <user>
          password: <password>
```

While it is recommended to have a certificate of authority for the out-of-band management addresses, you must include `disableCertificateVerification: True` in the `bmc` configuration if using self-signed certificates. The following example demonstrates a Redfish configuration using the `disableCertificateVerification: True` configuration parameter within the `install-config.yaml` file.

```
platform:
  baremetal:
    hosts:
      - name: openshift-master-0
        role: master
        bmc:
          address: redfish://<out-of-band-ip>/redfish/v1/Systems/System.Embedded.1
          username: <user>
          password: <password>
          disableCertificateVerification: True
```

Currently Redfish is only supported on Dell with iDRAC firmware versions `4.20.20.20` through `04.40.00.00` for IPI on bare metal deployments. There is a known issue with version `04.40.00.00`. With iDRAC 9 firmware version `04.40.00.00`, the Virtual Console plug-in defaults to `eHTML5`, which causes problems with the **InsertVirtualMedia** workflow. Set the plug-in to `HTML5` to avoid this issue. The menu path is: **Configuration** → **Virtual console** → **Plug-in Type** → **HTML5** .

Ensure the OpenShift Container Platform cluster nodes have AutoAttach Enabled through the iDRAC console. The menu path is: **Configuration** → **Virtual Media** → **Attach Mode** → **AutoAttach** .

The `redfish://` URL protocol corresponds to the `redfish` hardware type in Ironic.

BMC addressing for HPE

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: <host name>
        role: <master | worker>
        bmc:
          address: <address>
          username: <user>
          password: <password>
```

For HPE hardware, Red Hat supports Redfish virtual media, Redfish network boot, and IPMI.

Table 5. BMC address formats for HPE hardware

Protocol	Address Format
Redfish virtual media	`redfish-virtualmedia://<out-of-band-ip>/redfish/v1/Systems/1`
Redfish network boot	`redfish://<out-of-band-ip>/redfish/v1/Systems/1`

Protocol	Address Format
IPMI	`ipmi://<out-of-band-ip>`

See the following sections for additional details.

Redfish virtual media for HPE

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
```

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

To enable Redfish, use `redfish://` or `redfish+http://` to disable TLS. The installer requires both the host name 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
```

BMC addressing for Fujitsu

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: <host name>
        role: <master | worker>
        bmc:
          address: <address>
          username: <user>
          password: <password>
```

For Fujitsu hardware, Red Hat supports iRMC and IPMI.

Table 6. BMC address formats for Fujitsu hardware

Protocol	Address Format
iRMC	`irmc://<out-of-band-ip>`

Protocol	Address Format
IPMI	`ipmi://<out-of-band-ip>`

See the following sections for additional details.

iRMC for Fujitsu

Fujitsu nodes can use `irmc://<out-of-band-ip>` and defaults to port `623`. 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>
```

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>
```

IPMI does not encrypt communications. It is suitable for use within a data center over a secured network.

3.6.8. 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 7. Subfields

Subfield	Description
deviceName	A string containing a Linux device name like /dev/vda. The hint must match the actual value exactly.
hctl	A string containing a SCSI bus address like 0:0:0:0. The hint must match the actual value exactly.
model	A string containing a vendor-specific device identifier. The hint can be a substring of the actual value.
vendor	A string containing the name of the vendor or manufacturer of the device. The hint can be a sub-string of the actual value.
serialNumber	A string containing the device serial number. The hint must match the actual value exactly.
minSizeGigabytes	An integer representing the minimum size of the device in gigabytes.
wwn	A string containing the unique storage identifier. The hint must match the actual value exactly.
wwnWithExtension	A string containing the unique storage identifier with the vendor extension appended. The hint must match the actual value exactly.
wwnVendorExtension	A string containing the unique vendor storage identifier. The hint must match the actual value exactly.
rotational	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"
```

3.6.9. Creating the OpenShift Container Platform manifests

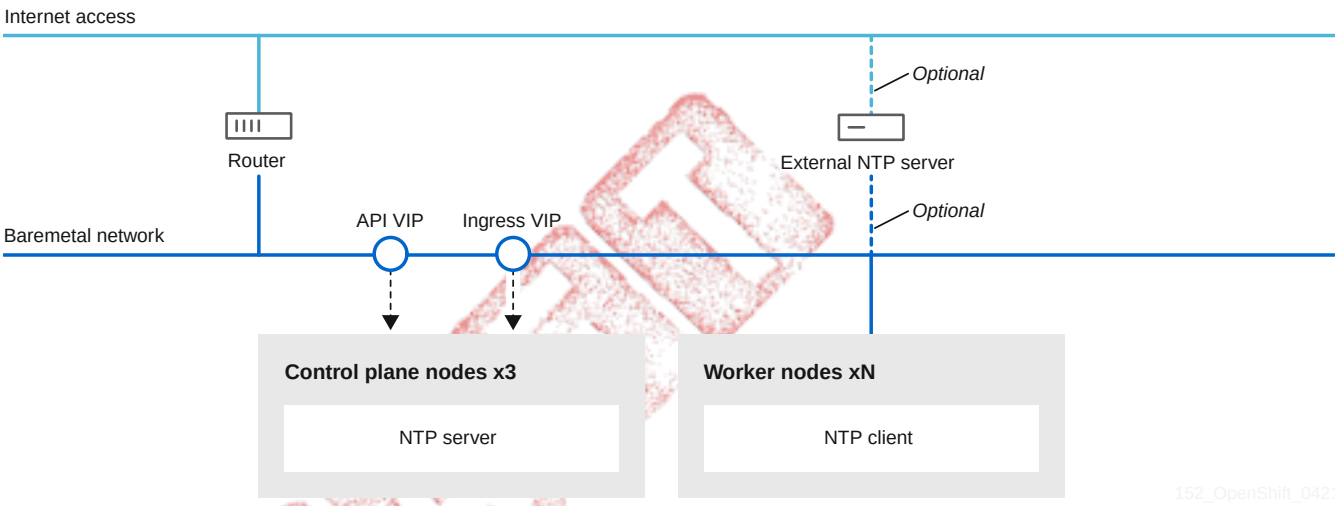
1. Create the OpenShift Container Platform manifests.

```
[kni@provisioner ~]$ ./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
```

3.6.10. Configuring NTP for disconnected clusters (optional)

OpenShift Container Platform installs the `chrony` Network Time Protocol (NTP) service on the cluster nodes. Use the following procedure to configure NTP servers on the control plane nodes and configure worker nodes as NTP clients of the control plane nodes before deployment.



OpenShift Container Platform nodes must agree on a date and time to run properly. When worker nodes retrieve the date and time from the NTP servers on the control plane nodes, it enables the installation and operation of clusters that are not connected to a routable network and thereby do not have access to a higher stratum NTP server.

Procedure

1. Create a `~/control-plane-chrony.conf` configuration file for the control plane nodes.

Configuration file example

```
# Use public servers from the pool.ntp.org project.
# Please consider joining the pool (https://www.pool.ntp.org/join.html).

# This file is managed by the machine config operator
server openshift-master-0.<cluster-name>.<domain> iburst ①
server openshift-master-1.<cluster-name>.<domain> iburst
server openshift-master-2.<cluster-name>.<domain> iburst

stratumweight 0
driftfile /var/lib/chrony/drift
rtcsync
makestep 10 3
bindcmdaddress 127.0.0.1
bindcmdaddress ::1
keyfile /etc/chrony.keys
commandkey 1
generatecommandkey
noclientlog
logchange 0.5
logdir /var/log/chrony

# Configure the control plane nodes to serve as local NTP servers
# for all worker nodes, even if they are not in sync with an
# upstream NTP server.

# Allow NTP client access from the local network.
allow all
# Serve time even if not synchronized to a time source.
local stratum 3 orphan
```

Where:

① You must replace `<cluster-name>` with the name of the cluster and replace `<domain>` with the fully qualified domain name.

2. Create a `~/worker-chrony.conf` configuration file for the worker nodes such that worker nodes reference the NTP servers on the control plane nodes.

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Configuration file example

```
# This file is managed by the machine config operator
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
```

Where:

① You must replace `<cluster-name>` with the name of the cluster and replace `<domain>` with the fully qualified domain name.

3. Create a `~/ntp-server.yaml` configuration file for telling the Machine Configuration Operator to apply the `~/control-plane-chrony.conf` settings to the NTP servers on the control plane nodes.

Configuration file example

```
# This example MachineConfig replaces ~/control-plane-chrony.conf
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: master
  name: 99-master-etc-chrony-conf-override-to-server
spec:
  config:
    ignition:
      version: 2.2.0
    storage:
      files:
        - contents:
            source: data:text/plain;charset=utf-8; base64,BASE64ENCODEDCONFIGFILE①
          filesystem: root
          mode: 0644
          path: /etc/control-plane-chrony.conf
```

Where:

① You must replace the `BASE64ENCODEDCONFIGFILE` string with the base64-encoded string of the `~/control-plane-chrony.conf` file in the subsequent step.

4. Generate a base64 string of the `~/control-plane-chrony.conf` file.

```
$ base64 ~/control-plane-chrony.conf
```

Example output

```
IyBVc2UgcHVibGljIHNlcnZlcnMgZnJvbSB0aGUgcG9vbC5udHAub3JnIHByb2plY3QuCiMgUGxl
YXNlIGNvbnNpZGVyIGpvaW5pbmcgdGhlIHBvb2wgKGh0dHBzOi8vd3d3LnBvb2wubnRwLm9yZy9q
b2luLmh0bWwpLgoKIyBUaGlzIGZpbGUgaXMgdWFuYWdlZCBieSB0aGUgbWFjaGluZSBjb25maWcg
b3BlcmF0b3IKc2VydmVyIG9wZW5zaGlmdC1tYXN0ZXItMC48Y2x1c3Rlci1uYW1lPi48ZG9tYWlu
PiBpYnVyc3QKc2VydmVyIG9wZW5zaGlmdC1tYXN0ZXItMS48Y2x1c3Rlci1uYW1lPi48ZG9tYWlu
PiBpYnVyc3QKc2VydmVyIG9wZW5zaGlmdC1tYXN0ZXItMi48Y2x1c3Rlci1uYW1lPi48ZG9tYWlu
PiBpYnVyc3QKCnN0cmF0dW13ZWlnaHQgMApkcmlmdGZpbGUgL3Zhci9saWIvY2hyb255L2RyaWZ0
CnJ0Y3N5bmMKbWFrZXN0ZXAgMTAgMwpiaW5kY21kYWRkcmVzcyAxMjcuMC4wLjEKYmluZGNtZGFk
ZHJlc3MgOjoxCmtleWZpbGUgL2V0Yy9jaHJvbnkua2V5cwpjb21tYW5ka2V5IDEKZ2VuZXJhdGVj
b21tYW5ka2V5Cm5vY2xpZW50bG9nCmxvZ2NoYW5nZSAwLjUKbG9nZGlyIC92YXIvbG9nL2Nocm9u
eQoKIyBDb25maWd1cmUgdGhlIGNvbnRyb2wgcGxhbmUgbm9kZXMgdG8c2VydmUgYXMgbG9jYWwg
TlRQIHNlcnZlcnMKIyBmb3IgYWxsIHdvcmtlciBub2RlcywgZXZlbiBpZiB0aGV5IGFyZSBub3Qg
aW4gc3luYyB3aXRoIGFuCiMgdXBzdHJlYW0gTlRQIHNlcnZlci4KCiMgQWxsb3cgTlRQIGNsaWVu
dCBhY2Nlc3MgZnJvbSB0aGUgbG9jYWwgbmV0d29yay4KYWxsb3cgYWxsCiMgU2VydmUgdGltZSBl
dmVuIGlmIG5vdCBzeW5jaHJvbml6ZWQgdG8gYSB0aW1lIHNvdXJjZS4KbG9jYWwgc3RyYXR1bSAz
IG9ycGhhbgo=
```

Replace the `BASE64ENCODEDCONFIGFILE` string in the `~/ntp-server.yaml` with the base64-encoded string.

5. Create a `~/ntp-client.yaml` configuration file for telling the Machine Configuration Operator to apply the `~/worker-chrony.conf` settings to the NTP clients on the worker nodes.

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Configuration file example

```
# This example MachineConfig replaces ~/worker-chrony.conf
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 99-master-etc-chrony-conf-override-for-worker
spec:
  config:
    ignition:
      version: 2.2.0
    storage:
      files:
        - contents:
            source: data:text/plain;charset=utf-8; base64,BASE64ENCODEDCONFIGFILE①
          filesystem: root
          mode: 0644
          path: /etc/worker-chrony.conf
```

Where:

① You must replace the `BASE64ENCODEDCONFIGFILE` string with the base64-encoded string of the `~/worker-chrony.conf` file in the subsequent step.

6. Generate a base64-encoded string of the `~/worker-chrony.conf` file.

```
$ base64 ~/worker-chrony.conf
```

Example output

```
IyBUaGlzIGZpbGUgaXMgbWFuYWdlZCBieSB0aGUgbWFjaGluZSBjb25maWcgb3BlcmF0b3IKc2Vy
dmVyIG9wZW5zaGlmdC1tYXN0ZXItMC48Y2x1c3Rlci1uYW1lPi48ZG9tYWluPiBpYnVyc3QKc2Vy
dmVyIG9wZW5zaGlmdC1tYXN0ZXItMS48Y2x1c3Rlci1uYW1lPi48ZG9tYWluPiBpYnVyc3QKc2Vy
dmVyIG9wZW5zaGlmdC1tYXN0ZXItMi48Y2x1c3Rlci1uYW1lPi48ZG9tYWluPiBpYnVyc3QKCnN0
cmF0dW13ZWlnaHQgMApkcmlmdGZpbGUgL3Zhci9saWIvY2hyb255L2RyaWZ0CnJ0Y3N5bmMKbWFr
ZXN0ZXAgMTAgMwpiaW5kY21kYWRkcmVzcyAxMjcuMC4wLjEKYmluZGNtZGFkZHJlc3MgOjoxCmtl
eWZpbGUgL2V0Yy9jaHJvbnkua2V5cwpjb21tYW5ka2V5IDEKZ2VuZXJhdGVjb21tYW5ka2V5Cm5v
Y2xpZW50bG9nCmxvZ2NoYW5nZSAwLjUKbG9nZGlyIC92YXIvbG9nL2Nocm9ueQo=
```

Replace the `BASE64ENCODEDCONFIGFILE` string in the `~/ntp-client.yaml` file with the base64-encoded string.

7. Copy the `~/ntp-server.yaml` file to the `~/clusterconfigs/manifests` directory.

```
$ cp ~/ntp-server.yaml ~/clusterconfigs/manifests
```

8. Copy the `~/ntp-client.yaml` file to the `~/clusterconfigs/manifests` directory.

```
$ cp ~/ntp-client.yaml ~/clusterconfigs/manifests
```

3.6.11. Configure network components to run on the control plane

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 `apiVIP` and `ingressVIP` virtual IP addresses. However, many environments deploy worker nodes in separate subnets from the control plane nodes. Consequently, you must place the `apiVIP` and `ingressVIP` virtual IP addresses exclusively with the control plane nodes.

Procedure

1. Change to the directory storing the `install-config.yaml` file.

```
$ cd ~/clusterconfigs
```

2. Switch to the `manifests` subdirectory.

```
$ cd manifests
```

3. Create a file named `cluster-network-avoid-workers-99-config.yaml`

```
$ touch cluster-network-avoid-workers-99-config.yaml
```

4. Open the `cluster-network-avoid-workers-99-config.yaml` file in an editor and enter a custom resource (CR) that describes the Operator configuration:

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```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  name: 50-worker-fix-ipi-rwn
  labels:
    machineconfiguration.openshift.io/role: worker
spec:
  config:
    ignition:
      version: 3.1.0
    systemd:
      units:
      - name: nodeip-configuration.service
        enabled: true
        contents: |
          [Unit]
          Description=Writes IP address configuration so that kubelet and crio
services select a valid node IP
          Wants=network-online.target
          After=network-online.target ignition-firstboot-complete.service
          Before=kubelet.service crio.service
          [Service]
          Type=oneshot
          ExecStart=/bin/bash -c "exit 0 "
          [Install]
          WantedBy=multi-user.target
    storage:
      files:
        - contents:
            source: data:,
            verification: {}
          filesystem: root
          mode: 420
          path: /etc/kubernetes/manifests/keepalived.yaml
        - contents:
            source: data:,
            verification: {}
          filesystem: root
          mode: 420
          path: /etc/kubernetes/manifests/mdns-publisher.yaml
        - contents:
            source: data:,
            verification: {}
          filesystem: root
          mode: 420
          path: /etc/kubernetes/manifests/coredns.yaml
```

This manifest will place the `apiVIP` and `ingressVIP` virtual IP addresses on the control plane nodes. Additionally, the following processes will deploy on the control plane nodes only:

- openshift-ingress-operator
- keepalived

5. Save the `cluster-network-avoid-workers-99-config.yaml` file.
6. Create a `manifests/cluster-ingress-default-ingresscontroller.yaml` file.

```
apiVersion: operator.openshift.io/v1
kind: IngressController
metadata:
  name: default
  namespace: openshift-ingress-operator
spec:
  nodePlacement:
    nodeSelector:
      matchLabels:
        node-role.kubernetes.io/master: ""
```

7. Consider backing up the `manifests` directory. The installer deletes the `manifests/` directory when creating the cluster.
8. Modify the `cluster-scheduler-02-config.yml` manifest to make the control plane nodes schedulable by setting the `mastersSchedulable` field to `true`. Control plane nodes are not schedulable by default. For example:

```
$ sed -i "s;mastersSchedulable: false;mastersSchedulable: true;g"
clusterconfigs/manifests/cluster-scheduler-02-config.yml
```

If control plane nodes are not schedulable, deploying the cluster will fail.

9. Before deploying the cluster, ensure that the `api.<cluster-name>.<domain>` domain name is resolvable in the DNS. When you configure network components to run exclusively on the control plane, the internal DNS resolution no longer works for worker nodes, which is an expected outcome.

Failure to create a DNS record for the API precludes worker nodes from joining the cluster.

3.7. Creating a disconnected registry (optional)

In some cases, you might want to install an OpenShift Container Platform cluster using a local copy of the installation registry. This could be for enhancing network efficiency because the cluster nodes are on a network that does not have access to the internet.

A local, or mirrored, copy of the registry requires the following:

- A certificate for the registry node. This can be a self-signed certificate.

- A web server that a container on a system will serve.
- An updated pull secret that contains the certificate and local repository information.

Creating a disconnected registry on a registry node is optional. The subsequent sections indicate that they are optional since they are steps you need to execute only when creating a disconnected registry on a registry node. You should execute all of the subsequent sub-sections labeled "(optional)" when creating a disconnected registry on a registry node.

3.7.1. Preparing the registry node to host the mirrored registry (optional)

Make the following changes to the registry node.

Procedure

1. Open the firewall port on the registry node.

```
[user@registry ~]$ sudo firewall-cmd --add-port=5000/tcp --zone=libvirt
--permanent
[user@registry ~]$ sudo firewall-cmd --add-port=5000/tcp --zone=public
--permanent
[user@registry ~]$ sudo firewall-cmd --reload
```

2. Install the required packages for the registry node.

```
[user@registry ~]$ sudo yum -y install python3 podman httpd httpd-tools jq
```

3. Create the directory structure where the repository information will be held.

```
[user@registry ~]$ sudo mkdir -p /opt/registry/{auth,certs,data}
```

3.7.2. Generating the self-signed certificate (optional)

Generate a self-signed certificate for the registry node and put it in the `/opt/registry/certs` directory.

Procedure

1. Adjust the certificate information as appropriate.

```
[user@registry ~]$ host_fqdn=$( hostname --long )
[user@registry ~]$ cert_c="<Country Name>"   # Country Name (C, 2 letter code)
[user@registry ~]$ cert_s="<State>"          # Certificate State (S)
[user@registry ~]$ cert_l="<Locality>"       # Certificate Locality (L)
[user@registry ~]$ cert_o="<Organization>"   # Certificate Organization (O)
[user@registry ~]$ cert_ou="<Org Unit>"      # Certificate Organizational Unit (OU)
[user@registry ~]$ cert_cn="${host_fqdn}"    # Certificate Common Name (CN)

[user@registry ~]$ openssl req \
    -newkey rsa:4096 \
    -nodes \
    -sha256 \
    -keyout /opt/registry/certs/domain.key \
    -x509 \
    -days 365 \
    -out /opt/registry/certs/domain.crt \
    -addext "subjectAltName = DNS:${host_fqdn}" \
    -subj "/C=${cert_c}/ST=${cert_s}/L=${cert_l}/O=${cert_o}/OU=${cert_ou}/CN=
${cert_cn}"
```

When replacing `<Country Name>`, ensure that it only contains two letters. For example, `US`.

2. Update the registry node's `ca-trust` with the new certificate.

```
[user@registry ~]$ sudo cp /opt/registry/certs/domain.crt /etc/pki/ca-
trust/source/anchors/
[user@registry ~]$ sudo update-ca-trust extract
```

3.7.3. Creating the registry podman container (optional)

The registry container uses the `/opt/registry` directory for certificates, authentication files, and to store its data files.

The registry container uses `httpd` and needs an `htpasswd` file for authentication.

Procedure

1. Create an `htpasswd` file in `/opt/registry/auth` for the container to use.

```
[user@registry ~]$ htpasswd -bBc /opt/registry/auth/htpasswd <user> <passwd>
```

   Replace `<user>` with the user name and `<passwd>` with the password.

2. Create and start the registry container.

```
[user@registry ~]$ podman create \
  --name ocpdiscon-registry \
  -p 5000:5000 \
  -e "REGISTRY_AUTH=htpasswd" \
  -e "REGISTRY_AUTH_HTPASSWD_REALM=Registry" \
  -e "REGISTRY_HTTP_SECRET=ALongRandomSecretForRegistry" \
  -e "REGISTRY_AUTH_HTPASSWD_PATH=/auth/htpasswd" \
  -e "REGISTRY_HTTP_TLS_CERTIFICATE=/certs/domain.crt" \
  -e "REGISTRY_HTTP_TLS_KEY=/certs/domain.key" \
  -e "REGISTRY_COMPATIBILITY_SCHEMA1_ENABLED=true" \
  -v /opt/registry/data:/var/lib/registry:z \
  -v /opt/registry/auth:/auth:z \
  -v /opt/registry/certs:/certs:z \
  docker.io/library/registry:2
```

```
[user@registry ~]$ podman start ocpdiscon-registry
```

3.7.4. Copy and update the pull-secret (optional)

Copy the pull secret file from the provisioner node to the registry node and modify it to include the authentication information for the new registry node.

Procedure

1. Copy the `pull-secret.txt` file.

```
[user@registry ~]$ scp kni@provisioner:/home/kni/pull-secret.txt pull-secret.txt
```

2. Update the `host_fqdn` environment variable with the fully qualified domain name of the registry node.

```
[user@registry ~]$ host_fqdn=$( hostname --long )
```

3. Update the `b64auth` environment variable with the base64 encoding of the `http` credentials used to create the `htpasswd` file.

```
[user@registry ~]$ b64auth=$( echo -n '<username>:<passwd>' | openssl base64 )
```

   Replace `<username>` with the user name and `<passwd>` with the password.

4. Set the `AUTHSTRING` environment variable to use the `base64` authorization string. The `$USER` variable is an environment variable containing the name of the current user.

```
[user@registry ~]$ AUTHSTRING="{\"$host_fqdn:5000\": {\"auth\": \"$b64auth\",
\"email\": \"$USER@redhat.com\"}}"
```

5. Update the `pull-secret.txt` file.

```
[user@registry ~]$ jq ".auths += $AUTHSTRING" < pull-secret.txt > pull-secret-
update.txt
```

3.7.5. Mirroring the repository (optional)

Procedure

1. Copy the `oc` binary from the provisioner node to the registry node.

```
[user@registry ~]$ sudo scp kni@provisioner:/usr/local/bin/oc /usr/local/bin
```

2. Get the release image and mirror the remote install images to the local repository.

```
[user@registry ~]$ export VERSION=latest-4.8
[user@registry ~]$ UPSTREAM_REPO=$(curl -s
https://mirror.openshift.com/pub/openshift-v4/x86_64/clients/ocp/
$VERSION/release.txt | awk  '/Pull From/ {print $3}')
[user@registry ~]$ /usr/local/bin/oc adm release mirror \
  -a pull-secret-update.txt
  --from=$UPSTREAM_REPO \
  --to-release-image=$LOCAL_REG/$LOCAL_REPO:${VERSION} \
  --to=$LOCAL_REG/$LOCAL_REPO
```

3.7.6. Modify the `install-config.yaml` file to use the disconnected registry (optional)

On the provisioner node, the `install-config.yaml` file should use the newly created pull-secret from the `pull-secret-update.txt` file. The `install-config.yaml` file must also contain the disconnected registry node's certificate and registry information.

Procedure

1. Add the disconnected registry node's certificate to the `install-config.yaml` file. The certificate should follow the `"additionalTrustBundle: |"` line and be properly indented, usually by two spaces.

```
$ echo "additionalTrustBundle: |" >> install-config.yaml
$ sed -e 's/^/  /' /opt/registry/certs/domain.crt >> install-config.yaml
```

2. Add the mirror information for the registry to the `install-config.yaml` file.

```
$ echo "imageContentSources:" >> install-config.yaml
$ echo "- mirrors:" >> install-config.yaml
$ echo "  - registry.example.com:5000/ocp4/openshift4" >> install-config.yaml
$ echo "  source: quay.io/openshift-release-dev/ocp-v4.0-art-dev" >> install-
config.yaml
$ echo "- mirrors:" >> install-config.yaml
$ echo "  - registry.example.com:5000/ocp4/openshift4" >> install-config.yaml
$ echo "  source: registry.svc.ci.openshift.org/ocp/release" >> install-config.yaml
$ echo "- mirrors:" >> install-config.yaml
$ echo "  - registry.example.com:5000/ocp4/openshift4" >> install-config.yaml
$ echo "  source: quay.io/openshift-release-dev/ocp-release" >> install-config.yaml
```

Replace `registry.example.com` with the registry's fully qualified domain name.

3.8. Deploying routers on worker nodes

During installation, the installer deploys router pods on worker nodes. By default, the installer installs two router pods. If the initial cluster has only one worker node, or if a deployed cluster requires additional routers to handle external traffic loads destined for services within the OpenShift Container Platform cluster, you can create a `yaml` file to set an appropriate number of router replicas.

By default, the installer deploys two routers. If the cluster has at least two worker nodes, you can skip this section. For more information on the Ingress Operator see: Ingress Operator in OpenShift Container Platform.

If the cluster has no worker nodes, the installer deploys the two routers on the control plane nodes by default. If the cluster has no worker nodes, you can skip this section.

Procedure

1. Create a `router-replicas.yaml` file.

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```
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: ""
```

Replace `<num-of-router-pods>` with an appropriate value. If working with just one worker node, set `replicas:` to `1`. If working with more than 3 worker nodes, you can increase `replicas:` from the default value `2` as appropriate.

2. Save and copy the `router-replicas.yaml` file to the `clusterconfigs/openshift` directory.

```
cp ~/router-replicas.yaml clusterconfigs/openshift/99_router-replicas.yaml
```

3.9. Validation checklist for installation

- ▢ OpenShift Container Platform installer has been retrieved.
- ▢ OpenShift Container Platform installer has been extracted.
- ▢ Required parameters for the `install-config.yaml` have been configured.
- ▢ The `hosts` parameter for the `install-config.yaml` has been configured.
- ▢ The `bmc` parameter for the `install-config.yaml` has been configured.
- ▢ Conventions for the values configured in the `bmc address` field have been applied.
- ▢ Created a disconnected registry (optional).
- ▢ Validate disconnected registry settings if in use. (optional)
- ▢ Deployed routers on worker nodes. (optional)

3.10. Deploying the cluster via the OpenShift Container Platform installer

Run the OpenShift Container Platform installer:

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```
[kni@provisioner ~]$ ./openshift-baremetal-install --dir ~/clusterconfigs --log-level
debug create cluster
```

3.11. Following the installation

During the deployment process, you can check the installation's overall status by issuing the `tail` command to the `.openshift_install.log` log file in the install directory folder.

```
[kni@provisioner ~]$ tail -f /path/to/install-dir/.openshift_install.log
```

3.12. Verifying static IP address configuration

If the DHCP reservation for a cluster node specifies an infinite leases, after the installer successfully provisions the node, the dispatcher script will check 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.

The dispatcher script may run on successfully provisioned nodes while the provisioning of other nodes in the cluster is ongoing.

To verify the network configuration is working properly, you can:

- Check the network interface configuration on the node.
- Turn off the DHCP server and reboot the OpenShift Container Platform node and and ensure that the network configuration works properly.

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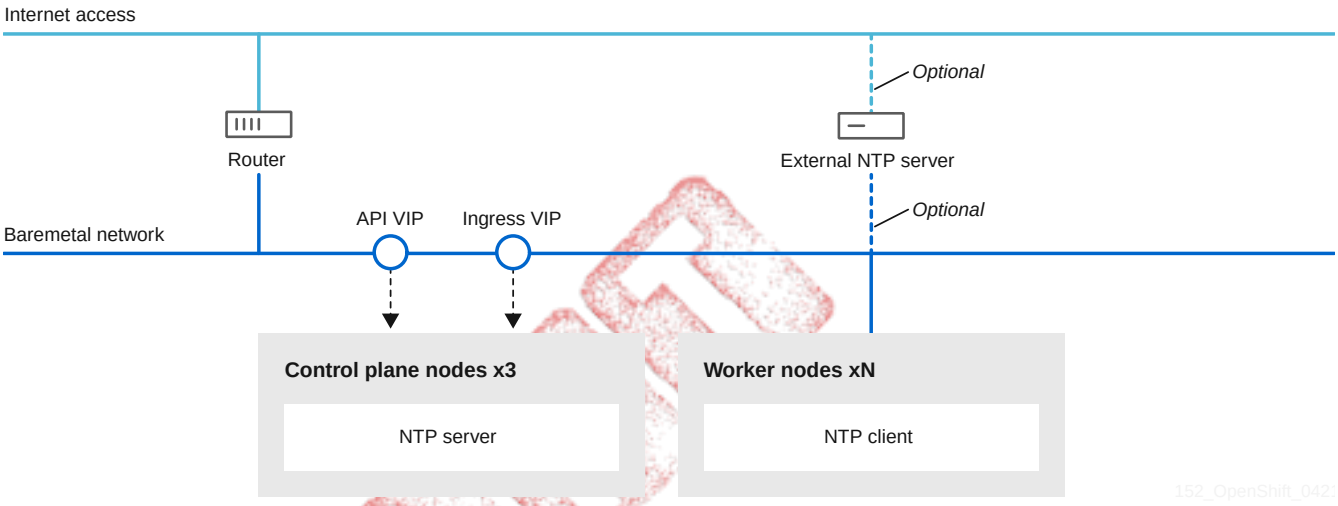
Chapter 4. Installer-provisioned post-installation configuration

After successfully deploying an installer-provisioned cluster, consider the following post-installation procedures.

4.1. Configuring NTP for disconnected clusters (optional)

OpenShift Container Platform installs the `chrony` Network Time Protocol (NTP) service on the cluster nodes. Use the following procedure to configure NTP servers on the control plane nodes and configure worker nodes as NTP clients of the control plane nodes after a successful deployment.



OpenShift Container Platform nodes must agree on a date and time to run properly. When worker nodes retrieve the date and time from the NTP servers on the control plane nodes, it enables the installation and operation of clusters that are not connected to a routable network and thereby do not have access to a higher stratum NTP server.

Procedure

1. Create a `~/control-plane-chrony.conf` configuration file for the control plane nodes.

Configuration file example

```
# Use public servers from the pool.ntp.org project.
# Please consider joining the pool (https://www.pool.ntp.org/join.html).

# This file is managed by the machine config operator
server openshift-master-0.<cluster-name>.<domain> iburst ①
server openshift-master-1.<cluster-name>.<domain> iburst
server openshift-master-2.<cluster-name>.<domain> iburst

stratumweight 0
driftfile /var/lib/chrony/drift
rtcsync
makestep 10 3
bindcmdaddress 127.0.0.1
bindcmdaddress ::1
keyfile /etc/chrony.keys
commandkey 1
generatecommandkey
noclientlog
logchange 0.5
logdir /var/log/chrony

# Configure the control plane nodes to serve as local NTP servers
# for all worker nodes, even if they are not in sync with an
# upstream NTP server.

# Allow NTP client access from the local network.
allow all
# Serve time even if not synchronized to a time source.
local stratum 3 orphan
```

Where:

① You must replace `<cluster-name>` with the name of the cluster and replace `<domain>` with the fully qualified domain name.

2. Create a `~/worker-chrony.conf` configuration file for the worker nodes such that worker nodes reference the NTP servers on the control plane nodes.

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Configuration file example

```
# This file is managed by the machine config operator
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
```

Where:

① You must replace `<cluster-name>` with the name of the cluster and replace `<domain>` with the fully qualified domain name.

3. Create a `~/ntp-server.yaml` configuration file for telling the Machine Configuration Operator to apply the `~/control-plane-chrony.conf` settings to the NTP servers on the control plane nodes.

Configuration file example

```
# This example MachineConfig replaces ~/control-plane-chrony.conf
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: master
  name: 99-master-etc-chrony-conf-override-to-server
spec:
  config:
    ignition:
      version: 2.2.0
    storage:
      files:
        - contents:
            source: data:text/plain;charset=utf-8; base64,BASE64ENCODEDCONFIGFILE①
          filesystem: root
          mode: 0644
          path: /etc/control-plane-chrony.conf
```

Where:

① You must replace the `BASE64ENCODEDCONFIGFILE` string with the base64-encoded string of the `~/control-plane-chrony.conf` file in the subsequent step.

4. Generate a base64 string of the `~/control-plane-chrony.conf` file.

```
$ base64 ~/control-plane-chrony.conf
```

Example output

```
IyBVc2UgcHVibGljIHNlcnZlcnMgZnJvbSB0aGUgcG9vbC5udHAub3JnIHByb2plY3QuCiMgUGxl
YXNlIGNvbnNpZGVyIGpvaW5pbmcgdGhlIHBvb2wgKGh0dHBzOi8vd3d3LnBvb2wubnRwLm9yZy9q
b2luLmh0bWwpLgoKIyBUaGlzIGZpbGUgaXMgdWFuYWdlZCBieSB0aGUgbWFjaGluZSBjb25maWcg
b3BlcmF0b3IKc2VydmVyIG9wZW5zaGlmdC1tYXN0ZXItMC48Y2x1c3Rlci1uYW1lPi48ZG9tYWlu
PiBpYnVyc3QKc2VydmVyIG9wZW5zaGlmdC1tYXN0ZXItMS48Y2x1c3Rlci1uYW1lPi48ZG9tYWlu
PiBpYnVyc3QKc2VydmVyIG9wZW5zaGlmdC1tYXN0ZXItMi48Y2x1c3Rlci1uYW1lPi48ZG9tYWlu
PiBpYnVyc3QKCnN0cmF0dW13ZWlnaHQgMApkcmlmdGZpbGUgL3Zhci9saWIvY2hyb255L2RyaWZ0
CnJ0Y3N5bmMKbWFrZXN0ZXAgMTAgMwpiaW5kY21kYWRkcmVzcyAxMjcuMC4wLjEKYmluZGNtZGFk
ZHJlc3MgOjoxCmtleWZpbGUgL2V0Yy9jaHJvbnkua2V5cwpjb21tYW5ka2V5IDEKZ2VuZXJhdGVj
b21tYW5ka2V5Cm5vY2xpZW50bG9nCmxvZ2NoYW5nZSAwLjUKbG9nZGlyIC92YXIvbG9nL2Nocm9u
eQoKIyBDb25maWd1cmUgdGhlIGNvbnRyb2wgcGxhbmUgbm9kZXMgdG8c2VydmUgYXMgbG9jYWwg
TlRQIHNlcnZlcnMKIyBmb3IgYWxsIHdvcmtlciBub2RlcywwgZXZlbiBpZiB0aGV5IGFyZSBub3Qg
aW4gc3luYyB3aXRoIGFuCiMgdXBzdHJlYW0gTlRQIHNlcnZlci4KCiMgQWxsb3cgTlRQIGNsaWVu
dCBhY2Nlc3MgZnJvbSB0aGUgbG9jYWwgbmV0d29yay4KYWxsb3cgYWxsCiMgU2VydmUgdGltZSBl
dmVuIGlmIG5vdCBzeW5jaHJvbml6ZWQgdG8gYSB0aW1lIHNvdXJjZS4KbG9jYWwgc3RyYXR1bSAz
IG9ycGhhbgo=
```

Replace the `BASE64ENCODEDCONFIGFILE` string in the `~/ntp-server.yaml` with the base64-encoded string.

5. Create a `~/ntp-client.yaml` configuration file for telling the Machine Configuration Operator to apply the `~/worker-chrony.conf` settings to the NTP clients on the worker nodes.

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Configuration file example

```
# This example MachineConfig replaces ~/worker-chrony.conf
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 99-master-etc-chrony-conf-override-for-worker
spec:
  config:
    ignition:
      version: 2.2.0
    storage:
      files:
        - contents:
            source: data:text/plain;charset=utf-8; base64,BASE64ENCODEDCONFIGFILE①
          filesystem: root
          mode: 0644
          path: /etc/worker-chrony.conf
```

Where:

① You must replace the `BASE64ENCODEDCONFIGFILE` string with the base64-encoded string of the `~/worker-chrony.conf` file in the subsequent step.

6. Generate a base64-encoded string of the `~/worker-chrony.conf` file.

```
$ base64 ~/worker-chrony.conf
```

Example output

```
IyBUaGlzIGZpbGUgaXMgbWFuYWdlZCBieSB0aGUgbWFjaGluZSBjb25maWcgb3BlcmF0b3IKc2Vy
dmVyIG9wZW5zaGlmdC1tYXN0ZXItMC48Y2x1c3Rlci1uYW1lPi48ZG9tYWluPiBpYnVyc3QKc2Vy
dmVyIG9wZW5zaGlmdC1tYXN0ZXItMS48Y2x1c3Rlci1uYW1lPi48ZG9tYWluPiBpYnVyc3QKc2Vy
dmVyIG9wZW5zaGlmdC1tYXN0ZXItMi48Y2x1c3Rlci1uYW1lPi48ZG9tYWluPiBpYnVyc3QKCnN0
cmF0dW13ZWlnaHQgMApkcmlmdGZpbGUgL3Zhci9saWIvY2hyb255L2RyaWZ0CnJ0Y3N5bmMKbWFr
ZXN0ZXAgMTAgMwpiaW5kY21kYWRkcmVzcyAxMjcuMC4wLjEKYmluZGNtZGFkZHJlc3MgOjoxCmtl
eWZpbGUgL2V0Yy9jaHJvbnkua2V5cwpjb21tYW5ka2V5IDEKZ2VuZXJhdGVjb21tYW5ka2V5Cm5v
Y2xpZW50bG9nCmxvZ2NoYW5nZSAwLjUKbG9nZGlyIC92YXIvbG9nL2Nocm9ueQo=
```

Replace the `BASE64ENCODEDCONFIGFILE` string in the `~/ntp-client.yaml` file with the base64-encoded string.

7. Apply the `ntp-server.yaml` policy to the control plane nodes.

```
$ oc apply -f ~/ntp-server.yaml
```

Example output

```
machineconfig.machineconfiguration.openshift.io/99-master-etc-chrony-conf-override-
for-server created
```

8. Apply the `~/ntp-client.yaml` policy to the worker nodes.

```
$ oc apply -f ~/worker-chrony.conf
```

Example output

```
machineconfig.machineconfiguration.openshift.io/99-master-etc-chrony-conf-override-
for-worker created
```

9. Check the status of the applied NTP settings.

```
$ oc describe machineconfigpool
```

4.2. Configuring an external load balancer

You can configure an OpenShift Container Platform cluster to use an external load balancer in place of the default load balancer.

Prerequisites

- On your load balancer, TCP over ports 6443, 443, and 80 must be available to any users of your system.
- Load balance the API port, 6443, between each of the control plane nodes.
- Load balance the application ports, 443 and 80, between all of the compute nodes.
- On your load balancer, port 22623, which is used to serve ignition start-up configurations to nodes, is not exposed outside of the cluster.
- Your load balancer must be able to access every machine in your cluster. Methods to allow this access include:
  - Attaching the load balancer to the cluster's machine subnet.
  - Attaching floating IP addresses to machines that use the load balancer.

External load balancing services and the control plane nodes must run on the same L2 network, and on the same VLAN when using VLANs to route traffic between the load balancing services and the control plane nodes.

Procedure

1. Enable access to the cluster from your load balancer on ports 6443, 443, and 80.

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As an example, note this HAProxy configuration:

A section of a sample HAProxy configuration

```
...
listen my-cluster-api-6443
    bind 0.0.0.0:6443
    mode tcp
    balance roundrobin
    server my-cluster-master-2 192.0.2.2:6443 check
    server my-cluster-master-0 192.0.2.3:6443 check
    server my-cluster-master-1 192.0.2.1:6443 check
listenmy-cluster-apps-443
        bind 0.0.0.0:443
        mode tcp
        balance roundrobin
        server my-cluster-worker-0 192.0.2.6:443 check
        server my-cluster-worker-1 192.0.2.5:443 check
        server my-cluster-worker-2 192.0.2.4:443 check
listenmy-cluster-apps-80
        bind 0.0.0.0:80
        mode tcp
        balance roundrobin
        server my-cluster-worker-0 192.0.2.7:80 check
        server my-cluster-worker-1 192.0.2.9:80 check
        server my-cluster-worker-2 192.0.2.8:80 check
```

2. Add records to your DNS server for the cluster API and apps over the load balancer. For example:

```
<load_balancer_ip_address> api.<cluster_name>.<base_domain>
<load_balancer_ip_address> apps.<cluster_name>.<base_domain>
```

3. From a command line, use `curl` to verify that the external load balancer and DNS configuration are operational.
   a. Verify that the cluster API is accessible:

   ```
   $ curl https://<loadbalancer_ip_address>:6443/version --insecure
   ```

   If the configuration is correct, you receive a JSON object in response:

```
{
  "major": "1",
  "minor": "11+",
  "gitVersion": "v1.11.0+ad103ed",
  "gitCommit": "ad103ed",
  "gitTreeState": "clean",
  "buildDate": "2019-01-09T06:44:10Z",
  "goVersion": "go1.10.3",
  "compiler": "gc",
  "platform": "linux/amd64"
}
```

b. Verify that cluster applications are accessible:

You can also verify application accessibility by opening the OpenShift Container Platform console in a web browser.

```
$ curl http://console-openshift-console.apps.<cluster_name>.<base_domain> -I -L
--insecure
```

If the configuration is correct, you receive an HTTP response:

```
HTTP/1.1 302 Found
content-length: 0
location: https://console-openshift-console.apps.<cluster-name>.<base domain>/
cache-control: no-cacheHTTP/1.1 200 OK
referrer-policy: strict-origin-when-cross-origin
set-cookie: csrf-
token=39HoZgztDnzjJkq/JuLJMeoKNXlfiVv2YgZc09c3TBOBU4NI6kDXaJH1LdicNhN1UsQWzon4Do
r9GWGfopaTEQ==; 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
```

Chapter 5. Day 2 operations

The following sections are optional, but may be of interest after the initial deployment has been completed.

5.1. Accessing the web console

The web console runs as a pod on the master. The static assets required to run the web console are served by the pod. Once OpenShift Container Platform is successfully installed, find the URL for the web console and login credentials for your installed cluster in the CLI output of the installation program. For example:

Example output

```
INFO Install complete!
INFO Run 'export KUBECONFIG=<your working directory>/auth/kubeconfig' to manage the
cluster with 'oc', the OpenShift CLI.
INFO The cluster is ready when 'oc login -u kubeadmin -p <provided>' succeeds (wait a
few minutes).
INFO Access the OpenShift web-console here: https://console-openshift-
console.apps.demo1.openshift4-beta-abcorp.com
INFO Login to the console with user: kubeadmin, password: <provided>
```

Use those details to log in and access the web console.

Additionally, you can execute:

```
oc whoami --show-console
```

To obtain the url for the console.

5.2. Backing up the cluster configuration

At this point you have a working OpenShift 4 cluster on baremetal. In order to take advantage of the baremetal hardware that was the provision node, you can repurpose the provisioning node as a worker. Prior to reprovisioning the node, it is recommended to backup some existing files.

Procedure

1. Tar the `clusterconfig` folder and download it to your local machine.

   ```
   tar cvfz clusterconfig.tar.gz ~/clusterconfig
   ```

2. Copy the Private part for the SSH Key configured on the `install-config.yaml` file to your local machine.

```
tar cvfz clusterconfigsh.tar.gz ~/.ssh/id_rsa*
```

3. Copy the `install-config.yaml` and `metal3-config.yaml` files.

```
tar cvfz yamlconfigs.tar.gz install-config.yaml metal3-config.yaml
```

5.3. 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.

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.

5.3.1. Preparing the bare metal node

Expanding the cluster requires a DHCP server. Each node must have a DHCP reservation.

Reserving IP addresses so they become static IP addresses

Some administrators prefer to use static IP addresses so that each node's IP address remains constant in the absence of a DHCP server. To use static IP addresses in the OpenShift Container Platform cluster, **reserve the IP addresses in the DHCP server with an infinite lease**. After the installer provisions the node successfully, the dispatcher script will check the node's network configuration. If the dispatcher script finds that the network configuration contains a DHCP infinite lease, it will recreate the connection as a static IP connection using the IP address from the DHCP infinite lease. NICs without DHCP infinite leases will remain unmodified.

Preparing the bare metal node requires executing the following procedure from the provisioner node.

Procedure

1. Get the `oc` binary, if needed. It should already exist on the provisioner node.

```
[kni@provisioner ~]$ export VERSION=latest-4.8
[kni@provisioner ~]$ curl -s https://mirror.openshift.com/pub/openshift-
v4/clients/ocp/$VERSION/openshift-client-linux-$VERSION.tar.gz | tar zxvf - oc
```

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```
[kni@provisioner ~]$ sudo cp oc /usr/local/bin
```

2. Power off the bare metal node via the baseboard management controller and ensure it is off.
3. Retrieve the user name and password of the bare metal node's baseboard management controller. Then, create `base64` strings from the user name and password. In the following example, the user name is `root` and the password is `calvin`.

```
[kni@provisioner ~]$ echo -ne "root" | base64
```

```
[kni@provisioner ~]$ echo -ne "calvin" | base64
```

4. Create a configuration file for the bare metal node.

```
[kni@provisioner ~]$ vim bmh.yaml
```

```
---
apiVersion: v1
kind: Secret
metadata:
  name: openshift-worker-<num>-bmc-secret
type: Opaque
data:
  username: <base64-of-uid>
  password: <base64-of-pwd>
---
apiVersion: metal3.io/v1alpha1
kind: BareMetalHost
metadata:
  name: openshift-worker-<num>
spec:
  online: true
  bootMACAddress: <NIC1-mac-address>
  bmc:
    address: <protocol>://<bmc-ip>
    credentialsName: openshift-worker-<num>-bmc-secret
```

Replace `<num>` for the worker number of the bare metal node in the two `name` fields and the `credentialsName` field. Replace `<base64-of-uid>` with the `base64` string of the user name. Replace `<base64-of-pwd>` with the `base64` string of the password. Replace `<NIC1-mac-address>` with the MAC address of the bare metal node's first NIC.

Refer to the BMC addressing section for additional BMC configuration options. Replace `<protocol>` with the BMC protocol, such as IPMI, RedFish, or others. Replace `<bmc-ip>` with the IP address of the bare metal node's baseboard management controller.

5. Create the bare metal node.

```
[kni@provisioner ~]$ oc -n openshift-machine-api create -f bmh.yaml
```

```
secret/openshift-worker-<num>-bmc-secret created
baremetalhost.metal3.io/openshift-worker-<num> created
```

Where <num> will be the worker number.

6. Power up and inspect the bare metal node.

```
[kni@provisioner ~]$ oc -n openshift-machine-api get bmh openshift-worker-<num>
```

Where <num> is the worker node number.

```
NAME                 STATUS   PROVISIONING STATUS   CONSUMER   BMC
HARDWARE PROFILE   ONLINE   ERROR
openshift-worker-<num>   OK       ready                          ipmi://<out-of-
band-ip>   unknown            true
```

5.3.2. Provisioning the bare metal node

Provisioning the bare metal node requires executing the following procedure from the provisioner node.

Procedure

1. Ensure the PROVISIONING STATUS is ready before provisioning the bare metal node.

```
[kni@provisioner ~]$  oc -n openshift-machine-api get bmh openshift-worker-<num>
```

Where <num> is the worker node number.

```
NAME                 STATUS   PROVISIONING STATUS   CONSUMER   BMC
HARDWARE PROFILE   ONLINE   ERROR
openshift-worker-<num>   OK       ready                          ipmi://<out-of-
band-ip>   unknown            true
```

2. Get a count of the number of worker nodes.

```
[kni@provisioner ~]$ oc get nodes
```

```
NAME                                          STATUS   ROLES           AGE
VERSION
provisioner.openshift.example.com             Ready    master          30h
v1.16.2
openshift-master-1.openshift.example.com      Ready    master          30h
v1.16.2
openshift-master-2.openshift.example.com      Ready    master          30h
v1.16.2
openshift-master-3.openshift.example.com      Ready    master          30h
v1.16.2
openshift-worker-0.openshift.example.com      Ready    master          30h
v1.16.2
openshift-worker-1.openshift.example.com      Ready    master          30h
v1.16.2
```

3. Get the machine set.

```
[kni@provisioner ~]$ 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.

```
[kni@provisioner ~]$ oc scale --replicas=<num> machineset <machineset> -n
openshift-machine-api
```

Replace `<num>` with the new number of worker nodes. Replace `<machineset>` with the name of the machine set from the previous step.

5. Check the status of the bare metal node.

```
[kni@provisioner ~]$ oc -n openshift-machine-api get bmh openshift-worker-<num>
```

Where `<num>` is the worker node number. The status changes from `ready` to `provisioning`.

```
NAME                 STATUS   PROVISIONING STATUS   CONSUMER                 BMC
HARDWARE PROFILE   ONLINE   ERROR
openshift-worker-<num>   OK       provisioning          openshift-worker-<num>-
65tjz   ipmi://<out-of-band-ip>   unknown            true
```

The `provisioning` status remains until the OpenShift Container Platform cluster provisions the

node. This can take 30 minutes or more. Once complete, the status will change to `provisioned`.

```
NAME                 STATUS   PROVISIONING STATUS   CONSUMER                  BMC
HARDWARE PROFILE   ONLINE   ERROR
openshift-worker-<num>   OK       provisioned           openshift-worker-<num>-
65tjz   ipmi://<out-of-band-ip>   unknown            true
```

6. Once provisioned, ensure the bare metal node is ready.

```
[kni@provisioner ~]$ oc get nodes
```

```
NAME                                         STATUS   ROLES   AGE     VERSION
provisioner.openshift.example.com            Ready    master  30h     v1.16.2
openshift-master-1.openshift.example.com     Ready    master  30h     v1.16.2
openshift-master-2.openshift.example.com     Ready    master  30h     v1.16.2
openshift-master-3.openshift.example.com     Ready    master  30h     v1.16.2
openshift-worker-0.openshift.example.com     Ready    master  30h     v1.16.2
openshift-worker-1.openshift.example.com     Ready    master  30h     v1.16.2
openshift-worker-<num>.openshift.example.com Ready    worker  3m27s   v1.16.2
```

You can also check the kubelet.

```
[kni@provisioner ~]$ ssh openshift-worker-<num>
```

```
[kni@openshift-worker-<num>]$ journalctl -fu kubelet
```

5.3.3. Preparing the provisioner node to be deployed as a worker node

Procedure

Perform the following steps prior to converting the provisioner node to a worker node.

1. `ssh` to a system (for example, a laptop) that can access the out of band management network of the current provisioner node.
2. Copy the backups `clusterconfig.tar.gz`, `clusterconfigsh.tar.gz`, and `amlconfigs.tar.gz` to the new system.
3. Copy the `oc` binary from the existing provisioning node to the new system.
4. Make a note of the mac addresses, the baremetal network IP used for the provisioner node, and the IP address of the Out of band Management Network.
5. Reboot the system and ensure that PXE is enabled on the provisioning network and PXE is disabled for all other NICs.
6. If installation was performed using a Satellite server, remove the Host entry for the existing

provisioning node.

7. Install the `ipmitool` on the new system in order to power off the provisioner node.

5.3.4. Adding a worker node to an existing cluster

Procedure

1. Retrieve the username and password of the bare metal node's baseboard management controller. Then, create `base64` strings from the username and password. In the following example, the username is `root` and the password is `calvin`.

```
[kni@provisioner ~]$ echo -ne "root" | base64
```

```
[kni@provisioner ~]$ echo -ne "calvin" | base64
```

2. Create a configuration file for the bare metal node.

```
[kni@provisioner ~]$ vim bmh.yaml
```

```
---
apiVersion: v1
kind: Secret
metadata:
  name: openshift-worker-<num>-bmc-secret
type: Opaque
data:
  username: <base64-of-uid>
  password: <base64-of-pwd>
---
apiVersion: metal3.io/v1alpha1
kind: BareMetalHost
metadata:
  name: openshift-worker-<num>
spec:
  online: true
  bootMACAddress: <NIC1-mac-address>
  bmc:
    address: ipmi://<bmc-ip>
    credentialsName: openshift-worker-<num>-bmc-secret
```

Replace `<num>` for the worker number of bare metal node in two `name` fields and `credentialsName` field. Replace `<base64-of-uid>` with the `base64` string of the username. Replace `<base64-of-pwd>` with the `base64` string of the password. Replace `<NIC1-mac-address>` with the MAC address of the bare metal node's first NIC. Replace `<bmc-ip>` with the IP address of the bare metal node's baseboard management controller.

When using `redfish` or `redfish-virtualmedia`, add the appropriate addressing as described in the BMC addressing section. See BMC addressing for details.

1. Create the bare metal node.

```
[kni@provisioner ~]$ oc -n openshift-machine-api create -f bmh.yaml
```

```
secret/openshift-worker-<num>-bmc-secret created
baremetalhost.metal3.io/openshift-worker-<num> created
```

Where `<num>` will be the worker number.

2. Power up and inspect the bare metal node.

```
[kni@provisioner ~]$ oc -n openshift-machine-api get bmh openshift-worker-<num>
```

Where `<num>` is the worker node number.

```
NAME                 STATUS   PROVISIONING STATUS   CONSUMER   BMC
HARDWARE PROFILE   ONLINE   ERROR
openshift-worker-<num>   OK       ready                          ipmi://<out-of-
band-ip>   unknown            true
```

3. Ensure the `PROVISIONING STATUS` is `ready` before provisioning the bare metal node.

```
[kni@provisioner ~]$  oc -n openshift-machine-api get bmh openshift-worker-<num>
```

Where `<num>` is the worker node number.

```
NAME                 STATUS   PROVISIONING STATUS   CONSUMER   BMC
HARDWARE PROFILE   ONLINE   ERROR
openshift-worker-<num>   OK       ready                          ipmi://<out-of-
band-ip>   unknown            true
```

4. Get a count of the number of worker nodes.

```
[kni@provisioner ~]$ oc get nodes
```

5. Get the machine set.

```
[kni@provisioner ~]$ 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
openshift-worker-2.example.com       1         1         1       1           55m
```

6. Increase the number of worker nodes by 1.

```
[kni@provisioner ~]$ oc scale --replicas=<num> machineset <machineset> -n
openshift-machine-api
```

Replace `<num>` with the new number of worker nodes. Replace `<machineset>` with the name of the machine set from the previous step.

7. Check the status of the bare metal node.

```
[kni@provisioner ~]$ oc -n openshift-machine-api get bmh openshift-worker-<num>
```

Where `<num>` is the worker node number. The status changes from `ready` to `provisioning`.

```
NAME                 STATUS   PROVISIONING STATUS   CONSUMER                  BMC
HARDWARE PROFILE   ONLINE   ERROR
openshift-worker-<num>   OK       provisioning          openshift-worker-<num>-
65tjz   ipmi://<out-of-band-ip>   unknown            true
```

The `provisioning` status remains until the OpenShift Container Platform cluster provisions the node. This may take 30 minutes or more. Once complete, the status will change to `provisioned`.

```
NAME                 STATUS   PROVISIONING STATUS   CONSUMER                  BMC
HARDWARE PROFILE   ONLINE   ERROR
openshift-worker-<num>   OK       provisioned           openshift-worker-<num>-
65tjz   ipmi://<out-of-band-ip>   unknown            true
```

8. Once provisioned, ensure the bare metal node is ready.

```
[kni@provisioner ~]$ oc get nodes
```

```
NAME                                                STATUS   ROLES           AGE
VERSION
provisioner.openshift.example.com            Ready    master          30h
v1.16.2
openshift-master-1.openshift.example.com            Ready    master          30h
v1.16.2
openshift-master-2.openshift.example.com            Ready    master          30h
v1.16.2
openshift-worker-<num>.openshift.example.com        Ready    worker          3m27s
v1.16.2
```

You can also check the kubelet.

```
[kni@provisioner ~]$ ssh openshift-worker-<num>
```

```
[kni@openshift-worker-<num>]$ journalctl -fu kubelet
```

Appending DNS records

Configuring Bind (Option 1)

Procedure

1. Login to the DNS server using `ssh`.
2. Suspend updates to all dynamic zones: `rndc freeze`.
3. Edit `/var/named/dynamic/example.com`.

```
$ORIGIN openshift.example.com.
<OUTPUT_OMITTED>
openshift-worker-1      A       <ip-of-worker-1>
openshift-worker-2      A       <ip-of-worker-2>
```

Remove the provisioner as it is replaced by openshift-worker-2.

4. Increase the SERIAL value by `1`.
5. Edit `/var/named/dynamic/1.0.10.in-addr.arpa`.

The filename `1.0.10.in-addr.arpa` is the reverse of the public CIDR example `10.0.1.0/24`.

6. Increase the SERIAL value by `1`.
7. Enable updates to all dynamic zones and reload them: `rndc thaw`.

Configuring dnsmasq (Option 2)

Procedure

Append the following DNS record to the `/etc/hosts` file on the server hosting the `dnsmasq` service.

```
<OUTPUT_OMITTED>
<NIC2-IP> openshift-worker-1.openshift.example.com openshift-worker-1
<NIC2-IP> openshift-worker-2.openshift.example.com openshift-worker-2
```

Remove the `provisioner.openshift.example.com` entry as it is replaced by worker-2

Appending DHCP reservations

Configuring dhcpd (Option 1)

Procedure

1. Login to the DHCP server using `ssh`.
2. Edit `/etc/dhcp/dhcpd.hosts`.

```
host openshift-worker-2 {
     option host-name "worker-2";
     hardware ethernet <NIC2-mac-address>;
     option domain-search "openshift.example.com";
     fixed-address <ip-address-of-NIC2>;
  }
```

Remove the provisioner as it is replaced by openshift-worker-2.

3. Restart the `dhcpd` service.

```
systemctl restart dhcpd
```

Configuring dnsmasq (Option 2)

Procedure

1. Append the following DHCP reservation to the `/etc/dnsmasq.d/example.dns` file on the server hosting the `dnsmasq` service.

```
<OUTPUT_OMITTED>
dhcp-host=<NIC2-mac-address>,openshift-worker-1.openshift.example.com,<ip-of-
worker-1>
dhcp-host=<NIC2-mac-address>,openshift-worker-2.openshift.example.com,<ip-of-
worker-2>
```

Remove the `provisioner.openshift.example.com` entry as it is replaced by worker-2

2. Restart the `dnsmasq` service.

```
systemctl restart dnsmasq
```

Deploying the provisioner node as a worker node using Metal3

After you have completed the prerequisites, perform the deployment process.

Procedure

1. Power off the node using `ipmitool` and confirm the provisioning node is powered off.

```
ssh <server-with-access-to-management-net>
# Use the user, password and Management net IP adddress to shutdown the system
ipmitool -I lanplus -U <user> -P <password> -H <management-server-ip> power off
# Confirm the server is powered down
ipmitool -I lanplus -U <user> -P <password> -H <management-server-ip> power status
Chassis Power is off
```

2. Get `base64` strings for the Out of band Management credentials. In this example, the user is `root` and the password is `calvin`.

```
# Use echo -ne, otherwise you will get your secrets with \n which will cause issues
# Get root username in base64
echo -ne "root" | base64
# Get root password in base64
echo -ne "calvin" | base64
```

3. Configure the BaremetalHost `bmh.yaml` file.

DRAFT

```
---
apiVersion: v1
kind: Secret
metadata:
  name: openshift-worker-2-bmc-secret
type: Opaque
data:
  username: ca2vdAo=
  password: MWAwTWdtdC0K
---
apiVersion: metal3.io/v1alpha1
kind: BareMetalHost
metadata:
  name: openshift-worker-2
spec:
  online: true
  bootMACAddress: <NIC1-mac-address>
  bmc:
    address: ipmi://<out-of-band-ip>
    credentialsName: openshift-worker-2-bmc-secret
```

4. Create the BaremetalHost.

```
./oc -n openshift-machine-api create -f bmh.yaml
secret/openshift-worker-2-bmc-secret created
baremetalhost.metal3.io/openshift-worker-2 created
```

5. Power up and inspect the node.

```
./oc -n openshift-machine-api get bmh openshift-worker-2

NAME                 STATUS   PROVISIONING STATUS   CONSUMER   BMC
HARDWARE PROFILE   ONLINE   ERROR
openshift-worker-2   OK       inspecting                       ipmi://<out-of-band-
ip>                      true
```

6. After finishing the inspection, the node is ready to be provisioned.

```
./oc -n openshift-machine-api get bmh openshift-worker-2

NAME                 STATUS   PROVISIONING STATUS   CONSUMER   BMC
HARDWARE PROFILE   ONLINE   ERROR
openshift-worker-2   OK       ready                            ipmi://<out-of-band-
ip>   unknown            true
```

7. Scale the workers machineset. Previously, there were two replicas during original installation.

```
./oc get machineset -n openshift-machine-api
NAME            DESIRED   CURRENT   READY   AVAILABLE   AGE
openshift-worker-2   0         0                             21h

./oc -n openshift-machine-api scale machineset openshift-worker-2 --replicas=3
```

8. The baremetal host moves to provisioning status. This can take as long as 30 minutes. You can follow the status from the node console.

```
oc -n openshift-machine-api get bmh openshift-worker-2

NAME                 STATUS   PROVISIONING STATUS   CONSUMER                 BMC
HARDWARE PROFILE   ONLINE   ERROR
openshift-worker-2   OK       provisioning          openshift-worker-0-65tjz
ipmi://<out-of-band-ip>   unknown            true
```

9. When the node is provisioned it moves to provisioned status.

```
oc -n openshift-machine-api get bmh openshift-worker-2

NAME                 STATUS   PROVISIONING STATUS   CONSUMER                 BMC
HARDWARE PROFILE   ONLINE   ERROR
openshift-worker-2   OK       provisioned           openshift-worker-2-65tjz
ipmi://<out-of-band-ip>   unknown            true
```

10. When the `kubelet` finishes initialization the node is ready for use. You can connect to the node and run `journalctl -fu kubelet` to check the process.

```
oc get node
NAME                                       STATUS   ROLES           AGE
VERSION
openshift-master-0.openshift.example.com   Ready    master          30h
v1.16.2
openshift-master-1.openshift.example.com   Ready    master          30h
v1.16.2
openshift-master-2.openshift.example.com   Ready    master          30h
v1.16.2
openshift-worker-0.openshift.example.com   Ready    worker          3m27s
v1.16.2
openshift-worker-1.openshift.example.com   Ready    worker          3m27s
v1.16.2
openshift-worker-2.openshift.example.com   Ready    worker          3m27s
v1.16.2
```

Chapter 6. Appendix

In this section of the document, extra information is provided that is outside of the regular workflow.

6.1. Troubleshooting

Troubleshooting the installation is out of scope of the Deployment Guide. For more details on troubleshooting deployment, refer to our Troubleshooting guide.

6.2. Creating DNS Records

Two options are documented for configuring DNS records:

- On a DNS Server (Bind)
- Using dnsmasq

6.2.1. Configuring Bind (Option 1)

Use Option 1 if access to the appropriate DNS server for the baremetal network is accessible or a request to your network admin to create the DNS records is an option. If this is not an option, skip this section and go to section Create DNS records using dnsmasq (Option 2).

Create a subzone with the name of the cluster that is going to be used on your domain. In our example, the domain used is `example.com` and the cluster name used is `openshift`. Make sure to change these according to your environment specifics.

Procedure

1. Login to the DNS server using `ssh`.
2. Suspend updates to all dynamic zones: `rndc freeze`.
3. Edit `/var/named/dynamic/example.com`.

DRAFT

```
$ORIGIN openshift.example.com.
$TTL 300        ; 5 minutes
@  IN  SOA  dns1.example.com.  hostmaster.example.com. (
       2001062501  ; serial
       21600       ; refresh after 6 hours
       3600        ; retry after 1 hour
       604800      ; expire after 1 week
       86400 )     ; minimum TTL of 1 day
;
api                     A       <api-ip>
ns1                     A       <dns-vip-ip>
$ORIGIN apps.openshift.example.com.
*                       A       <wildcard-ingress-lb-ip>
$ORIGIN openshift.example.com.
provisioner             A       <NIC2-ip-of-provision>
openshift-master-0      A       <NIC2-ip-of-openshift-master-0>
openshift-master-1      A       <NIC2-ip-of-openshift-master-1>
openshift-master-2      A       <NIC2-ip-of-openshift-master-2>
openshift-worker-0      A       <NIC2-ip-of-openshift-worker-0>
openshift-worker-1      A       <NIC2-ip-of-openshift-worker-1>
```

4. Increase the `serial` value by 1.
5. Edit `/var/named/dynamic/1.0.10.in-addr.arpa`.

```
$ORIGIN 1.0.10.in-addr.arpa.
$TTL 300
@  IN  SOA  dns1.example.com.  hostmaster.example.com. (
       2001062501  ; serial
       21600       ; refresh after 6 hours
       3600        ; retry after 1 hour
       604800      ; expire after 1 week
       86400 )     ; minimum TTL of 1 day
;
126 IN      PTR      provisioner.openshift.example.com.
127 IN          PTR     openshift-master-0.openshift.example.com.
128 IN          PTR     openshift-master-1.openshift.example.com.
129 IN          PTR     openshift-master-2.openshift.example.com.
130 IN          PTR     openshift-worker-0.openshift.example.com.
131 IN          PTR     openshift-worker-1.openshift.example.com.
132 IN      PTR     api.openshift.example.com.
133 IN      PTR     ns1.openshift.example.com.
```

In this example, the IP addresses 10.0.1.126-133 are pointed to the corresponding fully qualified domain name.

The filename `1.0.10.in-addr.arpa` is the reverse of the public CIDR example `10.0.1.0/24`.

6. Increase the `serial` value by 1.
7. Enable updates to all dynamic zones and reload them: `rndc thaw`.

6.2.2. Configuring dnsmasq (Option 2)

To create DNS records, open the `/etc/hosts` file and add the NIC2 (baremetal net) IP followed by the hostname. In our example, the domain used is `example.com` and the cluster name used is `openshift`. Make sure to change these according to your environment specifics.

Procedure

1. Edit `/etc/hosts` and add the NIC2 (baremetal net) IP followed by the hostname.

```
cat /etc/hosts
127.0.0.1   localhost localhost.localdomain localhost4 localhost4.localdomain4
::1         localhost localhost.localdomain localhost6 localhost6.localdomain6
<NIC2-IP> provisioner.openshift.example.com provisioner
<NIC2-IP> openshift-master-0.openshift.example.com openshift-master-0
<NIC2-IP> openshift-master-1.openshift.example.com openshift-master-1
<NIC2-IP> openshift-master-2.openshift.example.com openshift-master-2
<NIC2-IP> openshift-worker-0.openshift.example.com openshift-worker-0
<NIC2-IP> openshift-worker-1.openshift.example.com openshift-worker-1
<API-IP>  api.openshift.example.com api
<DNS-VIP-IP> ns1.openshift.example.com ns1
```

2. Open the appropriate `firewalld` DNS service and reload the rules.

```
systemctl restart firewalld
firewall-cmd --add-service=dns --permanent
firewall-cmd --reload
```

6.3. Creating DHCP reservations

Two options are documented for configuring DHCP:

- On dhcpd (Option 1)
- Using dnsmasq (Option 2)

6.3.1. Configuring dhcpd (Option 1)

Use Option 1 if access to the appropriate DHCP server for the baremetal network is accessible or a request to your network admin to create the DHCP reservations is an option. If this is not an option, skip this section and go to section Create DHCP records using dnsmasq (Option 2).

1. Login to the DHCP server using `ssh`.
2. Edit `/etc/dhcp/dhcpd.hosts`.

```
host provisioner {
     option host-name "provisioner";
     hardware ethernet <mac-address-of-NIC2>;
     option domain-search "openshift.example.com";
     fixed-address <ip-address-of-NIC2>;
  }
host openshift-master-0 {
     option host-name "openshift-master-0";
     hardware ethernet <mac-address-of-NIC2>;
     option domain-search "openshift.example.com";
     fixed-address <ip-address-of-NIC2>;
  }

host openshift-master-1 {
     option host-name "openshift-master-1";
     hardware ethernet <mac-address-of-NIC2>;
     option domain-search "openshift.example.com";
     fixed-address <ip-address-of-NIC2>;
  }

host openshift-master-2 {
     option host-name "openshift-master-2";
     hardware ethernet <mac-address-of-NIC2>;
     option domain-search "openshift.example.com";
     fixed-address <ip-address-of-NIC2>;
  }
host openshift-worker-0 {
     option host-name "openshift-worker-0";
     hardware ethernet <mac-address-of-NIC2>;
     option domain-search "openshift.example.com";
     fixed-address <ip-address-of-NIC2>;
  }
host openshift-worker-1 {
     option host-name "openshift-worker-1";
     hardware ethernet <mac-address-of-NIC2>;
     option domain-search "openshift.example.com";
     fixed-address <ip-address-of-NIC2>;
  }
```

3. Restart the `dhcpd` service.

```
systemctl restart dhcpd
```

6.3.2. Configuring dnsmasq (Option 2)

Set up `dnsmasq` on a server that can access the baremetal network.

Procedure

1. Install `dnsmasq`.

```
dnf install -y dnsmasq
```

2. Change to the `/etc/dnsmasq.d` directory.

```
cd /etc/dnsmasq.d
```

3. Create a file that reflects your OpenShift cluster appended by `.dns`.

```
touch <filename>.dns
```

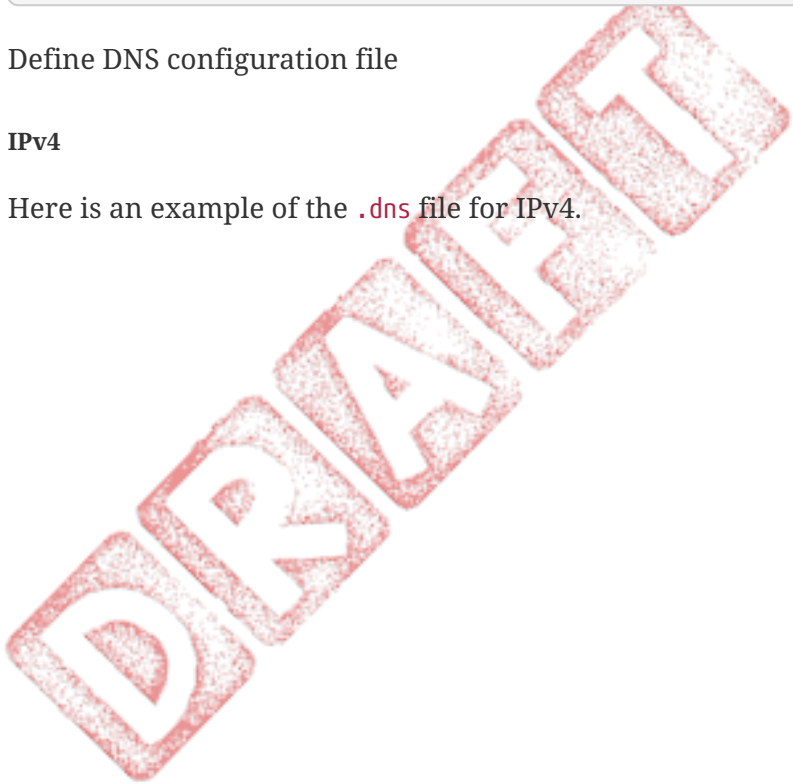
4. Open the appropriate `firewalld` DHCP service.

```
systemctl restart firewalld
firewall-cmd --add-service=dhcp --permanent
firewall-cmd --reload
```

5. Define DNS configuration file

IPv4

Here is an example of the `.dns` file for IPv4.



```
domain-needed
bind-dynamic
bogus-priv
domain=openshift.example.com
dhcp-range=<baremetal-net-starting-ip,baremetal-net-ending-ip>
#dhcp-range=10.0.1.4,10.0.14
dhcp-option=3,<baremetal-net-gateway-ip>
#dhcp-option=3,10.0.1.254
resolv-file=/etc/resolv.conf.upstream
interface=<nic-with-access-to-baremetal-net>
#interface=em2
server=<ip-of-existing-server-on-baremetal-net>


#Wildcard for apps -- make changes to cluster-name (openshift) and domain
(example.com)
address=/.apps.openshift.example.com/<wildcard-ingress-lb-ip>

#Static IPs for Masters
dhcp-host=<NIC2-mac-address>,provisioner.openshift.example.com,<ip-of-provisioner>
dhcp-host=<NIC2-mac-address>,openshift-master-0.openshift.example.com,<ip-of-
openshift-master-0>
dhcp-host=<NIC2-mac-address>,openshift-master-1.openshift.example.com,<ip-of-
openshift-master-1>
dhcp-host=<NIC2-mac-address>,openshift-master-2.openshift.example.com,<ip-of-
openshift-master-2>
dhcp-host=<NIC2-mac-address>,openshift-worker-0.openshift.example.com,<ip-of-
openshift-worker-0>
dhcp-host=<NIC2-mac-address>,openshift-worker-1.openshift.example.com,<ip-of-
openshift-worker-1>
```

IPv6

Here is an example of the `.dns` file for IPv6.

```
strict-order
bind-dynamic
bogus-priv
dhcp-authoritative
dhcp-range=baremetal,<baremetal-IPv6-dhcp-range-start>,<baremetal-IPv6-dhcp-range-
end>,<range-prefix>
dhcp-option=baremetal,option6:dns-server,[<IPv6-DNS-Server>]

resolv-file=/etc/resolv.conf.upstream
except-interface=lo
dhcp-lease-max=81
log-dhcp

domain=openshift.example.com,<baremetal-IPv6-cidr>,local

# static host-records
address=/.apps.openshift.example.com/<wildcard-ingress-lb-ip>
host-record=api.openshift.example.com,<api-ip>
host-record=ns1.openshift.example.com,<dns-ip>
host-record=openshift-master-0.openshift.example.com,<ip-of-openshift-master-0>
host-record=openshift-master-1.openshift.example.com,<ip-of-openshift-master-1>
host-record=openshift-master-2.openshift.example.com,<ip-of-openshift-master-1>
# Registry
host-record=registry.openshift.example.com,<ip-of-registry-server>

#Static IPs for Masters
dhcp-host=<baremetal-nic-duid>,openshift-master-0.openshift.example.com,<ip-of-
openshift-master-0>
dhcp-host=<baremetal-nic-duid>,openshift-master-1.openshift.example.com,<ip-of-
openshift-master-1>
dhcp-host=<baremetal-nic-duid>,openshift-master-2.openshift.example.com,<ip-of-
openshift-master-2>
```

6. Create the `resolv.conf.upstream` file to provide DNS fowarding to an existing DNS server for resolution to the outside world.

```
search <domain.com>
nameserver <ip-of-my-existing-dns-nameserver>
```

7. Restart the `dnsmasq` service.

```
systemctl restart dnsmasq
```

8. Verify the `dnsmasq` service is running.

```
systemctl status dnsmasq
```