Deploying Installer Provisioned Infrastructure (IPI) of OpenShift on Bare Metal - 4.7

Deployment Integration Team

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

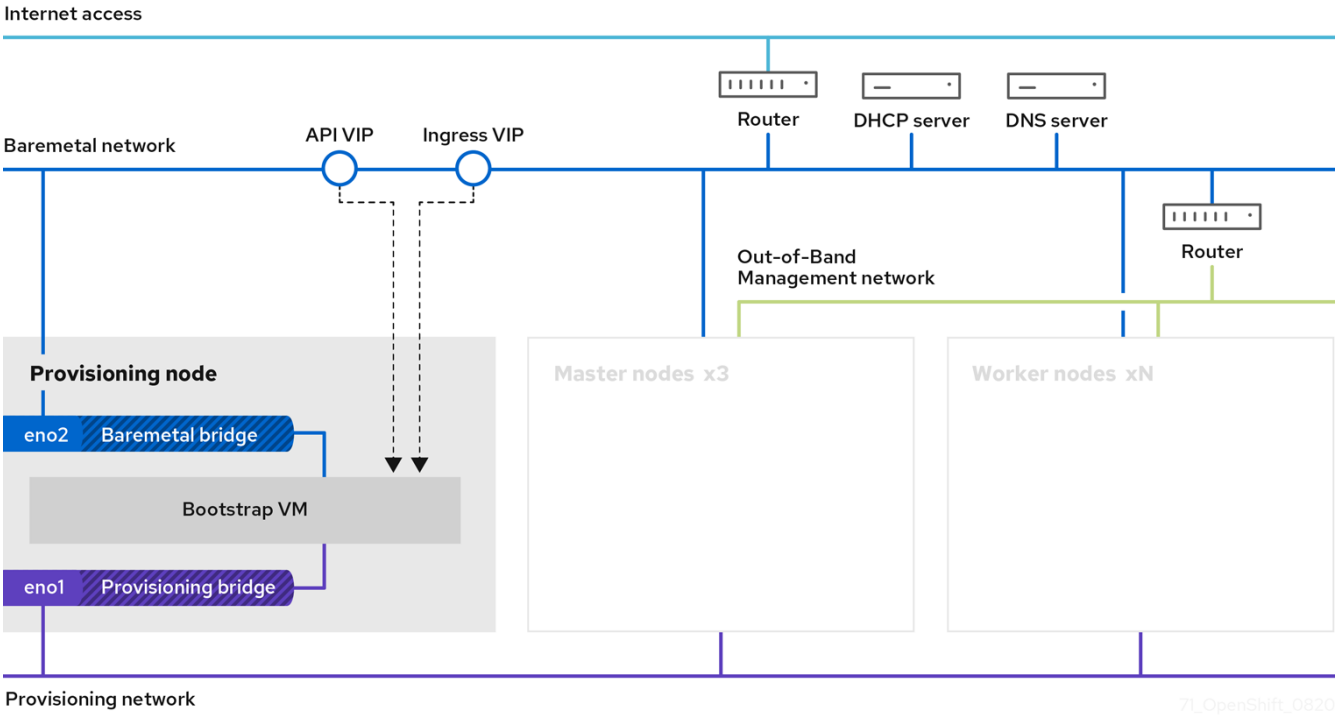
Download the PDF version of this document or visit https://openshift-kni.github.io/baremetal-deploy/

Chapter 1. Deploying IPI Bare Metal

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.

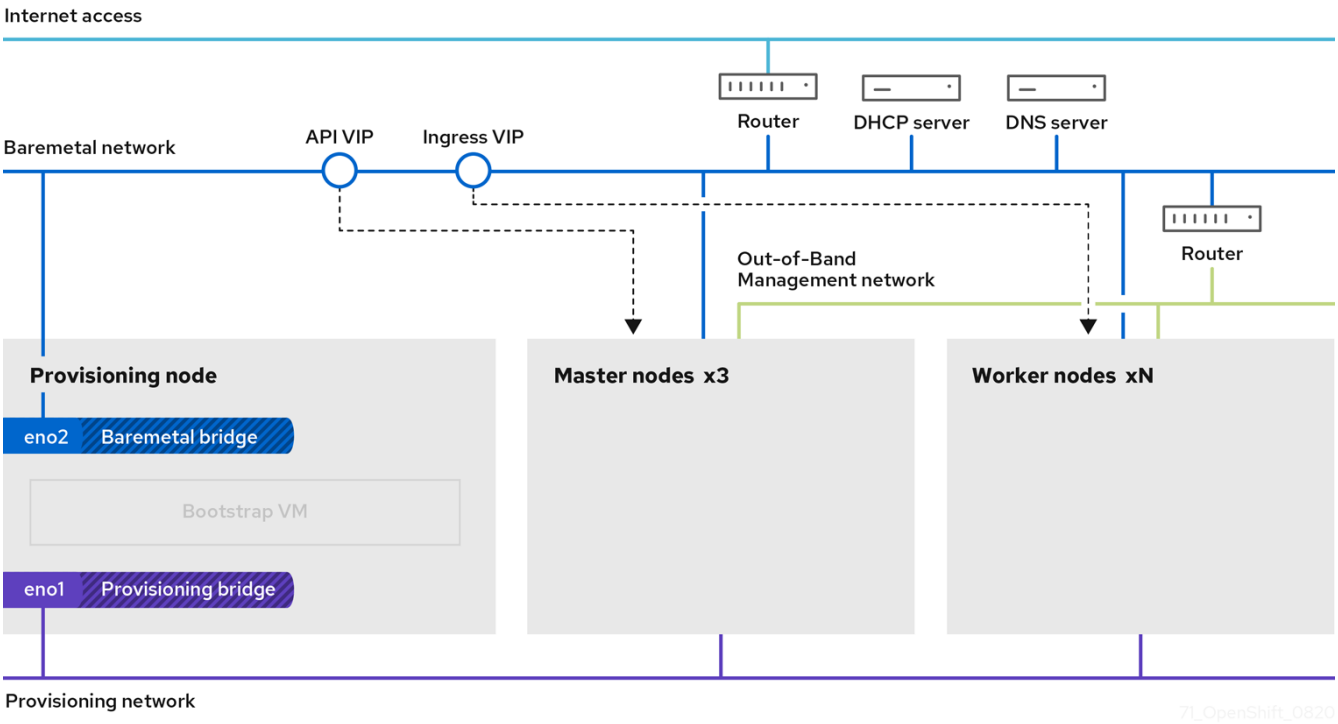
Installer Provisioned Infrastructure (IPI) installation provides support for installing OpenShift Container Platform on bare metal nodes. This guide provides a methodology to achieving a successful installation.

The bare metal node labeled as `provisioner` contains two network bridges: provisioning and baremetal, each one connected to a different network. During installation of IPI on baremetal, a bootstrap VM is created and connected to both the provisioning and baremetal network via those bridges. The role of the VM is to assist in the process of deploying an OpenShift Container Platform cluster.



When the installation of OpenShift control plane nodes, or master nodes, is complete and fully operational, the bootstrap VM is destroyed automatically and the appropriate VIPs are moved accordingly.

The API VIPs move into the control plane nodes and the Ingress VIP services applications that reside within the worker nodes.


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

Chapter 2. Prerequisites

Installing OpenShift Container Platform with Installer Provisioned Infrastructure (IPI) requires:

1. One provisioner node with RHEL 8.1 installed.
2. Three Control Plane nodes.
3. At least two worker nodes.
4. Baseboard Management Controller (BMC) access to each node.
5. At least one network:
    a. One **required** routable network
    b. One **optional** network for provisioning nodes; and,
    c. One **optional** management network.

Before installing OpenShift Container Platform with IPI, ensure the hardware environment meets the following requirements.

2.1. Node requirements

IPI installation involves a number of hardware node requirements:

- **CPU architecture:** All nodes must use `x86_64` CPU architecture.
- **Similar nodes:** It is recommended for nodes to have an identical configuration per role. That is, being the same brand and model with the same CPU, RAM 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. IPI installation relies on BMC protocols, which must be compatible across nodes. Additionally, {op-system-base} 8 ships with the most recent drivers for RAID controllers. Ensure that the nodes are recent enough to support {op-system-base} 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:** IPI installation requires one `provisioner` node.
- **Control plane:** IPI installation requires three control plane nodes for high availability.
- **Worker nodes:** A typical production cluster will have many worker nodes. IPI installation in a high availability environment requires at least two worker nodes in an initial cluster.
- **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` 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):** 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.**

2.2. Network requirements

IPI installation involves several network requirements by default. First, IPI installation involves a non-routable `provisioning` network for provisioning the OS on each bare metal node and a routable `baremetal` network. Since IPI 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.

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` 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
```

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.
    - 1 IP address for the API endpoint
    - 1 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.

The following table provides an exemplary embodiment of hostnames for each node in the OpenShift Container Platform cluster.

Usage	Hostname	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)

Additional requirements with no provisioning network

All IPI installations require a `baremetal` network. The `baremetal` network is a routable network used for external network access to the outside world. In addition to the IP address supplied to the OpenShift Container Platform cluster node, installations without a `provisioning` network require the following:

- Setting an available IP address from the `baremetal` network to the `bootstrapProvisioningIP` configuration setting within the `install-config.yaml` configuration file.
- Setting an available IP address from the `baremetal` network to the `provisioningHostIP`

configuration setting within the `install-config.yaml` configuration file.

- Deploying the OpenShift Container Platform cluster using RedFish Virtual Media/iDRAC Virtual Media.

Configuring additional IP addresses for `bootstrapProvisioningIP` and `provisioningHostIP` is not required when using a `provisioning` network.

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.

2.3. 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 RHEL 8.x installation process on the provisioner node might vary. To install 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.

2.4. Configuring Networks

Documentation for customizing the network configuration is out-of-scope for this release. For details on customizing the network configuration, see Customizing network configuration for OCP 4.6 bare metal IPI installation.

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

- 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

- ☐ 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

- ☐ 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.

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

[1] Stateless Address AutoConfiguration

Chapter 3. Installing RHEL on the provisioner node

With the networking configuration complete, the next step is to install {op-system-base} 8.X on the provisioner node. The installer uses the provisioner node as the orchestrator while installing the OpenShift Container Platform cluster on the three control plane nodes and the at least two worker nodes. 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.

Chapter 4. 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 ~]$ sudo nmcli con show
```

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

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.

Chapter 5. Retrieving OpenShift Installer

The following sections describe how to properly retrieve and extract the OpenShift Container Platform for either upstream or downstream. Choose the appropriate Installer for your use case.

- Development version
- GA version

5.1. Select Development version of installer

You can choose from the following approaches:

- Choose a successfully deployed release that passed CI
- Deploy the latest development version

5.1.1. Select an OpenShift installer release from CI (Development)

Procedure

1. Go to Release Status and choose a release that has passed the tests for metal.
2. Verify that the release is available in the OpenShift mirror Index of /pub/openshift-v4/clients/ocp-dev-preview.
3. Save the release name. For example, `4.7.0-0.nightly-2019-12-09-035405`.
4. Configure VARS.

```
export VERSION="4.7.0-0.nightly-2019-12-09-035405"
export RELEASE_IMAGE=$(curl -s https://mirror.openshift.com/pub/openshift-
v4/clients/ocp-dev-preview/$VERSION/release.txt
| grep 'Pull From: quay.io' | awk -F ' ' '{print $3}' )
```

5.1.2. Retrieving the latest OpenShift installer (Development)

Procedure

Export the following variables `VERSION` and `RELEASE_IMAGE`

```
export VERSION=$(curl -s https://mirror.openshift.com/pub/openshift-v4/clients/ocp-
dev-preview/latest/release.txt
| grep 'Name:' | awk -F: '{print $2}')
export RELEASE_IMAGE=$(curl -s https://mirror.openshift.com/pub/openshift-
v4/clients/ocp-dev-preview/latest/release.txt
| grep 'Pull From: quay.io' | awk -F ' ' '{print $3}')
```

5.1.3. Extracting the OpenShift Container Platform installer (Development)

Procedure

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

```
export cmd=openshift-baremetal-install
export pullsecret_file=~/pull-secret.txt
export extract_dir=$(pwd)
# Get the oc binary
curl -s https://mirror.openshift.com/pub/openshift-v4/clients/ocp-dev-preview/
$VERSION/openshift-client-linux.tar.gz | tar zxvf - oc
sudo cp oc /usr/local/bin
# Extract the baremetal installer
oc adm release extract --registry-config "${pullsecret_file}" --command=$cmd --to "
${extract_dir}" ${RELEASE_IMAGE}
sudo cp ./openshift-baremetal-install /usr/local/bin/
```

5.2. Retrieving OpenShift Installer GA

5.2.1. 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-4.7
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}')
```

5.2.2. 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}
```

Chapter 6. Creating an RHCOS images cache (optional)

To employ image caching, you must download two images: the 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`.

```
[kni@provisioner ~]$ sudo dnf install -y podman
```

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

```
[kni@provisioner ~]$ sudo firewall-cmd --add-port=8080/tcp --zone=public
--permanent
```

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

```
[kni@provisioner ~]$ mkdir /home/kni/rhcos_image_cache
```

4. Set the appropriate SELinux context for the newly created directory.

```
[kni@provisioner ~]$ sudo semanage fcontext -a -t httpd_sys_content_t
"/home/kni/rhcos_image_cache(/.*)?"
[kni@provisioner ~]$ sudo restorecon -Rv rhcos_image_cache/
```

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

```
[kni@provisioner ~]$ 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.

```
[kni@provisioner ~]$ 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.

```
[kni@provisioner ~]$ 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.

```
[kni@provisioner ~]$ 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.

```
[kni@provisioner ~]$ 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.

```
[kni@provisioner ~]$ 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.

```
[kni@provisioner ~]$ curl -L ${RHCOS_PATH}${RHCOS_QEMU_URI} -o
/home/kni/rhcos_image_cache/${RHCOS_QEMU_URI}
[kni@provisioner ~]$ 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.

```
[kni@provisioner ~]$ ls -Z /home/kni/rhcos_image_cache
```

13. Create the pod.

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

Chapter 7. Configuration Files

In this section of the document, we'll be covering the set-up of the different configuration files

7.1. 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
controlPlane:
  name: master
  replicas: 3
  platform:
    baremetal: {}
platform:
  baremetal:
    apiVIP: <api-ip>
    ingressVIP: <wildcard-ip>
    provisioningNetworkCIDR: <CIDR>
    hosts:
      - name: openshift-master-0
        role: master
        bmc:
          address: ipmi://<out-of-band-ip> ①
          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 Refer to the BMC adressing 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 default;
  sudo virsh vol-delete $i.ign --pool default;
done
```

7.2. 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>
```

An example of `noProxy` with values for clarity.

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

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

Key considerations:

- If you don't have an HTTPS Proxy, change the value from `https://` to `http://` for `httpsProxy`.
- If using a provisioning network, ensure to include it in your `noProxy` setting, otherwise the installer will fail.
- Ensure to set all your proxy settings as environment variables within the provision host, e.g. `HTTP_PROXY`, `HTTPS_PROXY`, `NO_PROXY`

7.3. 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"
    provisioningHostIP: <baremetal_network_IP1>
    bootstrapProvisioningIP: <baremetal_network_IP2>
```

Requires providing two IP addresses from the `baremetal` network for the `provisioningHostIP` and `bootstrapProvisioningIP` configuration settings, and removing the `provisioningBridge` and `provisioningNetworkCIDR` configuration settings.

7.4. 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 1. Required parameters

Parameters	Default	Description
`baseDomain`		The domain name for the cluster. For example, `example.com`.
`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.

Parameters	Default	Description
`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.
`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.
`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 2. 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 within the cluster where the provisioning services run. Defaults to the 3rd IP of the `provisioning` subnet. For example, `172.22.0.3`.

Parameters	Default	Description
bootstrapProvisioningIP	The second IP address of the provisioningNetworkCIDR	The IP on the bootstrap VM where the provisioning services run while the the installer is deploying the control plane (master) nodes. Defaults to the 2nd IP of the provisioning subnet. For example, 172.22.0.2 or 2620:52:0:1307::2. When using no provisioning network, set this value to an IP address that is available on the baremetal network.
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&gt" class="bare">https://mirror.openshift.com/rhcos-<version>-qemu.qcow2.gz?sha256=<uncompressed_sha256&gt;</code> or <code>http://[2620:52:0:1307::1]/rhcos-<version>-qemu.x86_64.qcow2.gz?sha256=<uncompressed_sha256></code>.
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, <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;.

Parameters	Default	Description
`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 2 IP's on the external network that are used for the provisioning services. Set this parameter to `managed` (default) to fully manage the provisioning network, including DHCP, TFTP, etc 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.
`provisioningHostingIp`		Set this parameter to an available IP address on the `baremetal` network when the `provisioningNetwork` configuration setting is set to `Disabled`.
`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.

7.5. BMC addressing

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.

IPMI

IPMI hosts use `ipmi://<out-of-band-ip>:<port>` and 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 for HPE

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

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

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

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

RedFish for Dell

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

```
platform:
  baremetal:
    hosts:
      - name: openshift-master-0
        role: master
        bmc:
          address: redfish://<out-of-band-ip>/redfish/v1/Systems/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 version `4.20.20.20` or higher for IPI on Bare metal deployments.

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>
```

RedFish Virtual Media for Dell

For RedFish Virtual Media on Dell servers, use `idrac-virtualmedia://` in the `address` setting.

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>
```

`idrac-virtualmedia` requires iDRAC firmware version 4.20.20.20 or higher.

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

7.6. Root device hints

The `rootDeviceHints` parameter enables the installer to provision the Red Hat Enterprise Linux CoreOS (RHCOS) image to a particular device. The installer examines the devices in the order it discovers them, and compares the discovered values with the hint values. The installer uses the first discovered device that matches the hint value. The configuration can combine multiple hints, but a device must match all hints for the installer to select it.

Table 3. 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"
```

7.7. Creating the OpenShift Container Platform manifests

1. Create the OpenShift Container Platform manifests.

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

Chapter 8. Creating a disconnected registry (optional)

In some cases, you might want to install an Openshift KNI 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 webserver - this will be served by a container on a system.
- 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.

8.1. 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}
```

8.2. 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="<Common Name>"    # Certificate Common Name (CN)
[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 \
    -subj "/C=${cert_c}/ST=${cert_s}/L=${cert_l}/O=${cert_o}/OU=${cert_ou}/CN=
${cert_cn}"
```

When replacing `<Common Name>`, ensure 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
```

8.3. 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
```

8.4. 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 file.

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

8.5. 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. Mirror the remote install images to the local repository.

```
[user@registry ~]$ /usr/local/bin/oc adm release mirror \
  -a pull-secret-update.json
  --from=$UPSTREAM_REPO \
  --to-release-image=$LOCAL_REG/$LOCAL_REPO:${VERSION} \
  --to=$LOCAL_REG/$LOCAL_REPO
```

8.6. 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.json 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.

```
[kni@provisioner ~]$ echo "additionalTrustBundle: |" >> install-config.yaml
[kni@provisioner ~]$ 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.

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

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

Chapter 9. Deploying routers on worker nodes

During the installation of an OpenShift cluster, router pods are deployed on worker nodes (the default is two router pods). In the event that an installation only has one worker node or additional routers are required in order to handle external traffic destined for services within your OpenShift cluster, a `yaml` file can be created to set the appropriate amount of router replicas.

By default two routers are deployed. If you already have two worker nodes you can skip this section. For more information on the Ingress Operator see: Ingress Operator in OpenShift Container Platform.

If you have an environment where no workers are deployed and only has master nodes, by default two routers are deployed on the master nodes. If this is the case, you can skip this section.

Procedure

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

```
apiVersion: operator.openshift.io/v1
kind: IngressController
metadata:
  name: default
  namespace: openshift-ingress-operator
spec:
  replicas: <num-of-router-pods>
  endpointPublishingStrategy:
    type: HostNetwork
  nodePlacement:
    nodeSelector:
      matchLabels:
        node-role.kubernetes.io/worker: "<value>" ①
```

① Setting for workers:

- When working with just one worker node, set this value to 1.
- When working with more than 3+ workers, additional router pods (default 2) may be recommended.

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

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

Chapter 10. Validation checklist for installation

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

Chapter 11. Deploying the cluster via the OpenShift Container Platform installer

Run the OpenShift Container Platform installer:

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

Chapter 12. 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
```

Chapter 13. Day 2 operations

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

13.1. 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
```

13.2. 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.

13.2.1. 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

13.2.2. 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
```

13.2.3. 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.

```
---
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 14. Appendix

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

14.1. Troubleshooting

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

14.2. Creating DNS Records

Two options are documented for configuring DNS records:

- On a DNS Server (Bind)
- Using dnsmasq

14.2.1. 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`.

```
$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`.

14.2.2. 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
```

14.3. Creating DHCP reservations

Two options are documented for configuring DHCP:

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

14.3.1. 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
```

14.3.2. 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
```

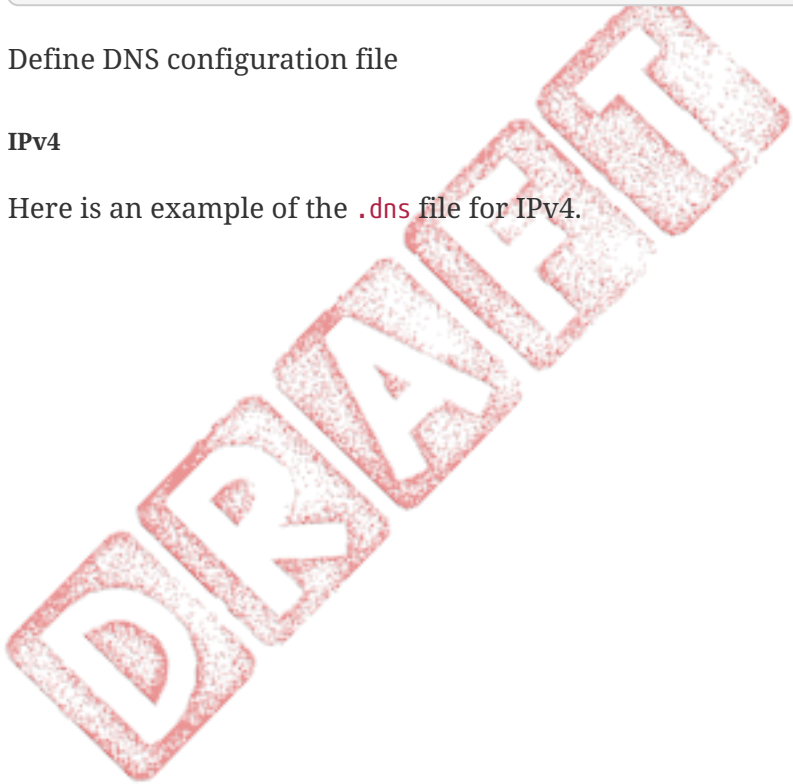
4. Open the appropriate `firewalld` DHCP service.

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

5. Define DNS configuration file

IPv4

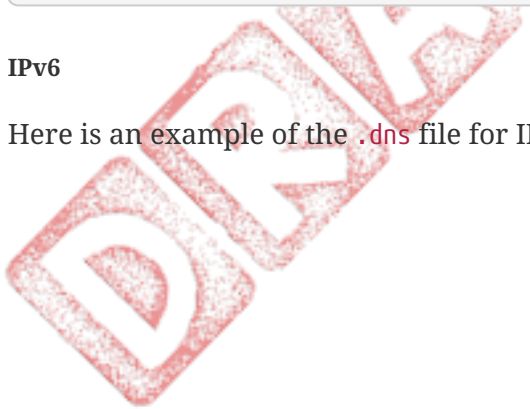
Here is an example of the `.dns` file for IPv4.



```
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
```