

Deploying Installer Provisioned Infrastructure (IPI) of OpenShift on Bare Metal - 4.4

Deployment Integration Team

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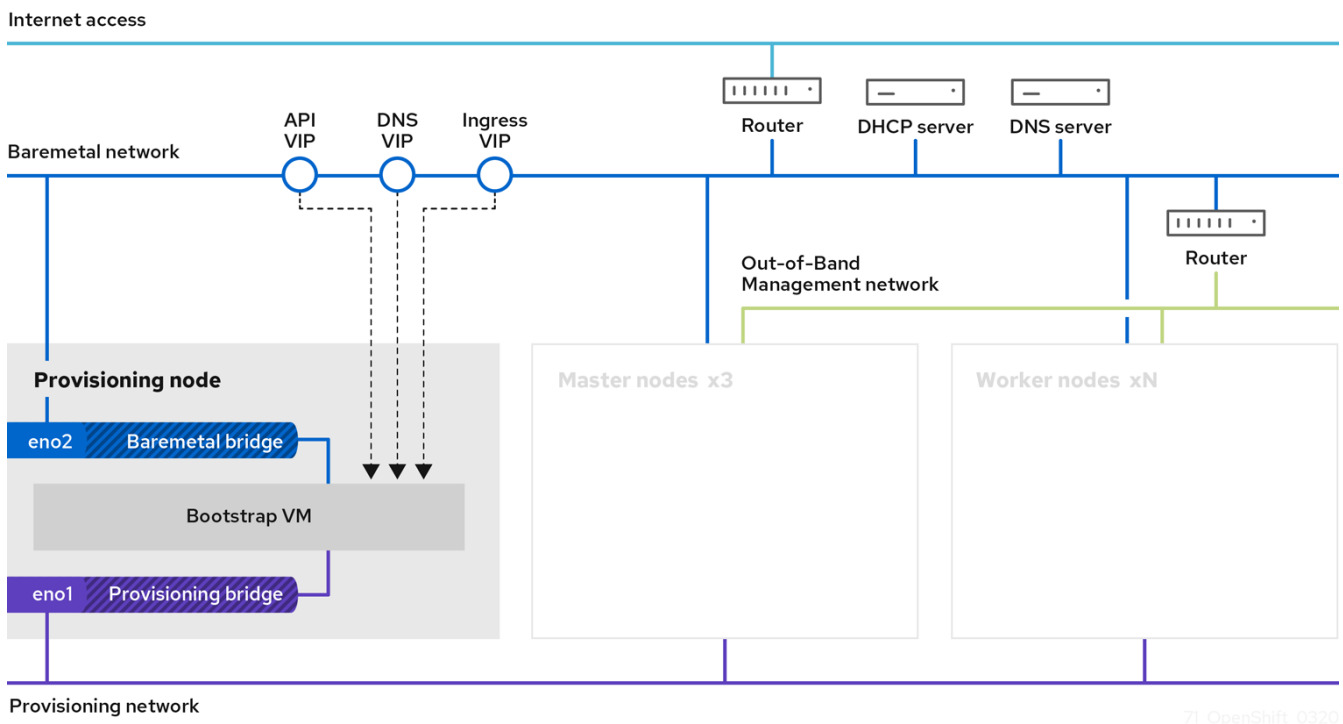


Download the PDF version of this document or visit <https://openshift-kni.github.io/baremetal-deploy/>

Chapter 1. Deploying IPI Bare Metal

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



Chapter 2. Prerequisites

Before installing OpenShift Container Platform, 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:** Nodes **should** have an identical configuration per role. That is, control plane nodes **should** be the same brand and model with the same CPU, RAM and storage configuration. Worker nodes should be **identical**.
- **Intelligent Platform Management Interface (IPMI):** IPI installation requires IPMI enabled on each node.
- **Latest generation:** Nodes should be of the most recent generation. IPI installation relies on IPMI, which should 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 provisioning node and all the OpenShift Container Platform nodes.
- **Network interfaces:** Each node **must** have at least two network interfaces (NICs)- one for the `provisioning` network and one for the public `baremetal` network. 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`, should be the same name on all of the other nodes. The same principle applies to the remaining NICs on each node. It is recommended these network interfaces be 10 GB NICs.
- **Provisioning node:** IPI installation requires one provisioning node.
- **Control plane:** IPI installation requires three control plane (master) nodes for high availability.
- **Worker nodes (Optional):** A typical production cluster may include worker nodes. IPI installation in a high availability environment provides the flexibility of deploying an initial cluster with or without worker nodes. If worker nodes are deployed, at **least** two worker nodes are required for the initial cluster deployment.
- **Registry node:** (Optional) If setting up a disconnected mirrored registry, it is recommended this reside in its own node.

Additional Node Considerations

- **Unified Extensible Firmware Interface (UEFI):** UEFI boot is required 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.

2.2. Network requirements

IPI installation involves several network requirements. First, IPI installation involves a non-routable `provisioning` network for provisioning the OS on each bare metal node and a routable `baremetal` network for access to the public 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 a non-routable network used for provisioning the underlying operating system on each node that is a part of the OpenShift Container Platform cluster. 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 used for external network access to the outside world. The second NIC on each node, such as **eth1** or **eno2**, **must** 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. Three virtual IP addresses.
 - 1 IP address for the API endpoint
 - 1 IP address for the wildcard ingress endpoint
 - 1 IP address for the name server

2. One IP Address for the Provisioning 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	<i>api.<cluster-name>.<domain></i>	<i><ip></i>
Ingress LB (apps)	<i>*.apps.<cluster-name>.<domain></i>	<i><ip></i>
Nameserver	<i>ns1.<cluster-name>.<domain></i>	<i><ip></i>
Provisioning node	<i>provisioner.<cluster-name>.<domain></i>	<i><ip></i>
Master-0	<i>openshift-master-0.<cluster-name>.<domain></i>	<i><ip></i>
Master-1	<i>openshift-master-1.<cluster-name>.<domain></i>	<i><ip></i>
Master-2	<i>openshift-master-2.<cluster-name>.<domain></i>	<i><ip></i>
Worker-0	<i>openshift-worker-0.<cluster-name>.<domain></i>	<i><ip></i>
Worker-1	<i>openshift-worker-1.<cluster-name>.<domain></i>	<i><ip></i>
Worker-n	<i>openshift-worker-n.<cluster-name>.<domain></i>	<i><ip></i>

For assistance in configuring the DHCP server, check [Appendix](#) section for:

- [Creating DHCP reservations with dhcpcd \(Option 1\)](#)
- [Creating DHCP reservations with dnsmasq \(Option 2\)](#)

2.3. Configuring nodes

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	<i><provisioning-vlan></i>
NIC2	baremetal	<i><baremetal-vlan></i>

The RHEL 8.1 installation process on the Provisioning node may vary. For this procedure, NIC2 is PXE-enabled to ensure easy installation using a local Satellite server.

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

PXE	Boot order
NIC1 PXE-enabled (provisioning network)	1
NIC2 PXE-enabled (baremetal network)	2



Ensure PXE is disabled on all other NICs.

Configure the control plane (master) and worker nodes as follows:

PXE	Boot order
NIC1 PXE-enabled (provisioning network)	1

2.4. 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 provisioning node.

Each node must be accessible via out-of-band management. The provisioning 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.

2.5. 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 and credentials
 - Examples
 - Dell (iDRAC) IP
 - HP (iLO) IP
- NIC1 (**provisioning**) MAC address

2.6. Validation checklist for nodes

- ☐ NIC1 VLAN is configured on the provisioning network.
- ☐ NIC2 VLAN is configured on the baremetal network.
- ☐ NIC1 is PXE-enabled on the provisioning network for the control plane (master) and worker nodes.
- ☐ (Optional) NIC2 is PXE-enabled on **only** the provisioning node for easy deployment of RHEL operating system via a local Satellite server or PXE server

- ❑ Aside from provisioning network NIC1, PXE has been disabled on all other NICs for all OpenShift Container Platform nodes
- ❑ DNS records configured for the OpenShift Container Platform nodes using a subdomain or subzone and cluster name i.e. `<cluster-name>.<domain-name>`
- ❑ DHCP reservations for the OpenShift Container Platform nodes, API, ingress endpoint, and nameserver.
- ❑ A separate out-of-band management network has been created.
- ❑ All nodes accessible via out-of-band management network.
- ❑ Required data for installation (out-of-band management IP and credentials, provisioning NIC1 MAC address for all OpenShift Container Platform nodes.

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

Chapter 3. Installing RHEL on the provision node

With the networking portions complete, the next step in installing the OpenShift Container Platform cluster is to install RHEL 8 on the provision node. This node will be used as the orchestrator in installing the OCP cluster on the three master and two worker nodes. For the purposes of this document, installing RHEL on the provision 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 user (for example, `kni`) to deploy as non-root and provide that user `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 in as the new user on the provision node.

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

5. Use Red Hat Subscription Manager to register your environment.

```
[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 tar
```

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 --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 network bridges for both `provisioning` and `baremetal` networks.



The `provisioning` bridge can be setup using an IPv4 address or an IPv6 address. Either option is supported and the selection should be based upon your environmental requirements.

```
[kni@provisioner ~]$ export PUB_CONN=<baremetal_nic_name>
[kni@provisioner ~]$ export PROV_CONN=<prov_nic_name>
[kni@provisioner ~]$ sudo nohup bash -c '
    nmcli con down "$PUB_CONN"
    nmcli con delete "$PUB_CONN"
    # RHEL 8.1 appends the word "System" in front of the connection, delete in case
it exists
    nmcli con down "System $PUB_CONN"
    nmcli con delete "System $PUB_CONN"
    nmcli connection add ifname baremetal type bridge con-name baremetal
    nmcli con add type bridge-slave ifname "$PUB_CONN" master baremetal
    nmcli con down baremetal
    nmcli con up baremetal
'
```



The **ssh** connection may disconnect after executing this step. You will want to have some sort of out-of-band connection to your host (eg., a serial console, local keyboard, or dedicated management interface) in the event that something goes wrong while executing these commands.

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 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 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 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, `4.4.0-0.nightly-2019-12-09-035405`.
4. Configure VARS.

```
export VERSION="4.4.0-0.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/
$VERSION/openshift-client-linux-$VERSION.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)

The latest-4.x can be used to deploy the latest Generally Available version of OpenShift Container Platform:

```
[kni@provisioner ~]$ export VERSION=latest-4.4
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}" ${RELEASE_IMAGE}
[kni@provisioner ~]$ sudo cp openshift-baremetal-install /usr/local/bin
```

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` and `policycoreutils-python-utils`.

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

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 `bootstrapimage` and `clusterimage`.

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

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
```

14. The above command creates a caching webserver with the name `rhcos_image_cache` which will be serving the images for deployment. The first image `${RHCOS_PATH}${RHCOS_QEMU_URI}?sha256=${RHCOS_QEMU_SHA_UNCOMPRESSED}` will be used as `bootstrapOSImage` and the second image `${RHCOS_PATH}${RHCOS_OPENSTACK_URI}?sha256=${RHCOS_OPENSTACK_SHA_COMPRESSED}` will be used as `clusterOSImage` in `install-config.yaml` file as shown in [Additional install-config parameters](#) section.

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 your environment, including `pullSecret` and `sshKey`.

```
apiVersion: v1
<a anchor="basedomain">basedomain</a>: <code><code>
metadata:
  <a anchor="metadataname">name</a>: <code><code>
networking:
  <a anchor="machinecidr">machineCIDR</a>: <code><code>
  networkType: OVNKubernetes
compute:
- <a anchor="workername">name</a>: worker
  <a anchor="computereplicas">replicas</a>: 2
controlPlane:
  <a anchor="controlplanename">name</a>: master
  <a anchor="controlplanereplicas">replicas</a>: 3
platform:
  baremetal: {}
platform:
  baremetal:
    <a anchor="apivip">apiVIP</a>: <code><code>
    <a anchor="ingressvip">ingressVIP</a>: <code><code>
    <a anchor="dnsVIP">dnsVIP</a>: <code><code>
    <a anchor="provisioningNetworkInterface">provisioningNetworkInterface</a>:
<code><code>
    <a anchor="provisioningNetworkCIDR">provisioningNetworkCIDR</a>: <code><code>
    <a anchor="hoststable">hosts</a>:
      - <a anchor="name">name</a>: openshift-master-0
        <a anchor="role">role</a>: master
        <a anchor="bmcaddressing">bmc</a>:
          address: ipmi://<code><code> ①
          username: <code><code>
          password: <code><code>
        <a anchor="bootMACAddress">bootMACAddress</a>: <code><code>
        <a anchor="hardwareProfile">hardwareProfile</a>: default
      - <a anchor="name">name</a>: openshift-master-1
        <a anchor="role">role</a>: master
        <a anchor="bmcaddressing">bmc</a>:
          address: ipmi://<code><code>
```

```

    username: &lt;user>;
    password: &lt;password>;
    <a anchor="bootMACAddress">bootMACAddress</a>: &lt;NIC1-mac-address>;
    <a anchor="hardwareProfile">hardwareProfile</a>: default
-   <a anchor="name">name</a>: openshift-master-2
    <a anchor="role">role</a>: master
    <a anchor="bmcaddressing">bmc</a>:
      address: ipmi://<out-of-band-ip>
      username: &lt;user>;
      password: &lt;password>;
    <a anchor="bootMACAddress">bootMACAddress</a>: &lt;NIC1-mac-address>;
    <a anchor="hardwareProfile">hardwareProfile</a>: default
-   <a anchor="name">name</a>: openshift-worker-0
    <a anchor="role">role</a>: worker
    <a anchor="bmcaddressing">bmc</a>:
      address: ipmi://&lt;out-of-band-ip>;
      username: &lt;user>;
      password: &lt;password>;
    <a anchor="bootMACAddress">bootMACAddress</a>: &lt;NIC1-mac-address>;
    <a anchor="hardwareProfile">hardwareProfile</a>: unknown
-   <a anchor="name">name</a>: openshift-worker-1
    <a anchor="role">role</a>: worker
    <a anchor="bmcaddressing">bmc</a>:
      address: ipmi://&lt;out-of-band-ip>;
      username: &lt;user>;
      password: &lt;password>;
    <a anchor="bootMACAddress">bootMACAddress</a>: &lt;NIC1-mac-address>;
    <a anchor="hardwareProfile">hardwareProfile</a>: unknown
pullSecret: '&lt;pull_secret>;'
sshKey: '&lt;ssh_pub_key>;'

```

① 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

```

7.2. Additional `install-config` parameters

This topic describes the required parameters, the `hosts` parameter, and the `bmc address` parameter for the `install-config.yaml` file.

Table 1. Required parameters

Parameters	Default	Description
<code>baseDomain</code>		The domain name for your cluster, e.g. <code>example.com</code>

Parameters	Default	Description
<pre>metadata: name:</pre>		The name to be given to your OpenShift Container Platform cluster. e.g. <code>openshift</code>
<pre>networking: machineCIDR:</pre>		The public CIDR (Classless Inter-Domain Routing) of your external network, e.g. <code>10.0.0.0/24</code>
<pre>compute: - name: worker</pre>		The OpenShift Container Platform cluster requires a name be provided for compute nodes even if no compute nodes are to be used.
<pre>compute: replicas: 2</pre>		Replicas sets the number of compute nodes that are to be included as part of your OpenShift Container Platform cluster.
<pre>controlPlane: name: master</pre>		The OpenShift Container Platform cluster requires a name be provided for control plane (master) nodes.
<pre>controlPlane: replicas: 3</pre>		Replicas sets the number of control plane (master) nodes that are to be included as part of your OpenShift Container Platform cluster.
<code>provisioningNetworkInterface</code>		The name of the network interface on control plane nodes connected to the provisioning network. (OpenShift Container Platform 4.4 only)
<code>hosts</code>		Details about bare metal hosts to use to build the cluster.
<code>defaultMachinePlatform</code>		The default configuration used for machine pools without a platform configuration.

Parameters	Default	Description
apiVIP	api.<clustername.clusterdomain>	<p>The VIP to use for internal API communication.</p> <p>This setting must either be provided or pre-configured in DNS so that the default name resolve correctly.</p>
disableCertificateVerification	False	<p>This parameter is needed when we use redfish or redfish-virtualmedia to manage BMC addresses. The value should be True if you are using self-signed certificate for BMC addresses.</p>
ingressVIP	test.apps.<clustername.clusterdomain>	<p>The VIP to use for ingress traffic.</p> <p>This setting must either be provided or pre-configured in DNS so that the default name resolve correctly.</p>
dnsVIP		<p>The VIP to use for internal DNS communication.</p> <p>This setting has no default and must always be provided.</p>

Table 2. Optional Parameters

Parameters	Default	Description
provisioningDHCPExternal	false	Defines if external DHCP will be used or the one configured by installer
provisioningDHCPRange	172.22.0.10,172.22.0.100	Defines the IP range to use for hosts on the provisioning network.
provisioningNetworkCIDR	172.22.0.0/24	The CIDR for the network to use for provisioning. This option is required when using IPv6 addressing on the provision network.
clusterProvisioningIP	3rd IP of provisioningNetworkCIDR	The IP within the cluster where the provisioning services run. Defaults to the 3rd IP of the provision subnet, e.g. 172.22.0.3
bootstrapProvisioningIP	2nd IP of provisioningNetworkCIDR	The IP on the bootstrap VM where the provisioning services run while the control plane is being deployed. Defaults to the 2nd IP of the provision subnet, e.g. 172.22.0.2

Parameters	Default	Description
<code>externalBridge</code>	<code>baremetal</code>	The name of the <code>baremetal</code> bridge of the hypervisor attached to the <code>baremetal</code> network.
<code>provisioningBridge</code>	<code>provisioning</code>	The name of the <code>provisioning</code> bridge on the <code>provision</code> host attached to the provisioning network.
<code>defaultMachinePlatform</code>		The default configuration used for machine pools without a platform configuration.
<code>bootstrapOSImage</code>		A URL to override the default operating system image for the bootstrap node. The URL must contain a sha256 hash of the image. Example <code>https://mirror.openshift.com/rhcos-&lt;version&gt;-qemu.qcow2.gz?sha256=&lt;uncompressed_sha256&gt;</code> ;
<code>clusterOSImage</code>		A URL to override the default operating system for cluster nodes. The URL must include a sha256 hash of the image. Example <code>https://mirror.openshift.com/images/rhcos-&lt;version&gt;-openstack.qcow2.gz?sha256=&lt;compressed_sha256&gt;</code> ;

Hosts

The `hosts` parameter is a list of separate bare metal assets that should be used to build the cluster.

Name	Default	Description
<code>name</code>		The name of the BareMetalHost resource to associate with the details. e.g. <code>openshift-master-0</code>
<code>role</code>		Either <code>master</code> or <code>worker</code> .
<code>bmc</code>		Connection details for the baseboard management controller. See below for details.
<code>bootMACAddress</code>		The MAC address of the NIC the host will use to boot on the provisioning network.

hardwareProfile	default	This parameter exposes the device name that the installer attempts to deploy the OpenShift Container Platform for the master and worker nodes. The value defaults to <code>default</code> for masters and <code>unknown</code> for workers. The list of profiles includes: <code>default</code> , <code>libvirt</code> , <code>dell</code> , <code>dell-raid</code> , <code>openstack</code> . The <code>default</code> parameter attempts to install on <code>/dev/sda</code> of your cluster node.
-----------------	---------	--

The `bmc` parameter for each host is a set of values for accessing the baseboard management controller in the host.

Name	Default	Description
username		The username for authenticating to the BMC.
password		The password associated with <code>username</code> .
address		The URL for communicating with the BMC controller, based on the provider being used. See below for details . See BMC Addressing for details.

7.2.1. BMC addressing

The `address` field for each `bmc` entry is a URL with details how to connect 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. Example output of using IPMI within your `install-config.yaml` file.

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

7.3. 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
```

Chapter 8. Creating a disconnected registry (optional)

In some cases, you may 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="<Country Name>" # Certificate Country Name (C)
[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 `<Country 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" \
-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.

- 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="{\"$host_fqdn:5000\": {\"auth\": \"\n$base64auth\", \"email\": \"$USER@redhat.com\"}}\""
```

- Update the pull-secret file.

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

8.5. Mirroring the repository (optional)

Procedure

- 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
```

- Mirror the remote install images to the local repository.

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

Example output of the variables used to mirror the install images



```
UPSTREAM_REPO=${RELEASE_IMAGE}\nLOCAL_REG=<registry_FQDN>:<registry_port>\nLOCAL_REPO='ocp4/openshift4'
```

The values of `RELEASE_IMAGE` and `VERSION` were set during [Retrieving OpenShift Installer](#)

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 ~]$ scp user@registry.example.com:/opt/registry/certs/domain.crt /home/kni
[kni@provisioner ~]$ echo "additionalTrustBundle: |" >> install-config.yaml
[kni@provisioner ~]$ sed -e 's/^/  /' /home/kni/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 your 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.
- ☐ (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

1. 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
```

2. Run the OpenShift Container Platform installer:

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

Chapter 12. Following the Installation

During the deployment process, we can check its overall status by issuing the `tail` command to the log file `.openshift_install.log` which will be under the `install` directory folder.

```
[kni@provisioner ~]$ tail -f ~/clusterconfigs/.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
```

/ Module included in the following assemblies:

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 address 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 v1.16.2	Ready	master	30h
openshift-master-1.openshift.example.com v1.16.2	Ready	master	30h
openshift-master-2.openshift.example.com v1.16.2	Ready	master	30h
openshift-worker-0.openshift.example.com v1.16.2	Ready	worker	3m27s
openshift-worker-1.openshift.example.com v1.16.2	Ready	worker	3m27s
openshift-worker-2.openshift.example.com v1.16.2	Ready	worker	3m27s

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 **dhcpcd** service.

```
systemctl restart dhcpcd
```

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>

```

6. Create the `resolv.conf.upstream` file to provide DNS forwarding 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
```