OpenShift Container Platform 4.18

Machine configuration

Managing and applying configuration and updates of the base operating system and container runtimes in OpenShift Container Platform

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Legal Notice

Abstract

This document provides instructions for managing changes to systemd, CRI-O, Kubelet, the kernel, and other system features by using MachineConfig, KubeletConfig, and ContainerRuntimeConfig objects. In addition, image layering allows you to easily customize the underlying node operating system by layering additional images onto the base image of any of your cluster worker nodes.

Table of Contents

CHAPTER 1. MACHINE CONFIGURATION OVERVIEW

There are times when you need to make changes to the operating systems running on OpenShift Container Platform nodes. This can include changing settings for network time service, adding kernel arguments, or configuring journaling in a specific way.

Aside from a few specialized features, most changes to operating systems on OpenShift Container Platform nodes can be done by creating what are referred to as **MachineConfig** objects that are managed by the Machine Config Operator. For example, you can use the Machine Config Operator (MCO) and machine configs to manage update to systemd, CRI-O and kubelet, the kernel, Network Manager and other system features.

Tasks in this section describe how to use features of the Machine Config Operator to configure operating system features on OpenShift Container Platform nodes.

IMPORTANT

NetworkManager stores new network configurations to **/etc/NetworkManager/system-connections/** in a key file format.

Previously, NetworkManager stored new network configurations to **/etc/sysconfig/network-scripts/** in the **ifcfg** format. Starting with RHEL 9.0, RHEL stores new network configurations at **/etc/NetworkManager/system-connections/** in a key file format. The connections configurations stored to **/etc/sysconfig/network-scripts/** in the old format still work uninterrupted. Modifications in existing profiles continue updating the older files.

1.1. ABOUT THE MACHINE CONFIG OPERATOR

OpenShift Container Platform 4.18 integrates both operating system and cluster management. Because the cluster manages its own updates, including updates to Red Hat Enterprise Linux CoreOS (RHCOS) on cluster nodes, OpenShift Container Platform provides an opinionated lifecycle management experience that simplifies the orchestration of node upgrades.

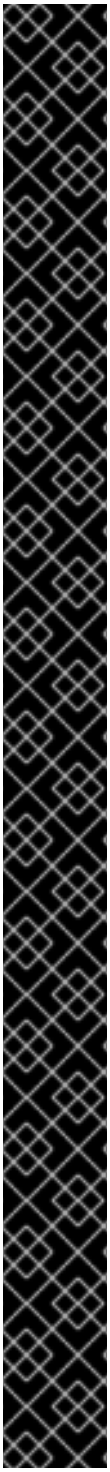
OpenShift Container Platform employs three daemon sets and controllers to simplify node management. These daemon sets orchestrate operating system updates and configuration changes to the hosts by using standard Kubernetes-style constructs. They include:

- The **machine-config-controller**, which coordinates machine upgrades from the control plane. It monitors all of the cluster nodes and orchestrates their configuration updates.
- The **machine-config-daemon** daemon set, which runs on each node in the cluster and updates a machine to configuration as defined by machine config and as instructed by the MachineConfigController. When the node detects a change, it drains off its pods, applies the update, and reboots. These changes come in the form of Ignition configuration files that apply the specified machine configuration and control kubelet configuration. The update itself is delivered in a container. This process is key to the success of managing OpenShift Container Platform and RHCOS updates together.
- The **machine-config-server** daemon set, which provides the Ignition config files to control plane nodes as they join the cluster.

The machine configuration is a subset of the Ignition configuration. The **machine-config-daemon** reads the machine configuration to see if it needs to do an OSTree update or if it must apply a series of systemd kubelet file changes, configuration changes, or other changes to the operating system or

OpenShift Container Platform configuration.

When you perform node management operations, you create or modify a **KubeletConfig** custom resource (CR).



IMPORTANT

When changes are made to a machine configuration, the Machine Config Operator (MCO) automatically reboots all corresponding nodes in order for the changes to take effect.

You can mitigate the disruption caused by some machine config changes by using a node disruption policy. See *Understanding node restart behaviors after machine config changes* .

Alternatively, you can prevent the nodes from automatically rebooting after machine configuration changes before making the changes. Pause the autoreboot process by setting the **spec.paused** field to **true** in the corresponding machine config pool. When paused, machine configuration changes are not applied until you set the **spec.paused** field to **false** and the nodes have rebooted into the new configuration.

- When the MCO detects any of the following changes, it applies the update without draining or rebooting the node:
  - Changes to the SSH key in the **spec.config.passwd.users.sshAuthorizedKeys** parameter of a machine config.
  - Changes to the global pull secret or pull secret in the **openshift-config** namespace.
  - Automatic rotation of the **/etc/kubernetes/kubelet-ca.crt** certificate authority (CA) by the Kubernetes API Server Operator.
- When the MCO detects changes to the **/etc/containers/registries.conf** file, such as editing an **ImageDigestMirrorSet**, **ImageTagMirrorSet**, or **ImageContentSourcePolicy** object, it drains the corresponding nodes, applies the changes, and uncordons the nodes. The node drain does not happen for the following changes:
  - The addition of a registry with the **pull-from-mirror = "digest-only"** parameter set for each mirror.
  - The addition of a mirror with the **pull-from-mirror = "digest-only"** parameter set in a registry.
  - The addition of items to the **unqualified-search-registries** list.

There might be situations where the configuration on a node does not fully match what the currently-applied machine config specifies. This state is called *configuration drift*. The Machine Config Daemon (MCD) regularly checks the nodes for configuration drift. If the MCD detects configuration drift, the MCO marks the node **degraded** until an administrator corrects the node configuration. A degraded node is online and operational, but, it cannot be updated.

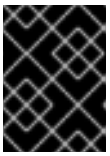
Additional resources

- About the OVN-Kubernetes network plugin

1.2. MACHINE CONFIG OVERVIEW

The Machine Config Operator (MCO) manages updates to systemd, CRI-O and Kubelet, the kernel, Network Manager and other system features. It also offers a **MachineConfig** CRD that can write configuration files onto the host (see machine-config-operator). Understanding what MCO does and how it interacts with other components is critical to making advanced, system-level changes to an OpenShift Container Platform cluster. Here are some things you should know about MCO, machine configs, and how they are used:

- A machine config can make a specific change to a file or service on the operating system of each system representing a pool of OpenShift Container Platform nodes.
- MCO applies changes to operating systems in pools of machines. All OpenShift Container Platform clusters start with worker and control plane node pools. By adding more role labels, you can configure custom pools of nodes. For example, you can set up a custom pool of worker nodes that includes particular hardware features needed by an application. However, examples in this section focus on changes to the default pool types.



IMPORTANT

A node can have multiple labels applied that indicate its type, such as **master** or **worker**, however it can be a member of only a **single** machine config pool.

- Machine configs are processed alphabetically, in lexicographically increasing order, by their name. The render controller uses the first machine config in the list as the base and appends the rest to the base machine config into a rendered machine config, which is then applied to the appropriate nodes.
- When you create a machine config for the worker nodes, the changes are also applied to the nodes in all custom pools.
  However, as of OpenShift Container Platform 4.15, any machine configs that target custom pools always override worker machine configs if the worker machine configs contain definitions for the same fields.
- After a machine config change, the MCO updates the affected nodes alphabetically by zone, based on the **topology.kubernetes.io/zone** label. If a zone has more than one node, the oldest nodes are updated first. For nodes that do not use zones, such as in bare metal deployments, the nodes are upgraded by age, with the oldest nodes updated first. The MCO updates the number of nodes as specified by the **maxUnavailable** field on the machine configuration pool at a time.
- Some machine configuration must be in place before OpenShift Container Platform is installed to disk. In most cases, this can be accomplished by creating a machine config that is injected directly into the OpenShift Container Platform installer process, instead of running as a postinstallation machine config. In other cases, you might need to do bare metal installation where you pass kernel arguments at OpenShift Container Platform installer startup, to do such things as setting per-node individual IP addresses or advanced disk partitioning.
- MCO manages items that are set in machine configs. Manual changes you do to your systems will not be overwritten by MCO, unless MCO is explicitly told to manage a conflicting file. In other words, MCO only makes specific updates you request, it does not claim control over the whole node.

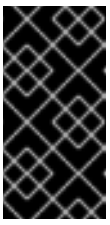
- Manual changes to nodes are strongly discouraged. If you need to decommission a node and start a new one, those direct changes would be lost.
- MCO is only supported for writing to files in **/etc** and **/var** directories, although there are symbolic links to some directories that can be writeable by being symbolically linked to one of those areas. The **/opt** and **/usr/local** directories are examples.
- Ignition is the configuration format used in MachineConfigs. See the Ignition Configuration Specification v3.4.0 for details.
- Although Ignition config settings can be delivered directly at OpenShift Container Platform installation time, and are formatted in the same way that MCO delivers Ignition configs, MCO has no way of seeing what those original Ignition configs are. Therefore, you should wrap Ignition config settings into a machine config before deploying them.
- When a file managed by MCO changes outside of MCO, the Machine Config Daemon (MCD) sets the node as **degraded**. It will not overwrite the offending file, however, and should continue to operate in a **degraded** state.
- A key reason for using a machine config is that it will be applied when you spin up new nodes for a pool in your OpenShift Container Platform cluster. The **machine-api-operator** provisions a new machine and MCO configures it.

MCO uses Ignition as the configuration format. OpenShift Container Platform 4.6 moved from Ignition config specification version 2 to version 3.

1.2.1. What can you change with machine configs?

The kinds of components that MCO can change include:

- **config**: Create Ignition config objects (see the Ignition configuration specification) to do things like modify files, systemd services, and other features on OpenShift Container Platform machines, including:
  - **Configuration files**: Create or overwrite files in the **/var** or **/etc** directory.
  - **systemd units**: Create and set the status of a systemd service or add to an existing systemd service by dropping in additional settings.
  - **users and groups**: Change SSH keys in the passwd section postinstallation.



IMPORTANT

- Changing SSH keys by using a machine config is supported only for the **core** user.
- Adding new users by using a machine config is not supported.

- **kernelArguments**: Add arguments to the kernel command line when OpenShift Container Platform nodes boot.
- **kernelType**: Optionally identify a non-standard kernel to use instead of the standard kernel. Use **realtime** to use the RT kernel (for RAN). This is only supported on select platforms. Use the **64k-pages** parameter to enable the 64k page size kernel. This setting is exclusive to machines with 64-bit ARM architectures.

- **fips**: Enable FIPS mode. FIPS should be set at installation-time setting and not a postinstallation procedure.

IMPORTANT

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

When running Red Hat Enterprise Linux (RHEL) or Red Hat Enterprise Linux CoreOS (RHCOS) booted in FIPS mode, OpenShift Container Platform core components use the RHEL cryptographic libraries that have been submitted to NIST for FIPS 140-2/140-3 Validation on only the x86_64, ppc64le, and s390x architectures.

- **extensions**: Extend RHCOS features by adding selected pre-packaged software. For this feature, available extensions include usbguard and kernel modules.
- **Custom resources (for ContainerRuntime and Kubelet)**: Outside of machine configs, MCO manages two special custom resources for modifying CRI-O container runtime settings (**ContainerRuntime** CR) and the Kubelet service (**Kubelet** CR).

The MCO is not the only Operator that can change operating system components on OpenShift Container Platform nodes. Other Operators can modify operating system-level features as well. One example is the Node Tuning Operator, which allows you to do node-level tuning through Tuned daemon profiles.

Tasks for the MCO configuration that can be done after installation are included in the following procedures. See descriptions of RHCOS bare metal installation for system configuration tasks that must be done during or before OpenShift Container Platform installation. By default, many of the changes you make with the MCO require a reboot.

- When the MCO detects any of the following changes, it applies the update without draining or rebooting the node:
  - Changes to the SSH key in the **spec.config.passwd.users.sshAuthorizedKeys** parameter of a machine config.
  - Changes to the global pull secret or pull secret in the **openshift-config** namespace.
  - Automatic rotation of the **/etc/kubernetes/kubelet-ca.crt** certificate authority (CA) by the Kubernetes API Server Operator.
- When the MCO detects changes to the **/etc/containers/registries.conf** file, such as editing an **ImageDigestMirrorSet**, **ImageTagMirrorSet**, or **ImageContentSourcePolicy** object, it drains the corresponding nodes, applies the changes, and uncordons the nodes. The node drain does not happen for the following changes:
  - The addition of a registry with the **pull-from-mirror = "digest-only"** parameter set for each mirror.
  - The addition of a mirror with the **pull-from-mirror = "digest-only"** parameter set in a registry.
  - The addition of items to the **unqualified-search-registries** list.

In other cases, you can mitigate the disruption to your workload when the MCO makes changes by using *node disruption policies*. For information, see *Understanding node restart behaviors after machine config changes*.

There might be situations where the configuration on a node does not fully match what the currently-applied machine config specifies. This state is called *configuration drift*. The Machine Config Daemon (MCD) regularly checks the nodes for configuration drift. If the MCD detects configuration drift, the MCO marks the node **degraded** until an administrator corrects the node configuration. A degraded node is online and operational, but, it cannot be updated. For more information on configuration drift, see *Understanding configuration drift detection*.

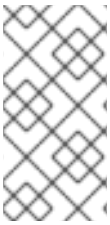
1.2.2. Node configuration management with machine config pools

Machines that run control plane components or user workloads are divided into groups based on the types of resources they handle. These groups of machines are called machine config pools (MCP). Each MCP manages a set of nodes and its corresponding machine configs. The role of the node determines which MCP it belongs to; the MCP governs nodes based on its assigned node role label. Nodes in an MCP have the same configuration; this means nodes can be scaled up and torn down in response to increased or decreased workloads.

By default, there are two MCPs created by the cluster when it is installed: **master** and **worker**. Each default MCP has a defined configuration applied by the Machine Config Operator (MCO), which is responsible for managing MCPs and facilitating MCP updates.

For worker nodes, you can create additional MCPs, or custom pools, to manage nodes with custom use cases that extend outside of the default node types. Custom MCPs for the control plane nodes are not supported.

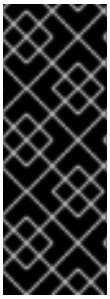
Custom pools are pools that inherit their configurations from the worker pool. They use any machine config targeted for the worker pool, but add the ability to deploy changes only targeted at the custom pool. Since a custom pool inherits its configuration from the worker pool, any change to the worker pool is applied to the custom pool as well. Custom pools that do not inherit their configurations from the worker pool are not supported by the MCO.



NOTE

A node can only be included in one MCP. If a node has multiple labels that correspond to several MCPs, like **worker,infra**, it is managed by the infra custom pool, not the worker pool. Custom pools take priority on selecting nodes to manage based on node labels; nodes that do not belong to a custom pool are managed by the worker pool.

It is recommended to have a custom pool for every node role you want to manage in your cluster. For example, if you create infra nodes to handle infra workloads, it is recommended to create a custom infra MCP to group those nodes together. If you apply an **infra** role label to a worker node so it has the **worker,infra** dual label, but do not have a custom infra MCP, the MCO considers it a worker node. If you remove the **worker** label from a node and apply the **infra** label without grouping it in a custom pool, the node is not recognized by the MCO and is unmanaged by the cluster.



IMPORTANT

Any node labeled with the **infra** role that is only running infra workloads is not counted toward the total number of subscriptions. The MCP managing an infra node is mutually exclusive from how the cluster determines subscription charges; tagging a node with the appropriate **infra** role and using taints to prevent user workloads from being scheduled on that node are the only requirements for avoiding subscription charges for infra workloads.

The MCO applies updates for pools independently; for example, if there is an update that affects all pools, nodes from each pool update in parallel with each other. If you add a custom pool, nodes from that pool also attempt to update concurrently with the master and worker nodes.

There might be situations where the configuration on a node does not fully match what the currently-applied machine config specifies. This state is called *configuration drift*. The Machine Config Daemon (MCD) regularly checks the nodes for configuration drift. If the MCD detects configuration drift, the MCO marks the node **degraded** until an administrator corrects the node configuration. A degraded node is online and operational, but, it cannot be updated.

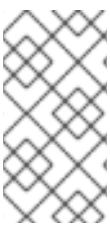
1.3. UNDERSTANDING THE MACHINE CONFIG OPERATOR NODE DRAIN BEHAVIOR

When you use a machine config to change a system feature, such as adding new config files, modifying systemd units or kernel arguments, or updating SSH keys, the Machine Config Operator (MCO) applies those changes and ensures that each node is in the desired configuration state.

After you make the changes, the MCO generates a new rendered machine config. In the majority of cases, when applying the new rendered machine config, the Operator performs the following steps on each affected node until all of the affected nodes have the updated configuration:

1. Cordon. The MCO marks the node as not schedulable for additional workloads.
2. Drain. The MCO terminates all running workloads on the node, causing the workloads to be rescheduled onto other nodes.
3. Apply. The MCO writes the new configuration to the nodes as needed.
4. Reboot. The MCO restarts the node.
5. Uncordon. The MCO marks the node as schedulable for workloads.

Throughout this process, the MCO maintains the required number of pods based on the **MaxUnavailable** value set in the machine config pool.



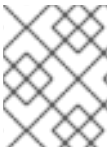
NOTE

There are conditions which can prevent the MCO from draining a node. If the MCO fails to drain a node, the Operator will be unable to reboot the node, preventing any changes made to the node through a machine config. For more information and mitigation steps, see the MCCDrainError runbook.

If the MCO drains pods on the master node, note the following conditions:

- In single-node OpenShift clusters, the MCO skips the drain operation.

- The MCO does not drain static pods in order to prevent interference with services, such as etcd.



NOTE

In certain cases the nodes are not drained. For more information, see "About the Machine Config Operator."

There are ways to mitigate the disruption caused by drain and reboot cycles by using node disruption policies or disabling control plane reboots. For more information, see "Understanding node restart behaviors after machine config changes" and "Disabling the Machine Config Operator from automatically rebooting."

Additional resources

- About the Machine Config Operator
- Using node disruption policies to minimize disruption from machine config changes
- Disabling the Machine Config Operator from automatically rebooting

1.4. UNDERSTANDING CONFIGURATION DRIFT DETECTION

There might be situations when the on-disk state of a node differs from what is configured in the machine config. This is known as *configuration drift*. For example, a cluster admin might manually modify a file, a systemd unit file, or a file permission that was configured through a machine config. This causes configuration drift. Configuration drift can cause problems between nodes in a Machine Config Pool or when the machine configs are updated.

The Machine Config Operator (MCO) uses the Machine Config Daemon (MCD) to check nodes for configuration drift on a regular basis. If detected, the MCO sets the node and the machine config pool (MCP) to **Degraded** and reports the error. A degraded node is online and operational, but, it cannot be updated.

The MCD performs configuration drift detection upon each of the following conditions:

- When a node boots.
- After any of the files (Ignition files and systemd drop-in units) specified in the machine config are modified outside of the machine config.
- Before a new machine config is applied.

NOTE

If you apply a new machine config to the nodes, the MCD temporarily shuts down configuration drift detection. This shutdown is needed because the new machine config necessarily differs from the machine config on the nodes. After the new machine config is applied, the MCD restarts detecting configuration drift using the new machine config.

When performing configuration drift detection, the MCD validates that the file contents and permissions fully match what the currently-applied machine config specifies. Typically, the MCD detects configuration drift in less than a second after the detection is triggered.

If the MCD detects configuration drift, the MCD performs the following tasks:

- Emits an error to the console logs
- Emits a Kubernetes event
- Stops further detection on the node
- Sets the node and MCP to **degraded**

You can check if you have a degraded node by listing the MCPs:

```
$ oc get mcp worker
```

If you have a degraded MCP, the **DEGRADEDMACHINECOUNT** field is non-zero, similar to the following output:

Example output

```
NAME     CONFIG                                             UPDATED   UPDATING   DEGRADED
MACHINECOUNT   READYMACHINECOUNT   UPDATEDMACHINECOUNT
DEGRADEDMACHINECOUNT   AGE
worker   rendered-worker-404caf3180818d8ac1f50c32f14b57c3   False     True       True       2
1                 1                   1                   5h51m
```

You can determine if the problem is caused by configuration drift by examining the machine config pool:

```
$ oc describe mcp worker
```

Example output

```
 ...
    Last Transition Time:  2021-12-20T18:54:00Z
    Message:               Node ci-ln-j4h8nkb-72292-pxqxz-worker-a-fjks4 is reporting: "content mismatch
for file \"/etc/mco-test-file\"" 1
    Reason:                1 nodes are reporting degraded status on sync
    Status:                True
    Type:                  NodeDegraded 2
 ...
```

1 This message shows that a node's **/etc/mco-test-file** file, which was added by the machine config, has changed outside of the machine config.

2 The state of the node is **NodeDegraded**.

Or, if you know which node is degraded, examine that node:

```
$ oc describe node/ci-ln-j4h8nkb-72292-pxqxz-worker-a-fjks4
```

Example output

```
 ...
```

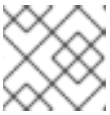
```
Annotations:        cloud.network.openshift.io/egress-ipconfig: [{"interface":"nic0","ifaddr":
{"ipv4":"10.0.128.0/17"},"capacity":{"ip":10}}]
                    csi.volume.kubernetes.io/nodeid:
                      {"pd.csi.storage.gke.io":"projects/openshift-gce-devel-ci/zones/us-central1-
a/instances/ci-ln-j4h8nkb-72292-pxqxz-worker-a-fjks4"}
                    machine.openshift.io/machine: openshift-machine-api/ci-ln-j4h8nkb-72292-pxqxz-worker-
a-fjks4
                    machineconfiguration.openshift.io/controlPlaneTopology: HighlyAvailable
                    machineconfiguration.openshift.io/currentConfig: rendered-worker-
67bd55d0b02b0f659aef33680693a9f9
                    machineconfiguration.openshift.io/desiredConfig: rendered-worker-
67bd55d0b02b0f659aef33680693a9f9
                    machineconfiguration.openshift.io/reason: content mismatch for file "/etc/mco-test-file"
(1)
                    machineconfiguration.openshift.io/state: Degraded (2)
 ...
```

(1) The error message indicating that configuration drift was detected between the node and the listed machine config. Here the error message indicates that the contents of the **/etc/mco-test-file**, which was added by the machine config, has changed outside of the machine config.

(2) The state of the node is **Degraded**.

You can correct configuration drift and return the node to the **Ready** state by performing one of the following remediations:

- Ensure that the contents and file permissions of the files on the node match what is configured in the machine config. You can manually rewrite the file contents or change the file permissions.
- Generate a force file on the degraded node. The force file causes the MCD to bypass the usual configuration drift detection and reapplies the current machine config.



NOTE

Generating a force file on a node causes that node to reboot.

1.5. CHECKING MACHINE CONFIG POOL STATUS

To see the status of the Machine Config Operator (MCO), its sub-components, and the resources it manages, use the following **oc** commands:

Procedure

1. To see the number of MCO-managed nodes available on your cluster for each machine config pool (MCP), run the following command:

```
$ oc get machineconfigpool
```

Example output

```
NAME      CONFIG              UPDATED  UPDATING  DEGRADED  MACHINECOUNT
READYMACHINECOUNT  UPDATEDMACHINECOUNT DEGRADEDMACHINECOUNT
```

```
AGE
master   rendered-master-06c9c4…   True    False    False   3          3              3
0                4h42m
worker   rendered-worker-f4b64…    False   True     False   3          2              2
0                4h42m
```

where:

UPDATED

The **True** status indicates that the MCO has applied the current machine config to the nodes in that MCP. The current machine config is specified in the **STATUS** field in the **oc get mcp** output. The **False** status indicates a node in the MCP is updating.

UPDATING

The **True** status indicates that the MCO is applying the desired machine config, as specified in the **MachineConfigPool** custom resource, to at least one of the nodes in that MCP. The desired machine config is the new, edited machine config. Nodes that are updating might not be available for scheduling. The **False** status indicates that all nodes in the MCP are updated.

DEGRADED

A **True** status indicates the MCO is blocked from applying the current or desired machine config to at least one of the nodes in that MCP, or the configuration is failing. Nodes that are degraded might not be available for scheduling. A **False** status indicates that all nodes in the MCP are ready.

MACHINECOUNT

Indicates the total number of machines in that MCP.

READYMACHINECOUNT

Indicates the number of machines that are both running the current machine config and are ready for scheduling. This count is always less than or equal to the **UPDATEDMACHINECOUNT** number.

UPDATEDMACHINECOUNT

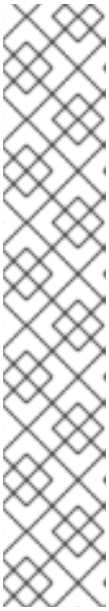
Indicates the total number of machines in that MCP that have the current machine config.

DEGRADEDMACHINECOUNT

Indicates the total number of machines in that MCP that are marked as degraded or unreconcilable.

In the previous output, there are three control plane (master) nodes and three worker nodes. The control plane MCP and the associated nodes are updated to the current machine config. The nodes in the worker MCP are being updated to the desired machine config. Two of the nodes in the worker MCP are updated and one is still updating, as indicated by the **UPDATEDMACHINECOUNT** being **2**. There are no issues, as indicated by the **DEGRADEDMACHINECOUNT** being **0** and **DEGRADED** being **False**.

While the nodes in the MCP are updating, the machine config listed under **CONFIG** is the current machine config, which the MCP is being updated from. When the update is complete, the listed machine config is the desired machine config, which the MCP was updated to.



NOTE

If a node is being cordoned, that node is not included in the **READYMACHINECOUNT**, but is included in the **MACHINECOUNT**. Also, the MCP status is set to **UPDATING**. Because the node has the current machine config, it is counted in the **UPDATEDMACHINECOUNT** total:

Example output

```
NAME     CONFIG                 UPDATED  UPDATING   DEGRADED
MACHINECOUNT  READYMACHINECOUNT  UPDATEDMACHINECOUNT
DEGRADEDMACHINECOUNT  AGE
master   rendered-master-06c9c4…  True     False      False    3          3
3                0                4h42m
worker   rendered-worker-c1b41a…  False    True       False    3          2
3                0                4h42m
```

2. To check the status of the nodes in an MCP by examining the **MachineConfigPool** custom resource, run the following command: :

```
$ oc describe mcp worker
```

Example output

```
...
  Degraded Machine Count:     0
  Machine Count:              3
  Observed Generation:        2
  Ready Machine Count:        3
  Unavailable Machine Count:  0
  Updated Machine Count:      3
Events:                       <none>
```

NOTE

If a node is being cordoned, the node is not included in the **Ready Machine Count**. It is included in the **Unavailable Machine Count**:

Example output

```
...
  Degraded Machine Count:     0
  Machine Count:              3
  Observed Generation:        2
  Ready Machine Count:        2
  Unavailable Machine Count:  1
  Updated Machine Count:      3
```

3. To see each existing **MachineConfig** object, run the following command:

```
$ oc get machineconfigs
```

Example output

```
NAME                          GENERATEDBYCONTROLLER          IGNITIONVERSION  AGE
00-master                     2c9371fbb673b97a6fe8b1c52...   3.4.0            5h18m
00-worker                     2c9371fbb673b97a6fe8b1c52...   3.4.0            5h18m
01-master-container-runtime   2c9371fbb673b97a6fe8b1c52...   3.4.0            5h18m
01-master-kubelet             2c9371fbb673b97a6fe8b1c52…     3.4.0            5h18m
...
rendered-master-dde...        2c9371fbb673b97a6fe8b1c52...   3.4.0            5h18m
rendered-worker-fde...        2c9371fbb673b97a6fe8b1c52...   3.4.0            5h18m
```

Note that the **MachineConfig** objects listed as **rendered** are not meant to be changed or deleted.

4. To view the contents of a particular machine config (in this case, **01-master-kubelet**), run the following command:

```
$ oc describe machineconfigs 01-master-kubelet
```

The output from the command shows that this **MachineConfig** object contains both configuration files (**cloud.conf** and **kubelet.conf**) and a systemd service (Kubernetes Kubelet):

Example output

```
Name:         01-master-kubelet
...
Spec:
  Config:
    Ignition:
      Version:  3.4.0
    Storage:
      Files:
        Contents:
          Source:   data:,
        Mode:       420
        Overwrite:  true
        Path:       /etc/kubernetes/cloud.conf
        Contents:
          Source:
data:,kind%3A%20KubeletConfiguration%0AapiVersion%3A%20kubelet.config.k8s.io%2Fv1bet
a1%0Aauthentication%3A%0A%20%20x509%3A%0A%20%20%20%20clientCAFile%3A%20
%2Fetc%2Fkubernetes%2Fkubelet-ca.crt%0A%20%20anonymous...
        Mode:       420
        Overwrite:  true
        Path:       /etc/kubernetes/kubelet.conf
    Systemd:
      Units:
        Contents:  [Unit]
Description=Kubernetes Kubelet
Wants=rpc-statd.service network-online.target crio.service
After=network-online.target crio.service

ExecStart=/usr/bin/hyperkube \
    kubelet \
      --config=/etc/kubernetes/kubelet.conf \ ...
```

If something goes wrong with a machine config that you apply, you can always back out that change. For example, if you had run **oc create -f ./myconfig.yaml** to apply a machine config, you could remove that machine config by running the following command:

```
$ oc delete -f ./myconfig.yaml
```

If that was the only problem, the nodes in the affected pool should return to a non-degraded state. This actually causes the rendered configuration to roll back to its previously rendered state.

If you add your own machine configs to your cluster, you can use the commands shown in the previous example to check their status and the related status of the pool to which they are applied.

1.6. ABOUT NODE STATUS DURING UPDATES

If you make changes to a machine config pool (MCP) that results in a new machine config, for example by using a **MachineConfig** or **KubeletConfig** object, you can get detailed information about the progress of the node updates by using the machine config nodes custom resource. This information can be helpful if issues arise during the update and you need to troubleshoot a node.

You can view this detailed information for nodes in the **control plane** and **worker** machine config pools that were created upon OpenShift Container Platform installation. You cannot use custom machine config pools.

The **MachineConfigNode** custom resource allows you to monitor the progress of individual node updates as they move through the upgrade phases. This information can be helpful with troubleshooting if one of the nodes has an issue during the update. The custom resource reports where in the update process the node is at the moment, the phases that have completed, and the phases that are remaining.

IMPORTANT

The machine config node custom resource is a Technology Preview feature only. Technology Preview features are not supported with Red Hat production service level agreements (SLAs) and might not be functionally complete. Red Hat does not recommend using them in production. These features provide early access to upcoming product features, enabling customers to test functionality and provide feedback during the development process.

For more information about the support scope of Red Hat Technology Preview features, see Technology Preview Features Support Scope .

The node update process consists of the following phases and subphases that are tracked by the machine config node custom resource, explained with more detail later in this section:

- **Update Prepared**. The MCO stops the configuration drift monitoring process and verifies that the newly-created machine config can be applied to a node.
  - **UpdateCompatible**
- **Update Executed**. The MCO cordons and drains the node and applies the new machine config to the node's files and operating system, as needed. It contains the following sub-phases:
  - **Cordoned**
  - **Drained**

    - AppliedFilesAndOS

- **PinnedImageSetsProgressing** The MCO is performing the steps needed to pin and pre-load container images.
- **PinnedImageSetsDegraded** The pinned image process failed. You can view the reason for the failure by using the **oc describe machineconfignode** command, as described later in this section.
- **Update Post update action**. The MCO reboots the node or reloads CRI-O, as needed.
    - RebootedNode
    - ReloadedCRIO
- **Update Complete**. The MCO uncordons the nodes, updates the node state to the cluster, and resumes producing node metrics.
    - Updated
    - Uncordoned
- **Resumed**. The MCO restarts the config drift monitor process and the node returns to operational state.

As the update moves through these phases, you can query the **MachineConfigNode** custom resource, which reports one of the following conditions for each phase:

- **True**. The phase is complete on that node or the MCO has started that phase on that node.
- **False**. The phase is either being executed or will not be executed on that node.
- **Unknown**. The phase is either being executed on that node or has an error. If the phase has an error, you can use the **oc describe machineconfignodes** command for more information, as described later in this section.

For example, consider a cluster with a newly-created machine config:

```
$ oc get machineconfig
```

Example output

```
# ...
rendered-master-23cf200e4ee97daa6e39fdce24c9fb67
c00e2c941bc6e236b50e0bf3988e6c790cf2bbb2   3.4.0          6d15h
rendered-master-a386c2d1550b927d274054124f58be68
c00e2c941bc6e236b50e0bf3988e6c790cf2bbb2   3.4.0          7m26s
# ...
rendered-worker-01f27f752eb84eba917450e43636b210
c00e2c941bc6e236b50e0bf3988e6c790cf2bbb2   3.4.0          6d15h (1)
rendered-worker-f351f6947f15cd0380514f4b1c89f8f2
c00e2c941bc6e236b50e0bf3988e6c790cf2bbb2   3.4.0          7m26s (2)
# ...
```

(1) The current machine config for the control plane and worker nodes.

2 A newly-created machine config that is being applied to the control plane and worker nodes.

You can watch as the nodes are updated with the new machine config:

```
$ oc get machineconfignodes
```

Example output

```
NAME                                POOLNAME   DESIREDCONFIG
CURRENTCONFIG                                 UPDATED
ci-ln-ds73n5t-72292-9xsm9-master-0        master     rendered-master-
a386c2d1550b927d274054124f58be68   rendered-master-a386c2d1550b927d274054124f58be68
True
ci-ln-ds73n5t-72292-9xsm9-master-1        master     rendered-master-
a386c2d1550b927d274054124f58be68   rendered-master-23cf200e4ee97daa6e39fdce24c9fb67
False
ci-ln-ds73n5t-72292-9xsm9-master-2        master     rendered-master-
23cf200e4ee97daa6e39fdce24c9fb67   rendered-master-23cf200e4ee97daa6e39fdce24c9fb67
True
ci-ln-ds73n5t-72292-9xsm9-worker-a-2d8tz   worker     rendered-worker-
f351f6947f15cd0380514f4b1c89f8f2   rendered-worker-f351f6947f15cd0380514f4b1c89f8f2   True
(1)
ci-ln-ds73n5t-72292-9xsm9-worker-b-gw5sd   worker     rendered-worker-
f351f6947f15cd0380514f4b1c89f8f2   rendered-worker-01f27f752eb84eba917450e43636b210
False (2)
ci-ln-ds73n5t-72292-9xsm9-worker-c-t227w   worker     rendered-worker-
01f27f752eb84eba917450e43636b210   rendered-worker-01f27f752eb84eba917450e43636b210
True (3)
```

1 This node has been updated. The new machine config, **rendered-worker-f351f6947f15cd0380514f4b1c89f8f2**, is shown as the desired and current machine configs.

2 This node is currently being updated to the new machine config. The previous and new machine configs are shown as the desired and current machine configs, respectively.

3 This node has not yet been updated to the new machine config. The previous machine config is shown as the desired and current machine configs.

Table 1.1. Basic machine config node fields

Field	Meaning
NAME	The name of the node.
POOLNAME	The name of the machine config pool associated with that node.
DESIREDCONFIG	The name of the new machine config that the node updates to.

Field	Meaning
CURRENTCONFIG	The name of the current machine configuration on that node.
UPDATED	Indicates if the node has been updated with one of the following conditions: • If **False**, the node is being updated to the new machine configuration shown in the **DESIREDCONFIG** field. • If **True**, and the **CURRENTCONFIG** matches the new machine configuration shown in the **DESIREDCONFIG** field, the node has been updated. • If **True**, and the **CURRENTCONFIG** matches the old machine configuration shown in the **DESIREDCONFIG** field, that node has not been updated yet.

You can use the **-o wide** flag to display additional information about the updates:

```
$ oc get machineconfignodes -o wide
```

Example output

```
$ oc get machineconfignode -o wide
NAME                                POOLNAME   DESIREDCONFIG
CURRENTCONFIG                                UPDATED   UPDATEPREPARED   UPDATEEXECUTED
UPDATEPOSTACTIONCOMPLETE   UPDATECOMPLETE   RESUMED   UPDATECOMPATIBLE
UPDATEDFILESANDOS   CORDONEDNODE   DRAINEDNODE   REBOOTEDNODE
RELOADEDCRIO   UNCORDONEDNODE
ci-ln-ds73n5t-72292-9xsm9-master-0        master     rendered-master-
23cf200e4ee97daa6e39fdce24c9fb67   rendered-master-23cf200e4ee97daa6e39fdce24c9fb67
True      False          False          False                False          False     False          False
False         False         False         False         False
ci-ln-ds73n5t-72292-9xsm9-master-1        master     rendered-master-
23cf200e4ee97daa6e39fdce24c9fb67   rendered-master-23cf200e4ee97daa6e39fdce24c9fb67
True      False          False          False                False          False     False          False
False         False         False         False         False
ci-ln-ds73n5t-72292-9xsm9-master-2        master     rendered-master-
23cf200e4ee97daa6e39fdce24c9fb67   rendered-master-23cf200e4ee97daa6e39fdce24c9fb67
True      False          False          False                False          False     False          False
False         False         False         False         False
ci-ln-ds73n5t-72292-9xsm9-worker-a-2d8tz   worker     rendered-worker-
f351f6947f15cd0380514f4b1c89f8f2   rendered-worker-f351f6947f15cd0380514f4b1c89f8f2   True
False          False          False                False          False     False          False          False
False         False         False         False
ci-ln-ds73n5t-72292-9xsm9-worker-b-gw5sd   worker     rendered-worker-
f351f6947f15cd0380514f4b1c89f8f2   rendered-worker-01f27f752eb84eba917450e43636b210
False     True           True           Unknown              False          False     True           True
True          True          Unknown       False         False
ci-ln-ds73n5t-72292-9xsm9-worker-c-t227w   worker     rendered-worker-
01f27f752eb84eba917450e43636b210   rendered-worker-01f27f752eb84eba917450e43636b210
True      False          False          False                False          False     False          False
False         False         False         False         False
```

In addition to the fields defined in the previous table, the **-o wide** output displays the following fields:

Table 1.2. Machine config node fields in the-o wide output

Phase Name	Definition
UPDATEPREPARED	Indicates if the MCO is preparing to update the node.
UPDATEEXECUTED	Indicates if the MCO has completed the body of the update on the node.
UPDATEPOSTACTIONCOMPLETE	Indicates if the MCO has executed the post-update actions on the node.
UPDATECOMPLETE	Indicates if the MCO has completed the update on the node.
RESUMED	Indicates if the node has resumed normal processes.
UPDATECOMPATIBLE	Indicates if the MCO has determined it can execute the update on the node.
UPDATEDFILESANDOS	Indicates if the MCO has updated the node files and operating system.
CORDONEDNODE	Indicates if the MCO has marked the node as not schedulable.
DRAINEDNODE	Indicates if the MCO has drained the node.
REBOOTEDNODE	Indicates if the MCO has restarted the node.
RELOADEDCRIO	Indicates if the MCO has restarted the CRI-O service.
UNCORDONEDNODE	Indicates if the MCO has marked the node as schedulable.

For more details on the update status, you can use the **oc describe machineconfignode** command:

```
$ oc describe machineconfignode/<machine_config_node_name>
```

Example output

```
Name:       <machine_config_node_name> 1
```

```
Namespace:
Labels:       <none>
Annotations:  <none>
API Version:  machineconfiguration.openshift.io/v1alpha1
Kind:         MachineConfigNode
Metadata:
  Creation Timestamp:  2023-10-17T13:08:58Z
  Generation:          1
  Resource Version:    49443
  UID:                 4bd758ab-2187-413c-ac42-882e61761b1d
Spec:
  Node Ref:
    Name:        <node_name>
  Pool:
    Name:        worker
  ConfigVersion:
    Desired: rendered-worker-f351f6947f15cd0380514f4b1c89f8f2 (2)
Status:
  Conditions:
    Last Transition Time:  2025-01-14T17:01:16Z
    Message:               Node ci-ln-ds73n5t-72292-9xsm9-worker-b-gw5sd needs an update
    Reason:                Updated
    Status:                False
    Type:                  Updated
    Last Transition Time:  2025-01-14T17:01:18Z
    Message:               Update is Compatible.
    Reason:                UpdateCompatible
    Status:                True
    Type:                  UpdatePrepared
    Last Transition Time:  2025-01-14T17:04:08Z
    Message:               Updated the Files and OS on disk as a part of the in progress phase
    Reason:                AppliedFilesAndOS
    Status:                True
    Type:                  UpdateExecuted
    Last Transition Time:  2025-01-14T17:04:08Z
    Message:               Node will reboot into config rendered-worker-
db01b33f959e5645a721da50a6db1fbb
    Reason:                RebootedNode
    Status:                Unknown
    Type:                  UpdatePostActionComplete
    Last Transition Time:  2025-01-14T16:04:27Z
    Message:               Action during update to rendered-worker-f351f6947f15cd0380514f4b1c89f8f2:
UnCordoned Node as part of completing upgrade phase
    Reason:                Uncordoned
    Status:                False
    Type:                  UpdateComplete
    Last Transition Time:  2025-01-14T16:04:27Z
    Message:               Action during update to rendered-worker-f351f6947f15cd0380514f4b1c89f8f2:
In desired config rendered-worker-01f27f752eb84eba917450e43636b210. Resumed normal
operations.
    Reason:                Resumed
    Status:                False
    Type:                  Resumed
    Last Transition Time:  2025-01-14T17:01:18Z
    Message:               Update Compatible. Post Cfg Actions []: Drain Required: true
    Reason:                UpdatePreparedUpdateCompatible
```

```
    Status:               True
    Type:                 UpdateCompatible
    Last Transition Time:  2025-01-14T17:03:57Z
    Message:              Drained node. The drain is complete as the desired drainer matches current
drainer: drain-rendered-worker-db01b33f959e5645a721da50a6db1fbb
    Reason:               UpdateExecutedDrained
    Status:               True
    Type:                 Drained
    Last Transition Time:  2025-01-14T17:04:08Z
    Message:              Applied files and new OS config to node. OS did not need an update. SSH Keys
did not need an update
    Reason:               UpdateExecutedAppliedFilesAndOS
    Status:               True
    Type:                 AppliedFilesAndOS
    Last Transition Time:  2025-01-14T17:01:23Z
    Message:              Cordoned node. The node is reporting Unschedulable = true
    Reason:               UpdateExecutedCordoned
    Status:               True
    Type:                 Cordoned
    Last Transition Time:  2025-01-14T17:04:08Z
    Message:              Upgrade requires a reboot. Currently doing this as the post update action.
    Reason:               UpdatePostActionCompleteRebootedNode
    Status:               Unknown
    Type:                 RebootedNode
    Last Transition Time:  2025-01-14T15:30:57Z
    Message:              This node has not yet entered the ReloadedCRIO phase
    Reason:               NotYetOccured
    Status:               False
    Type:                 ReloadedCRIO
    Last Transition Time:  2025-01-14T16:04:27Z
    Message:              Action during update to rendered-worker-f351f6947f15cd0380514f4b1c89f8f2:
UnCordoned node. The node is reporting Unschedulable = false
    Reason:               UpdateCompleteUncordoned
    Status:               False
    Type:                 Uncordoned
    Last Transition Time:  2025-01-14T16:04:07Z
    Message:              All is good
    Reason:               AsExpected
    Status:               False
    Type:                 PinnedImageSetsDegraded
    Last Transition Time:  2025-01-14T16:04:07Z
    Message:              All pinned image sets complete
    Reason:               AsExpected
    Status:               False
    Type:                 PinnedImageSetsProgressing
  Config Version:
    Current:          rendered-worker-01f27f752eb84eba917450e43636b210 (3)
    Desired:          rendered-worker-f351f6947f15cd0380514f4b1c89f8f2
  Observed Generation:  6
# ...
```

(1) The **MachineConfigNode** object name.

(2) The new machine configuration. This field updates after the MCO validates the machine config in the **UPDATEPREPARED** phase, then the status adds the new configuration.

3 The current machine config on the node.

1.6.1. Checking node status during updates

During the update of a machine config pool (MCP), you can monitor the progress of all of the nodes in your cluster by using the **oc get machineconfignodes** and **oc describe machineconfignodes** commands. These commands provide information that can be helpful if issues arise during the update and you need to troubleshoot a node.

For more information on the meaning of these fields, see "About checking machine config node status."

Prerequisites

- You enabled the required Technology Preview features for your cluster by editing the **FeatureGate** CR named **cluster**:

```
$ oc edit featuregate cluster
```

Example FeatureGate CR

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

WARNING

Enabling the **TechPreviewNoUpgrade** feature set on your cluster cannot be undone and prevents minor version updates. This feature set allows you to enable these Technology Preview features on test clusters, where you can fully test them. Do not enable this feature set on production clusters.

After you save the changes, new machine configs are created, the machine config pools are updated, and scheduling on each node is disabled while the change is being applied.

Procedure

- View the update status of all nodes in the cluster, including the current and desired machine configurations, by running the following command:

```
$ oc get machineconfignodes
```

Example output

```
NAME                        POOLNAME   DESIREDCONFIG
```

```
CURRENTCONFIG                                UPDATED
ci-ln-mdb23yt-72292-kzdsg-master-0       master     rendered-master-
f21b093d20f68a7c06f922ed3ea5fbc8   rendered-master-
1abc053eec29e6c945670f39d6dc8afa   False
ci-ln-mdb23yt-72292-kzdsg-master-1       master     rendered-master-
1abc053eec29e6c945670f39d6dc8afa   rendered-master-
1abc053eec29e6c945670f39d6dc8afa   True
ci-ln-mdb23yt-72292-kzdsg-master-2       master     rendered-master-
1abc053eec29e6c945670f39d6dc8afa   rendered-master-
1abc053eec29e6c945670f39d6dc8afa   True
ci-ln-mdb23yt-72292-kzdsg-worker-a-gfqjr   worker     rendered-worker-
d0130cd74e9e576d7ba78ce166272bfb   rendered-worker-
8f61bf839898a4487c3b5263a430e94a   False
ci-ln-mdb23yt-72292-kzdsg-worker-b-gknq4   worker     rendered-worker-
8f61bf839898a4487c3b5263a430e94a   rendered-worker-
8f61bf839898a4487c3b5263a430e94a   True
ci-ln-mdb23yt-72292-kzdsg-worker-c-mffrx   worker     rendered-worker-
8f61bf839898a4487c3b5263a430e94a   rendered-worker-
8f61bf839898a4487c3b5263a430e94a   True
```

- View of all machine config node status fields for the nodes in your cluster by running the following command:

```
$ oc get machineconfignodes -o wide
```

Example output

```
NAME                                POOLNAME   DESIREDCONFIG
CURRENTCONFIG                                UPDATED   UPDATEPREPARED
UPDATEEXECUTED   UPDATEPOSTACTIONCOMPLETE   UPDATECOMPLETE
RESUMED   UPDATECOMPATIBLE   UPDATEDFILESANDOS   CORDONEDNODE
DRAINEDNODE   REBOOTEDNODE   RELOADEDCRIO   UNCORDONEDNODE
ci-ln-g6dr34b-72292-g9btv-master-0       master     rendered-master-
d4e122320b351cdbe1df59ddb63ddcfc   rendered-master-
6f2064fcb36d2a914de5b0c660dc49ff   False     True          Unknown         False
False          False     True          Unknown          False          False          False          False
False
ci-ln-g6dr34b-72292-g9btv-master-1       master     rendered-master-
6f2064fcb36d2a914de5b0c660dc49ff   rendered-master-
6f2064fcb36d2a914de5b0c660dc49ff   True      False         False          False
False          False     False         False          False          False          False          False
False
ci-ln-g6dr34b-72292-g9btv-master-2       master     rendered-master-
6f2064fcb36d2a914de5b0c660dc49ff   rendered-master-
6f2064fcb36d2a914de5b0c660dc49ff   True      False         False          False
False          False     False         False          False          False          False          False
False
ci-ln-g6dr34b-72292-g9btv-worker-a-sjh5r   worker     rendered-worker-
671b88c8c569fa3f60dc1a27cf9c91f2   rendered-worker-
d5534cb730e5e108905fc285c2a42b6c   False     True          Unknown         False
False          False     True          Unknown          False          False          False          False
False
ci-ln-g6dr34b-72292-g9btv-worker-b-xthbz   worker     rendered-worker-
d5534cb730e5e108905fc285c2a42b6c   rendered-worker-
d5534cb730e5e108905fc285c2a42b6c   True      False         False          False
```

```
False      False    False      False      False      False      False      False
False
ci-ln-g6dr34b-72292-g9btv-worker-c-gnpd6   worker    rendered-worker-
d5534cb730e5e108905fc285c2a42b6c   rendered-worker-
d5534cb730e5e108905fc285c2a42b6c   True      False      False      False
False      False    False      False      False      False      False      False
False
```

- Check the update status of nodes in a specific machine config pool by running the following command:

```
$ oc get machineconfignodes $(oc get machineconfignodes -o json | jq -r
'.items[]|select(.spec.pool.name=="<pool_name>")|.metadata.name') 1
```

Example output

```
NAME                                POOLNAME   DESIREDCONFIG
CURRENTCONFIG                                 UPDATED
ci-ln-g6dr34b-72292-g9btv-worker-a-sjh5r   worker    rendered-worker-
d5534cb730e5e108905fc285c2a42b6c   rendered-worker-
d5534cb730e5e108905fc285c2a42b6c   True
ci-ln-g6dr34b-72292-g9btv-worker-b-xthbz   worker    rendered-worker-
d5534cb730e5e108905fc285c2a42b6c   rendered-worker-
faf6b50218a8bbce21f1370866283de5   False
ci-ln-g6dr34b-72292-g9btv-worker-c-gnpd6   worker    rendered-worker-
faf6b50218a8bbce21f1370866283de5   rendered-worker-
faf6b50218a8bbce21f1370866283de5   True
```

- Check the update status of an individual node by running the following command:

```
$ oc describe machineconfignode/<node_name>
```

Example output

```
Name:        <node_name>
Namespace:
Labels:      <none>
Annotations:  <none>
API Version:  machineconfiguration.openshift.io/v1alpha1
Kind:        MachineConfigNode
Metadata:
  Creation Timestamp:  2023-10-17T13:08:58Z
  Generation:          1
  Resource Version:    49443
  UID:                 4bd758ab-2187-413c-ac42-882e61761b1d
Spec:
  Node Ref:
    Name:        <node_name>
  Pool:
    Name:        master
  ConfigVersion:
    Desired: rendered-worker-823ff8dc2b33bf444709ed7cd2b9855b
Status:
# ...
```

```
    Message:               Drained node. The drain is complete as the desired drainer matches
current drainer: drain-rendered-worker-01f27f752eb84eba917450e43636b210
    Reason:                UpdateExecutedDrained
    Status:                True
    Type:                  Drained
    Last Transition Time:  2025-01-14T15:45:55Z
# ...
  Config Version:
    Current:           rendered-master-8110974a5cea69dff5b263237b58abd8
    Desired:           rendered-worker-823ff8dc2b33bf444709ed7cd2b9855b
  Observed Generation:  6
# ...
```

Additional resources

- For more information about feature gates, see Enabling feature sets using the web console.

1.7. UNDERSTANDING MACHINE CONFIG OPERATOR CERTIFICATES

Machine Config Operator certificates are used to secure connections between the Red Hat Enterprise Linux CoreOS (RHCOS) nodes and the Machine Config Server. For more information, see Machine Config Operator certificates.

1.7.1. Viewing and interacting with certificates

The following certificates are handled in the cluster by the Machine Config Controller (MCC) and can be found in the **ControllerConfig** resource:

- **/etc/kubernetes/kubelet-ca.crt**
- **/etc/kubernetes/static-pod-resources/configmaps/cloud-config/ca-bundle.pem**
- **/etc/pki/ca-trust/source/anchors/openshift-config-user-ca-bundle.crt**

The MCC also handles the image registry certificates and its associated user bundle certificate.

You can get information about the listed certificates, including the underyling bundle the certificate comes from, and the signing and subject data.

Prerequisites

- This procedure contains optional steps that require that the **python-yq** RPM package is installed.

Procedure

- Get detailed certificate information by running the following command:

```
$ oc get controllerconfig/machine-config-controller -o yaml | yq -y
'.status.controllerCertificates'
```

Example output

```
- bundleFile: KubeAPIServerServingCAData
```

```
  notAfter: '2034-10-23T13:13:02Z'
  notBefore: '2024-10-25T13:13:02Z'
  signer: CN=admin-kubeconfig-signer,OU=openshift
  subject: CN=admin-kubeconfig-signer,OU=openshift
- bundleFile: KubeAPIServerServingCAData
  notAfter: '2024-10-26T13:13:05Z'
  notBefore: '2024-10-25T13:27:14Z'
  signer: CN=kubelet-signer,OU=openshift
  subject: CN=kube-csr-signer_@1729862835
- bundleFile: KubeAPIServerServingCAData
  notAfter: '2024-10-26T13:13:05Z'
  notBefore: '2024-10-25T13:13:05Z'
  signer: CN=kubelet-signer,OU=openshift
  subject: CN=kubelet-signer,OU=openshift
# ...
```

- Get a simpler version of the information found in the **ControllerConfig** resource by checking the machine config pool status using the following command:

```
$ oc get mcp master -o yaml | yq -y '.status.certExpirys'
```

Example output

```
- bundle: KubeAPIServerServingCAData
  expiry: '2034-10-23T13:13:02Z'
  subject: CN=admin-kubeconfig-signer,OU=openshift
- bundle: KubeAPIServerServingCAData
  expiry: '2024-10-26T13:13:05Z'
  subject: CN=kube-csr-signer_@1729862835
- bundle: KubeAPIServerServingCAData
  expiry: '2024-10-26T13:13:05Z'
  subject: CN=kubelet-signer,OU=openshift
- bundle: KubeAPIServerServingCAData
  expiry: '2025-10-25T13:13:05Z'
  subject: CN=kube-apiserver-to-kubelet-signer,OU=openshift
# ...
```

This method is meant for OpenShift Container Platform applications that already consume machine config pool information.

- Check which image registry certificates are on the nodes:

  a. Log in to a node:

  ```
  $ oc debug node/<node_name>
  ```

  b. Set **/host** as the root directory within the debug shell:

  ```
  sh-5.1# chroot /host
  ```

  c. Look at the contents of the **/etc/docker/cert.d** directory:

  ```
  sh-5.1# ls /etc/docker/certs.d
  ```

Example output

```
image-registry.openshift-image-registry.svc.cluster.local:5000
image-registry.openshift-image-registry.svc:5000
```

CHAPTER 2. USING MACHINE CONFIG OBJECTS TO CONFIGURE NODES

You can use the tasks in this section to create **MachineConfig** objects that modify files, systemd unit files, and other operating system features running on OpenShift Container Platform nodes. For more ideas on working with machine configs, see content related to updating SSH authorized keys, verifying image signatures, enabling SCTP, and configuring iSCSI initiatornames for OpenShift Container Platform.

OpenShift Container Platform supports Ignition specification version 3.4. You should base all new machine configs you create going forward on Ignition specification version 3.4. If you are upgrading your OpenShift Container Platform cluster, any existing machine configs with a previous Ignition specification will be translated automatically to specification version 3.4.

There might be situations where the configuration on a node does not fully match what the currently-applied machine config specifies. This state is called *configuration drift*. The Machine Config Daemon (MCD) regularly checks the nodes for configuration drift. If the MCD detects configuration drift, the MCO marks the node **degraded** until an administrator corrects the node configuration. A degraded node is online and operational, but, it cannot be updated. For more information on configuration drift, see Understanding configuration drift detection.

TIP

Use the following "Configuring chrony time service" procedure as a model for how to go about adding other configuration files to OpenShift Container Platform nodes.

2.1. CONFIGURING CHRONY TIME SERVICE

You can set the time server and related settings used by the chrony time service (**chronyd**) by modifying the contents of the **chrony.conf** file and passing those contents to your nodes as a machine config.

Procedure

1. Create a Butane config including the contents of the **chrony.conf** file. For example, to configure chrony on worker nodes, create a **99-worker-chrony.bu** file.

NOTE

The Butane version you specify in the config file should match the OpenShift Container Platform version and always ends in **0**. For example, **4.18.0**. See "Creating machine configs with Butane" for information about Butane.

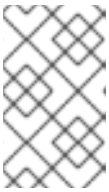
```
variant: openshift
version: 4.18.0
metadata:
  name: 99-worker-chrony (1)
  labels:
    machineconfiguration.openshift.io/role: worker (2)
storage:
  files:
  - path: /etc/chrony.conf
```

```
    mode: 0644 3
    overwrite: true
    contents:
      inline: |
        pool 0.rhel.pool.ntp.org iburst 4
        driftfile /var/lib/chrony/drift
        makestep 1.0 3
        rtcsync
        logdir /var/log/chrony
```

1 1 2 On control plane nodes, substitute **master** for **worker** in both of these locations.

3 Specify an octal value mode for the **mode** field in the machine config file. After creating the file and applying the changes, the **mode** is converted to a decimal value. You can check the YAML file with the command **oc get mc <mc-name> -o yaml**.

4 Specify any valid, reachable time source, such as the one provided by your DHCP server.



NOTE

For all-machine to all-machine communication, the Network Time Protocol (NTP) on UDP is port **123**. If an external NTP time server is configured, you must open UDP port **123**.

Alternatively, you can specify any of the following NTP servers: **1.rhel.pool.ntp.org**, **2.rhel.pool.ntp.org**, or **3.rhel.pool.ntp.org**. When you use NTP with your DHCP server, you must set the **sourcedir /run/chrony-dhcp** parameter in the **chrony.conf** file.

2. Use Butane to generate a **MachineConfig** object file, **99-worker-chrony.yaml**, containing the configuration to be delivered to the nodes:

```
$ butane 99-worker-chrony.bu -o 99-worker-chrony.yaml
```

3. Apply the configurations in one of two ways:

   - If the cluster is not running yet, after you generate manifest files, add the **MachineConfig** object file to the **<installation_directory>/openshift** directory, and then continue to create the cluster.

   - If the cluster is already running, apply the file:

```
$ oc apply -f ./99-worker-chrony.yaml
```

Additional resources

- Creating machine configs with Butane

2.2. DISABLING THE CHRONY TIME SERVICE

You can disable the chrony time service (**chronyd**) for nodes with a specific role by using a **MachineConfig** custom resource (CR).

Prerequisites

- Install the OpenShift CLI (**oc**).
- Log in as a user with **cluster-admin** privileges.

Procedure

1. Create the **MachineConfig** CR that disables **chronyd** for the specified node role.
   a. Save the following YAML in the **disable-chronyd.yaml** file:

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: <node_role> 1
  name: disable-chronyd
spec:
  config:
    ignition:
      version: 3.4.0
    systemd:
      units:
        - contents: |
            [Unit]
            Description=NTP client/server
            Documentation=man:chronyd(8) man:chrony.conf(5)
            After=ntpdate.service sntp.service ntpd.service
            Conflicts=ntpd.service systemd-timesyncd.service
            ConditionCapability=CAP_SYS_TIME
            [Service]
            Type=forking
            PIDFile=/run/chrony/chronyd.pid
            EnvironmentFile=-/etc/sysconfig/chronyd
            ExecStart=/usr/sbin/chronyd $OPTIONS
            ExecStartPost=/usr/libexec/chrony-helper update-daemon
            PrivateTmp=yes
            ProtectHome=yes
            ProtectSystem=full
            [Install]
            WantedBy=multi-user.target
          enabled: false
          name: "chronyd.service"
        - name: "kubelet-dependencies.target"
          contents: |
            [Unit]
            Description=Dependencies necessary to run kubelet
            Documentation=https://github.com/openshift/machine-config-operator/
            Requires=basic.target network-online.target
            Wants=NetworkManager-wait-online.service crio-wipe.service
            Wants=rpc-statd.service
```

1 Node role where you want to disable **chronyd**, for example, **master**.

b. Create the **MachineConfig** CR by running the following command:

```
$ oc create -f disable-chronyd.yaml
```

2.3. ADDING KERNEL ARGUMENTS TO NODES

In some special cases, you can add kernel arguments to a set of nodes in your cluster to customize the kernel behavior to meet specific needs you might have.

You should add kernel arguments with caution and a clear understanding of the implications of the arguments you set.

WARNING

Improper use of kernel arguments can result in your systems becoming unbootable.

Examples of kernel arguments you could set include:

- **nosmt**: Disables symmetric multithreading (SMT) in the kernel. Multithreading allows multiple logical threads for each CPU. You could consider **nosmt** in multi-tenant environments to reduce risks from potential cross-thread attacks. By disabling SMT, you essentially choose security over performance.
- **systemd.unified_cgroup_hierarchy**: Enables Linux control group version 2 (cgroup v2). cgroup v2 is the next version of the kernel control group and offers multiple improvements.

IMPORTANT

cgroup v1 is a deprecated feature. Deprecated functionality is still included in OpenShift Container Platform and continues to be supported; however, it will be removed in a future release of this product and is not recommended for new deployments.

For the most recent list of major functionality that has been deprecated or removed within OpenShift Container Platform, refer to the *Deprecated and removed features* section of the OpenShift Container Platform release notes.

- **enforcing=0**: Configures Security Enhanced Linux (SELinux) to run in permissive mode. In permissive mode, the system acts as if SELinux is enforcing the loaded security policy, including labeling objects and emitting access denial entries in the logs, but it does not actually deny any operations. While not supported for production systems, permissive mode can be helpful for debugging.

WARNING

Disabling SELinux on RHCOS in production is not supported. After SELinux has been disabled on a node, it must be re-provisioned before re-inclusion in a production cluster.

See Kernel.org kernel parameters for a list and descriptions of kernel arguments.

In the following procedure, you create a **MachineConfig** object that identifies:

- A set of machines to which you want to add the kernel argument. In this case, machines with a worker role.
- Kernel arguments that are appended to the end of the existing kernel arguments.
- A label that indicates where in the list of machine configs the change is applied.

Prerequisites

- You have **cluster-admin** privileges.
- Your cluster is running.

Procedure

1. List existing **MachineConfig** objects for your OpenShift Container Platform cluster to determine how to label your machine config:

```
$ oc get MachineConfig
```

Example output

```
NAME                                               GENERATEDBYCONTROLLER
IGNITIONVERSION   AGE
00-master                                          52dd3ba6a9a527fc3ab42afac8d12b693534c8c9   3.4.0
33m
00-worker                                          52dd3ba6a9a527fc3ab42afac8d12b693534c8c9   3.4.0
33m
01-master-container-runtime                              52dd3ba6a9a527fc3ab42afac8d12b693534c8c9
3.4.0             33m
01-master-kubelet                                      52dd3ba6a9a527fc3ab42afac8d12b693534c8c9
3.4.0             33m
01-worker-container-runtime                              52dd3ba6a9a527fc3ab42afac8d12b693534c8c9
3.4.0             33m
01-worker-kubelet                                      52dd3ba6a9a527fc3ab42afac8d12b693534c8c9
3.4.0             33m
99-master-generated-registries                           52dd3ba6a9a527fc3ab42afac8d12b693534c8c9
3.4.0             33m
99-master-ssh                                                                 3.2.0             40m
99-worker-generated-registries                           52dd3ba6a9a527fc3ab42afac8d12b693534c8c9
```

```
3.4.0             33m
99-worker-ssh                                                 3.2.0             40m
rendered-master-23e785de7587df95a4b517e0647e5ab7
52dd3ba6a9a527fc3ab42afac8d12b693534c8c9   3.4.0             33m
rendered-worker-5d596d9293ca3ea80c896a1191735bb1
52dd3ba6a9a527fc3ab42afac8d12b693534c8c9   3.4.0             33m
```

2. Create a **MachineConfig** object file that identifies the kernel argument (for example, **05-worker-kernelarg-selinuxpermissive.yaml**)

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 05-worker-kernelarg-selinuxpermissive
spec:
  kernelArguments:
    - enforcing=0
```

where:

machineconfiguration.openshift.io/role

Specifies a label to apply changes to specific nodes.

name

Specifies a name to identify where it fits among the machine configs (05) and what it does (adds a kernel argument to configure SELinux permissive mode).

kernelArguments

Specifies the exact kernel argument as **enforcing=0**.

3. Create the new machine config:

```
$ oc create -f 05-worker-kernelarg-selinuxpermissive.yaml
```

4. Check the machine configs to see that the new one was added:

```
$ oc get MachineConfig
```

Example output

```
NAME                                               GENERATEDBYCONTROLLER
IGNITIONVERSION   AGE
00-master                                          52dd3ba6a9a527fc3ab42afac8d12b693534c8c9   3.4.0
33m
00-worker                                          52dd3ba6a9a527fc3ab42afac8d12b693534c8c9   3.4.0
33m
01-master-container-runtime                              52dd3ba6a9a527fc3ab42afac8d12b693534c8c9
3.4.0             33m
01-master-kubelet                                      52dd3ba6a9a527fc3ab42afac8d12b693534c8c9
3.4.0             33m
01-worker-container-runtime                              52dd3ba6a9a527fc3ab42afac8d12b693534c8c9
3.4.0             33m
01-worker-kubelet                                      52dd3ba6a9a527fc3ab42afac8d12b693534c8c9
```

```
3.4.0             33m
05-worker-kernelarg-selinuxpermissive                                3.4.0             105s
99-master-generated-registries                 52dd3ba6a9a527fc3ab42afac8d12b693534c8c9
3.4.0             33m
99-master-ssh                                                        3.2.0             40m
99-worker-generated-registries                 52dd3ba6a9a527fc3ab42afac8d12b693534c8c9
3.4.0             33m
99-worker-ssh                                                        3.2.0             40m
rendered-master-23e785de7587df95a4b517e0647e5ab7
52dd3ba6a9a527fc3ab42afac8d12b693534c8c9   3.4.0             33m
rendered-worker-5d596d9293ca3ea80c896a1191735bb1
52dd3ba6a9a527fc3ab42afac8d12b693534c8c9   3.4.0             33m
```

5. Check the nodes:

```
$ oc get nodes
```

Example output

```
NAME                         STATUS                     ROLES    AGE   VERSION
ip-10-0-136-161.ec2.internal   Ready                      worker   28m   v1.31.3
ip-10-0-136-243.ec2.internal   Ready                      master   34m   v1.31.3
ip-10-0-141-105.ec2.internal   Ready,SchedulingDisabled   worker   28m   v1.31.3
ip-10-0-142-249.ec2.internal   Ready                      master   34m   v1.31.3
ip-10-0-153-11.ec2.internal    Ready                      worker   28m   v1.31.3
ip-10-0-153-150.ec2.internal   Ready                      master   34m   v1.31.3
```

You can see that scheduling on each worker node is disabled as the change is being applied.

6. Check that the kernel argument worked by going to one of the worker nodes and listing the kernel command-line arguments (in **/proc/cmdline** on the host):

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

Example output

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

sh-4.2# cat /host/proc/cmdline
BOOT_IMAGE=/ostree/rhcos-... console=tty0 console=ttyS0,115200n8
rootflags=defaults,prjquota rw root=UUID=fd0... ostree=/ostree/boot.0/rhcos/16...
coreos.oem.id=qemu coreos.oem.id=ec2 ignition.platform.id=ec2 enforcing=0

sh-4.2# exit
```

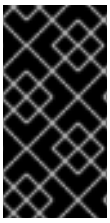
You should see the **enforcing=0** argument added to the other kernel arguments.

2.4. ENABLING MULTIPATHING WITH KERNEL ARGUMENTS ON RHCOS

IMPORTANT

Enabling multipathing during installation is supported and recommended for nodes provisioned in OpenShift Container Platform. In setups where any I/O to non-optimized paths results in I/O system errors, you must enable multipathing at installation time. For more information about enabling multipathing during installation time, see "Enabling multipathing post installation" in the *Installing on bare metal* documentation.

Red Hat Enterprise Linux CoreOS (RHCOS) supports multipathing on the primary disk, allowing stronger resilience to hardware failure to achieve higher host availability. Postinstallation support is available by activating multipathing via the machine config.



IMPORTANT

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

IMPORTANT

When an OpenShift Container Platform cluster is installed or configured as a postinstallation activity on a single VIOS host with "vSCSI" storage on IBM Power® with multipath configured, the CoreOS nodes with multipath enabled fail to boot. This behavior is expected, as only one path is available to the node.

Prerequisites

- You have a running OpenShift Container Platform cluster.
- You are logged in to the cluster as a user with administrative privileges.
- You have confirmed that the disk is enabled for multipathing. Multipathing is only supported on hosts that are connected to a SAN via an HBA adapter.

Procedure

1. To enable multipathing postinstallation on control plane nodes:
   - Create a machine config file, such as **99-master-kargs-mpath.yaml**, that instructs the cluster to add the **master** label and that identifies the multipath kernel argument, for example:

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: "master"
  name: 99-master-kargs-mpath
spec:
  kernelArguments:
    - 'rd.multipath=default'
    - 'root=/dev/disk/by-label/dm-mpath-root'
```

2. To enable multipathing postinstallation on worker nodes:

   - Create a machine config file, such as **99-worker-kargs-mpath.yaml**, that instructs the cluster to add the **worker** label and that identifies the multipath kernel argument, for example:

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: "worker"
  name: 99-worker-kargs-mpath
spec:
  kernelArguments:
    - 'rd.multipath=default'
    - 'root=/dev/disk/by-label/dm-mpath-root'
```

3. Create the new machine config by using either the master or worker YAML file you previously created:

```
$ oc create -f ./99-worker-kargs-mpath.yaml
```

4. Check the machine configs to see that the new one was added:

```
$ oc get MachineConfig
```

Example output

```
NAME                                               GENERATEDBYCONTROLLER
IGNITIONVERSION   AGE
00-master                                          52dd3ba6a9a527fc3ab42afac8d12b693534c8c9   3.4.0
33m
00-worker                                          52dd3ba6a9a527fc3ab42afac8d12b693534c8c9   3.4.0
33m
01-master-container-runtime                              52dd3ba6a9a527fc3ab42afac8d12b693534c8c9
3.4.0             33m
01-master-kubelet                                        52dd3ba6a9a527fc3ab42afac8d12b693534c8c9
3.4.0             33m
01-worker-container-runtime                              52dd3ba6a9a527fc3ab42afac8d12b693534c8c9
3.4.0             33m
01-worker-kubelet                                        52dd3ba6a9a527fc3ab42afac8d12b693534c8c9
3.4.0             33m
99-master-generated-registries                           52dd3ba6a9a527fc3ab42afac8d12b693534c8c9
3.4.0             33m
99-master-ssh                                                                3.2.0             40m
99-worker-generated-registries                           52dd3ba6a9a527fc3ab42afac8d12b693534c8c9
3.4.0             33m
99-worker-kargs-mpath                                    52dd3ba6a9a527fc3ab42afac8d12b693534c8c9
3.4.0             105s
99-worker-ssh                                                                3.2.0             40m
rendered-master-23e785de7587df95a4b517e0647e5ab7
52dd3ba6a9a527fc3ab42afac8d12b693534c8c9   3.4.0             33m
rendered-worker-5d596d9293ca3ea80c896a1191735bb1
52dd3ba6a9a527fc3ab42afac8d12b693534c8c9   3.4.0             33m
```

5. Check the nodes:

```
$ oc get nodes
```

Example output

```
NAME                         STATUS                        ROLES    AGE   VERSION
ip-10-0-136-161.ec2.internal   Ready                         worker   28m   v1.31.3
ip-10-0-136-243.ec2.internal   Ready                         master   34m   v1.31.3
ip-10-0-141-105.ec2.internal   Ready,SchedulingDisabled      worker   28m   v1.31.3
ip-10-0-142-249.ec2.internal   Ready                         master   34m   v1.31.3
ip-10-0-153-11.ec2.internal    Ready                         worker   28m   v1.31.3
ip-10-0-153-150.ec2.internal   Ready                         master   34m   v1.31.3
```

You can see that scheduling on each worker node is disabled as the change is being applied.

6. Check that the kernel argument worked by going to one of the worker nodes and listing the kernel command-line arguments (in **/proc/cmdline** on the host):

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

Example output

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

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

sh-4.2# exit
```

You should see the added kernel arguments.

Additional resources

- See Enabling multipathing with kernel arguments on RHCOS for more information about enabling multipathing during installation time.

2.5. ADDING A REAL-TIME KERNEL TO NODES

If your OpenShift Container Platform workloads require real-time operating system characteristics, you can switch your machines to the Linux real-time kernel. Switching to the real-time kernel provides a higher degree of determinism for your OpenShift Container Platform workloads.

Even though Linux is not a real-time operating system, the Linux real-time kernel includes a preemptive scheduler that provides the operating system with real-time characteristics. For OpenShift Container Platform, 4.18 you can make the switch to real-time kernel by using a **MachineConfig** object.

Although making the change is as simple as changing a machine config **kernelType** setting to **realtime**, there are a few other considerations before making the change:

- Currently, real-time kernel is supported only on worker nodes, and only for radio access network (RAN) use.
- The following procedure is fully supported with bare metal installations that use systems that are certified for Red Hat Enterprise Linux for Real Time 8.
- Real-time support in OpenShift Container Platform is limited to specific subscriptions.
- The following procedure is also supported for use with Google Cloud.

Prerequisites

- Have a running OpenShift Container Platform cluster (version 4.4 or later).
- Log in to the cluster as a user with administrative privileges.

Procedure

1. Create a machine config for the real-time kernel: Create a YAML file (for example, **99-worker-realtime.yaml**) that contains a **MachineConfig** object for the **realtime** kernel type. This example tells the cluster to use a real-time kernel for all worker nodes:

```
$ cat << EOF > 99-worker-realtime.yaml
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: "worker"
  name: 99-worker-realtime
spec:
  kernelType: realtime
EOF
```

2. Add the machine config to the cluster. Type the following to add the machine config to the cluster:

```
$ oc create -f 99-worker-realtime.yaml
```

3. Check the real-time kernel: Once each impacted node reboots, log in to the cluster and run the following commands to make sure that the real-time kernel has replaced the regular kernel for the set of nodes you configured:

```
$ oc get nodes
```

Example output

```
NAME                                        STATUS  ROLES    AGE   VERSION
ip-10-0-143-147.us-east-2.compute.internal  Ready   worker   103m  v1.31.3
ip-10-0-146-92.us-east-2.compute.internal   Ready   worker   101m  v1.31.3
ip-10-0-169-2.us-east-2.compute.internal    Ready   worker   102m  v1.31.3
```

```
$ oc debug node/ip-10-0-143-147.us-east-2.compute.internal
```

Example output

```
Starting pod/ip-10-0-143-147us-east-2computeinternal-debug ...
To use host binaries, run `chroot /host`

sh-4.4# uname -a
Linux <worker_node> 4.18.0-147.3.1.rt24.96.el8_1.x86_64 #1 SMP PREEMPT RT
        Wed Nov 27 18:29:55 UTC 2019 x86_64 x86_64 x86_64 GNU/Linux
```

The kernel name contains **rt** and text “PREEMPT RT” indicates that this is a real-time kernel.

4. To go back to the regular kernel, delete the **MachineConfig** object:

```
$ oc delete -f 99-worker-realtime.yaml
```

2.6. CONFIGURING JOURNALD SETTINGS

If you need to configure settings for the **journald** service on OpenShift Container Platform nodes, you can do that by modifying the appropriate configuration file and passing the file to the appropriate pool of nodes as a machine config.

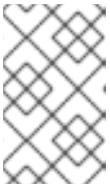
This procedure describes how to modify **journald** rate limiting settings in the **/etc/systemd/journald.conf** file and apply them to worker nodes. See the **journald.conf** man page for information on how to use that file.

Prerequisites

- Have a running OpenShift Container Platform cluster.
- Log in to the cluster as a user with administrative privileges.

Procedure

1. Create a Butane config file, **40-worker-custom-journald.bu**, that includes an **/etc/systemd/journald.conf** file with the required settings.



NOTE

The Butane version you specify in the config file should match the OpenShift Container Platform version and always ends in **0**. For example, **4.18.0**. See "Creating machine configs with Butane" for information about Butane.

```
variant: openshift
version: 4.18.0
metadata:
  name: 40-worker-custom-journald
  labels:
    machineconfiguration.openshift.io/role: worker
storage:
  files:
  - path: /etc/systemd/journald.conf
    mode: 0644
    overwrite: true
```

```
    contents:
      inline: |
        # Disable rate limiting
        RateLimitInterval=1s
        RateLimitBurst=10000
        Storage=volatile
        Compress=no
        MaxRetentionSec=30s
```

2. Use Butane to generate a **MachineConfig** object file, **40-worker-custom-journald.yaml**, containing the configuration to be delivered to the worker nodes:

```
$ butane 40-worker-custom-journald.bu -o 40-worker-custom-journald.yaml
```

3. Apply the machine config to the pool:

```
$ oc apply -f 40-worker-custom-journald.yaml
```

4. Check that the new machine config is applied and that the nodes are not in a degraded state. It might take a few minutes. The worker pool will show the updates in progress, as each node successfully has the new machine config applied:

```
$ oc get machineconfigpool
```

Example output

```
NAME   CONFIG              UPDATED UPDATING DEGRADED MACHINECOUNT
READYMACHINECOUNT UPDATEDMACHINECOUNT DEGRADEDMACHINECOUNT
AGE
master rendered-master-35 True    False    False    3          3              3                0
34m
worker rendered-worker-d8 False   True     False    3          1              1                0
34m
```

5. To check that the change was applied, you can log in to a worker node:

```
$ oc get node | grep worker
```

Example output

```
ip-10-0-0-1.us-east-2.compute.internal   Ready    worker   39m   v0.0.0-master+$Format:%h$
```

```
$ oc debug node/ip-10-0-0-1.us-east-2.compute.internal
```

Example output

```
Starting pod/ip-10-0-141-142us-east-2computeinternal-debug ...
...
sh-4.2# chroot /host
sh-4.4# cat /etc/systemd/journald.conf
# Disable rate limiting
RateLimitInterval=1s
```

```
RateLimitBurst=10000
Storage=volatile
Compress=no
MaxRetentionSec=30s
sh-4.4# exit
```

Additional resources

- Creating machine configs with Butane

2.7. ADDING EXTENSIONS TO RHCOS

RHCOS is a minimal container-oriented RHEL operating system, designed to provide a common set of capabilities to OpenShift Container Platform clusters across all platforms. Although adding software packages to RHCOS systems is generally discouraged, the MCO provides an **extensions** feature you can use to add a minimal set of features to RHCOS nodes.

Currently, the following extensions are available:

- **usbguard**: The **usbguard** extension protects RHCOS systems from attacks by intrusive USB devices. For more information, see USBGuard for details.
- **kerberos**: The **kerberos** extension provides a mechanism that allows both users and machines to identify themselves to the network to receive defined, limited access to the areas and services that an administrator has configured. For more information, see Using Kerberos for details, including how to set up a Kerberos client and mount a Kerberized NFS share.
- **sandboxed-containers**: The **sandboxed-containers** extension contains RPMs for Kata, QEMU, and its dependencies. For more information, see OpenShift Sandboxed Containers.
- **ipsec**: The **ipsec** extension contains RPMs for libreswan and NetworkManager-libreswan.
- **wasm**: The **wasm** extension enables Developer Preview functionality in OpenShift Container Platform for users who want to use WASM-supported workloads.
- **sysstat**: Adding the **sysstat** extension provides additional performance monitoring for OpenShift Container Platform nodes, including the system activity reporter (**sar**) command for collecting and reporting information.
- **kernel-devel**: The **kernel-devel** extension provides kernel headers and makefiles sufficient to build modules against the kernel package.

The following procedure describes how to use a machine config to add one or more extensions to your RHCOS nodes.

Prerequisites

- Have a running OpenShift Container Platform cluster (version 4.6 or later).
- Log in to the cluster as a user with administrative privileges.

Procedure

1. Create a machine config for extensions: Create a YAML file (for example, **80-extensions.yaml**) that contains a **MachineConfig extensions** object. This example tells the cluster to add the **usbguard** extension.

```
$ cat << EOF > 80-extensions.yaml
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 80-worker-extensions
spec:
  config:
    ignition:
      version: 3.4.0
  extensions:
    - usbguard
EOF
```

2. Add the machine config to the cluster. Type the following to add the machine config to the cluster:

```
$ oc create -f 80-extensions.yaml
```

   This sets all worker nodes to have rpm packages for **usbguard** installed.

3. Check that the extensions were applied:

```
$ oc get machineconfig 80-worker-extensions
```

   Example output

```
NAME                 GENERATEDBYCONTROLLER IGNITIONVERSION AGE
80-worker-extensions                       3.4.0          57s
```

4. Check that the new machine config is now applied and that the nodes are not in a degraded state. It may take a few minutes. The worker pool will show the updates in progress, as each machine successfully has the new machine config applied:

```
$ oc get machineconfigpool
```

   Example output

```
NAME   CONFIG              UPDATED UPDATING DEGRADED MACHINECOUNT
READYMACHINECOUNT UPDATEDMACHINECOUNT DEGRADEDMACHINECOUNT
AGE
master rendered-master-35 True    False    False    3          3              3                0
34m
worker rendered-worker-d8 False   True     False    3          1              1                0
34m
```

5. Check the extensions. To check that the extension was applied, run:

```
$ oc get node | grep worker
```

Example output

```
NAME                                STATUS  ROLES    AGE   VERSION
ip-10-0-169-2.us-east-2.compute.internal    Ready   worker   102m  v1.31.3
```

```
$ oc debug node/ip-10-0-169-2.us-east-2.compute.internal
```

Example output

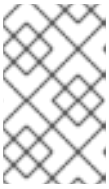
```
...
To use host binaries, run `chroot /host`
sh-4.4# chroot /host
sh-4.4# rpm -q usbguard
usbguard-0.7.4-4.el8.x86_64.rpm
```

2.8. LOADING CUSTOM FIRMWARE BLOBS IN THE MACHINE CONFIG MANIFEST

Because the default location for firmware blobs in **/usr/lib** is read-only, you can locate a custom firmware blob by updating the search path. This enables you to load local firmware blobs in the machine config manifest when the blobs are not managed by RHCOS.

Procedure

1. Create a Butane config file, **98-worker-firmware-blob.bu**, that updates the search path so that it is root-owned and writable to local storage. The following example places the custom blob file from your local workstation onto nodes under **/var/lib/firmware**.



NOTE

The Butane version you specify in the config file should match the OpenShift Container Platform version and always ends in **0**. For example, **4.18.0**. See "Creating machine configs with Butane" for information about Butane.

Butane config file for custom firmware blob

```
variant: openshift
version: 4.18.0
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 98-worker-firmware-blob
storage:
  files:
  - path: /var/lib/firmware/<package_name> 1
    contents:
      local: <package_name> 2
    mode: 0644 3
```

```
openshift:
  kernel_arguments:
    - 'firmware_class.path=/var/lib/firmware' (4)
```

(1) Sets the path on the node where the firmware package is copied to.

(2) Specifies a file with contents that are read from a local file directory on the system running Butane. The path of the local file is relative to a **files-dir** directory, which must be specified by using the **--files-dir** option with Butane in the following step.

(3) Sets the permissions for the file on the RHCOS node. It is recommended to set **0644** permissions.

(4) The **firmware_class.path** parameter customizes the kernel search path of where to look for the custom firmware blob that was copied from your local workstation onto the root file system of the node. This example uses **/var/lib/firmware** as the customized path.

2. Run Butane to generate a **MachineConfig** object file that uses a copy of the firmware blob on your local workstation named **98-worker-firmware-blob.yaml**. The firmware blob contains the configuration to be delivered to the nodes. The following example uses the **--files-dir** option to specify the directory on your workstation where the local file or files are located:

```
$ butane 98-worker-firmware-blob.bu -o 98-worker-firmware-blob.yaml --files-dir
<directory_including_package_name>
```

3. Apply the configurations to the nodes in one of two ways:

   - If the cluster is not running yet, after you generate manifest files, add the **MachineConfig** object file to the **<installation_directory>/openshift** directory, and then continue to create the cluster.

   - If the cluster is already running, apply the file:

     ```
     $ oc apply -f 98-worker-firmware-blob.yaml
     ```

     A **MachineConfig** object YAML file is created for you to finish configuring your machines.

4. Save the Butane config in case you need to update the **MachineConfig** object in the future.

Additional resources

- Creating machine configs with Butane

2.9. CHANGING THE CORE USER PASSWORD FOR NODE ACCESS

By default, Red Hat Enterprise Linux CoreOS (RHCOS) creates a user named **core** on the nodes in your cluster. You can use the **core** user to access the node through a cloud provider serial console or a bare metal baseboard controller manager (BMC). This can be helpful, for example, if a node is down and you cannot access that node by using SSH or the **oc debug node** command. However, by default, there is no password for this user, so you cannot log in without creating one.

You can create a password for the **core** user by using a machine config. The Machine Config Operator (MCO) assigns the password and injects the password into the **/etc/shadow** file, allowing you to log in

with the **core** user. The MCO does not examine the password hash. As such, the MCO cannot report if there is a problem with the password.

NOTE

- The password works only through a cloud provider serial console or a BMC. It does not work with SSH.
- If you have a machine config that includes an /**etc**/**shadow** file or a systemd unit that sets a password, it takes precedence over the password hash.

You can change the password, if needed, by editing the machine config you used to create the password. Also, you can remove the password by deleting the machine config. Deleting the machine config does not remove the user account.

Procedure

1. Using a tool that is supported by your operating system, create a hashed password. For example, create a hashed password using **mkpasswd** by running the following command:

```
$ mkpasswd -m SHA-512 testpass
```

Example output

```
$
$6$CBZwA6s6AVFOtiZe$aUKDWpthhJEyR3nnhM02NM1sKCpHn9XN.NPrJNQ3HYewioaorp
wL3mKGLxvW0AOb4pJxqoqP4nFX77y0p00.8.
```

2. Create a machine config file that contains the **core** username and the hashed password:

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: set-core-user-password
spec:
  config:
    ignition:
      version: 3.4.0
    passwd:
      users:
      - name: core 1
        passwordHash: <password> 2
```

1. This must be **core**.
2. The hashed password to use with the **core** account.

3. Create the machine config by running the following command:

```
$ oc create -f <file-name>.yaml
```

The nodes do not reboot and should become available in a few moments. You can use the **oc get mcp** to watch for the machine config pools to be updated, as shown in the following example:

```
NAME     CONFIG                                             UPDATED   UPDATING   DEGRADED
MACHINECOUNT   READYMACHINECOUNT   UPDATEDMACHINECOUNT
DEGRADEDMACHINECOUNT   AGE
master   rendered-master-d686a3ffc8fdec47280afec446fce8dd   True      False      False      3
3              3                   0                   64m
worker   rendered-worker-4605605a5b1f9de1d061e9d350f251e5   False     True       False
3              0                   0                   0                   64m
```

Verification

1. After the nodes return to the **UPDATED=True** state, start a debug session for a node by running the following command:

```
$ oc debug node/<node_name>
```

2. Set **/host** as the root directory within the debug shell by running the following command:

```
sh-4.4# chroot /host
```

3. Check the contents of the **/etc/shadow** file:

Example output

```
...
core:$6$2sE/010goDuRSxxv$o18K52wor.wlwZp:19418:0:99999:7:::
...
```

The hashed password is assigned to the **core** user.

CHAPTER 3. USING NODE DISRUPTION POLICIES TO MINIMIZE DISRUPTION FROM MACHINE CONFIG CHANGES

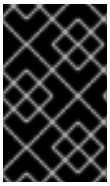
By default, when you make certain changes to the fields in a **MachineConfig** object, the Machine Config Operator (MCO) drains and reboots the nodes associated with that machine config. However, you can create a *node disruption policy* that defines a set of changes to some Ignition config objects that would require little or no disruption to your workloads.

A node disruption policy allows you to define the configuration changes that cause a disruption to your cluster, and which changes do not. This allows you to reduce node downtime when making small machine configuration changes in your cluster. To configure the policy, you modify the **MachineConfiguration** object, which is in the **openshift-machine-config-operator** namespace. See the example node disruption policies in the **MachineConfiguration** objects that follow.

NOTE

There are machine configuration changes that always require a reboot, regardless of any node disruption policies. For more information, see *About the Machine Config Operator* .

After you create the node disruption policy, the MCO validates the policy to search for potential issues in the file, such as problems with formatting. The MCO then merges the policy with the cluster defaults and populates the **status.nodeDisruptionPolicyStatus** fields in the machine config with the actions to be performed upon future changes to the machine config. The configurations in your policy always overwrite the cluster defaults.



IMPORTANT

The MCO does not validate whether a change can be successfully applied by your node disruption policy. Therefore, you are responsible to ensure the accuracy of your node disruption policies.

For example, you can configure a node disruption policy so that sudo configurations do not require a node drain and reboot. Or, you can configure your cluster so that updates to **sshd** are applied with only a reload of that one service.

You can control the behavior of the MCO when making the changes to the following Ignition configuration objects:

- **configuration files**: You add to or update the files in the **/var** or **/etc** directory. You can configure a policy for a specific file anywhere in the directory or for a path to a specific directory. For a path, a change or addition to any file in that directory triggers the policy.

  NOTE

  If a file is included in more than one policy, only the policy with the best match to that file is applied.

  For example, if you have a policy for the **/etc/** directory and a policy for the **/etc/pki/** directory, a change to the **/etc/pki/tls/certs/ca-bundle.crt** file would apply the **etc/pki** policy.

- **systemd units**: You create and set the status of a systemd service or modify a systemd service.

- **users and groups**: You change SSH keys in the **passwd** section postinstallation.
- **ICSP**, **ITMS**, **IDMS** objects: You can remove mirroring rules from an **ImageContentSourcePolicy** (ICSP), **ImageTagMirrorSet** (ITMS), and **ImageDigestMirrorSet** (IDMS) object.

When you make any of these changes, the node disruption policy determines which of the following actions are required when the MCO implements the changes:

- **Reboot**: The MCO drains and reboots the nodes. This is the default behavior.
- **None**: The MCO does not drain or reboot the nodes. The MCO applies the changes with no further action.
- **Drain**: The MCO cordons and drains the nodes of their workloads. The workloads restart with the new configurations.
- **Reload**: For services, the MCO reloads the specified services without restarting the service.
- **Restart**: For services, the MCO fully restarts the specified services.
- **DaemonReload**: The MCO reloads the systemd manager configuration.
- **Special**: This is an internal MCO-only action that is set by default for changes to the **/etc/containers/registries.conf** file. When this action is set, the MCO determines if a node cordon and drain is required, based on the changed content in the **registries.conf** file. You can override this setting. However, this is not recommended. You cannot set this action for another path or service.

NOTE

- The **Reboot** and **None** actions cannot be used with any other actions, as the **Reboot** and **None** actions override the others.
- Actions are applied in the order that they are set in the node disruption policy list.
- If you make other machine config changes that do require a reboot or other disruption to the nodes, that reboot supercedes the node disruption policy actions.

3.1. EXAMPLE NODE DISRUPTION POLICIES

You can use the following example **MachineConfiguration** objects to help you create a node disruption policy that can help reduce disruption to the workloads in your cluster.

TIP

A **MachineConfiguration** object and a **MachineConfig** object are different objects. A **MachineConfiguration** object is a singleton object in the MCO namespace that contains configuration parameters for the MCO operator. A **MachineConfig** object defines changes that are applied to a machine config pool.

The following example **MachineConfiguration** object shows no user defined policies. The default node disruption policy values are shown in the **status** stanza.

Default node disruption policy

```
apiVersion: operator.openshift.io/v1
kind: MachineConfiguration
metadata:
  name: cluster
spec:
  logLevel: Normal
  managementState: Managed
  operatorLogLevel: Normal
status:
  nodeDisruptionPolicyStatus:
    clusterPolicies:
      files:
      - actions:
        - type: None
        path: /etc/mco/internal-registry-pull-secret.json
      - actions:
        - type: None
        path: /var/lib/kubelet/config.json
      - actions:
        - reload:
            serviceName: crio.service
          type: Reload
        path: /etc/machine-config-daemon/no-reboot/containers-gpg.pub
      - actions:
        - reload:
            serviceName: crio.service
          type: Reload
        path: /etc/containers/policy.json
      - actions:
        - type: Special
        path: /etc/containers/registries.conf
      - actions:
        - reload:
            serviceName: crio.service
          type: Reload
        path: /etc/containers/registries.d
      - actions:
        - type: None
        path: /etc/nmstate/openshift
      - actions:
        - restart:
            serviceName: coreos-update-ca-trust.service
          type: Restart
        - restart:
            serviceName: crio.service
          type: Restart
        path: /etc/pki/ca-trust/source/anchors/openshift-config-user-ca-bundle.crt
      sshkey:
        actions:
        - type: None
  observedGeneration: 9
```

The default node disruption policy does not contain a policy for changes to the

/etc/containers/registries.conf.d file. This is because both OpenShift Container Platform and Red Hat Enterprise Linux (RHEL) use the **registries.conf.d** file to specify aliases for image short names. It is recommended that you always pull an image by its fully-qualified name. This is particularly important with public registries, because the image might not deploy if the public registry requires authentication. You can create a user-defined policy to use with the **/etc/containers/registries.conf.d** file, if you need to use image short names.

In the following example, when changes are made to the **registries.conf.d** file, the MCO restarts the **crio-service**.

Example node disruption policy for a change to the registries.conf.d file

```
apiVersion: operator.openshift.io/v1
kind: MachineConfiguration
metadata:
  name: cluster
  namespace: openshift-machine-config-operator
spec:
  nodeDisruptionPolicy:
    files:
      - path: /etc/containers/registries.conf.d
        actions:
          - type: Restart
            restart:
              serviceName: crio.service
```

In the following example, when changes are made to the SSH keys, the MCO reloads the systemd manager configuration, and restarts the **crio-service**.

Example node disruption policy for an SSH key change

```
apiVersion: operator.openshift.io/v1
kind: MachineConfiguration
metadata:
  name: cluster
# ...
spec:
  nodeDisruptionPolicy:
    sshkey:
      actions:
      - type: DaemonReload
      - type: Restart
          restart:
            serviceName: crio.service

# ...
```

In the following example, when changes are made to the **/etc/chrony.conf** file, the MCO restarts the **chronyd.service** on the cluster nodes. If files are added to or modified in the **/var/run** directory, the MCO applies the changes with no further action.

Example node disruption policy for a configuration file change

```
apiVersion: operator.openshift.io/v1
```

```
kind: MachineConfiguration
metadata:
  name: cluster
# ...
spec:
  nodeDisruptionPolicy:
    files:
    - actions:
      - restart:
          serviceName: chronyd.service
        type: Restart
      path: /etc/chrony.conf
    - actions:
      - type: None
      path: /var/run
```

In the following example, when changes are made to the **auditd.service** systemd unit, the MCO drains the cluster nodes, reloads the **crio.service**, reloads the systemd manager configuration, and restarts the **crio.service**.

Example node disruption policy for a systemd unit change

```
apiVersion: operator.openshift.io/v1
kind: MachineConfiguration
metadata:
  name: cluster
# ...
spec:
  nodeDisruptionPolicy:
    units:
      - name: auditd.service
        actions:
          - type: Drain
          - type: Reload
            reload:
              serviceName: crio.service
          - type: DaemonReload
          - type: Restart
            restart:
              serviceName: crio.service
```

3.2. CONFIGURING NODE RESTART BEHAVIORS UPON MACHINE CONFIG CHANGES

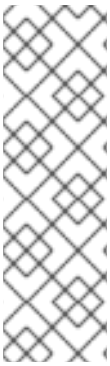
You can create a node disruption policy to define the machine configuration changes that cause a disruption to your cluster, and which changes do not.

You can control how your nodes respond to changes in the files in the **/var** or **/etc** directory, the systemd units, the SSH keys, and the **registries.conf** file.

When you make any of these changes, the node disruption policy determines which of the following actions are required when the MCO implements the changes:

- **Reboot**: The MCO drains and reboots the nodes. This is the default behavior.

- **None**: The MCO does not drain or reboot the nodes. The MCO applies the changes with no further action.
- **Drain**: The MCO cordons and drains the nodes of their workloads. The workloads restart with the new configurations.
- **Reload**: For services, the MCO reloads the specified services without restarting the service.
- **Restart**: For services, the MCO fully restarts the specified services.
- **DaemonReload**: The MCO reloads the systemd manager configuration.
- **Special**: This is an internal MCO-only action that is set by default for changes to the **/etc/containers/registries.conf** file. When this action is set, the MCO determines if a node cordon and drain is required, based on the changed content in the **registries.conf** file. You can override this setting. However, this is not recommended. You cannot set this action for another path or service.



NOTE

- The **Reboot** and **None** actions cannot be used with any other actions, as the **Reboot** and **None** actions override the others.
- Actions are applied in the order that they are set in the node disruption policy list.
- If you make other machine config changes that do require a reboot or other disruption to the nodes, that reboot supercedes the node disruption policy actions.

Procedure

1. Edit the **machineconfigurations.operator.openshift.io** object to define the node disruption policy:

```
$ oc edit MachineConfiguration cluster -n openshift-machine-config-operator
```

2. Add a node disruption policy similar to the following:

```
apiVersion: operator.openshift.io/v1
kind: MachineConfiguration
metadata:
  name: cluster
# ...
spec:
  nodeDisruptionPolicy: 1
    files: 2
    - actions: 3
      - restart: 4
          serviceName: chronyd.service 5
        type: Restart
      path: /etc/chrony.conf 6
    sshkey: 7
      actions:
      - type: Drain
```

```
    - reload:
        serviceName: crio.service
      type: Reload
    - type: DaemonReload
    - restart:
        serviceName: crio.service
      type: Restart
  units: 8
  - actions:
    - type: Drain
    - reload:
        serviceName: crio.service
      type: Reload
    - type: DaemonReload
    - restart:
        serviceName: crio.service
      type: Restart
    name: sshd.service
```

1. Specifies the node disruption policy.
2. Specifies a list of machine config file definitions and actions to take to changes on those paths. This list supports a maximum of 50 entries.
3. Specifies the series of actions to be executed upon changes to the specified files. Actions are applied in the order that they are set in this list. This list supports a maximum of 10 entries.
4. Specifies that the listed service is to be reloaded upon changes to the specified files.
5. Specifies the full name of the service to be acted upon.
6. Specifies the location of a file that is managed by a machine config. The actions in the policy apply when changes are made to the file in **path**.
7. Specifies a list of service names and actions to take upon changes to the SSH keys in the cluster.
8. Specifies a list of systemd unit names and actions to take upon changes to those units.

Verification

- View the **MachineConfiguration** object file that you created:

```
$ oc get MachineConfiguration/cluster -o yaml
```

Example output

```
apiVersion: operator.openshift.io/v1
kind: MachineConfiguration
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: cluster
# ...
```

```
status:
  nodeDisruptionPolicyStatus: 1
    clusterPolicies:
      files:
# ...
      - actions:
        - restart:
            serviceName: chronyd.service
          type: Restart
        path: /etc/chrony.conf
      sshkey:
        actions:
        - type: Drain
        - reload:
            serviceName: crio.service
          type: Reload
        - type: DaemonReload
        - restart:
            serviceName: crio.service
          type: Restart
      units:
      - actions:
        - type: Drain
        - reload:
            serviceName: crio.service
          type: Reload
        - type: DaemonReload
        - restart:
            serviceName: crio.service
          type: Restart
        name: sshd.service
# ...
```

1 Specifies the current cluster-validated policies.

CHAPTER 4. CONFIGURING MCO-RELATED CUSTOM RESOURCES

Besides managing **MachineConfig** objects, the MCO manages two custom resources (CRs): **KubeletConfig** and **ContainerRuntimeConfig**. Those CRs let you change node-level settings impacting how the kubelet and CRI-O container runtime services behave.

4.1. CREATING A KUBELETCONFIG CR TO EDIT KUBELET PARAMETERS

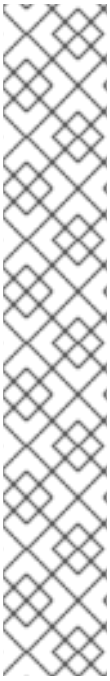
The kubelet configuration is currently serialized as an Ignition configuration, so it can be directly edited. However, there is also a new **kubelet-config-controller** added to the Machine Config Controller (MCC). This lets you use a **KubeletConfig** custom resource (CR) to edit the kubelet parameters.

NOTE

As the fields in the **kubeletConfig** object are passed directly to the kubelet from upstream Kubernetes, the kubelet validates those values directly. Invalid values in the **kubeletConfig** object might cause cluster nodes to become unavailable. For valid values, see the Kubernetes documentation.

Consider the following guidance:

- Edit an existing **KubeletConfig** CR to modify existing settings or add new settings, instead of creating a CR for each change. It is recommended that you create a CR only to modify a different machine config pool, or for changes that are intended to be temporary, so that you can revert the changes.
- Create one **KubeletConfig** CR for each machine config pool with all the config changes you want for that pool.
- As needed, create multiple **KubeletConfig** CRs with a limit of 10 per cluster. For the first **KubeletConfig** CR, the Machine Config Operator (MCO) creates a machine config appended with **kubelet**. With each subsequent CR, the controller creates another **kubelet** machine config with a numeric suffix. For example, if you have a **kubelet** machine config with a **-2** suffix, the next **kubelet** machine config is appended with **-3**.



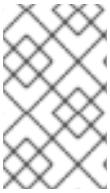
NOTE

If you are applying a kubelet or container runtime config to a custom machine config pool, the custom role in the **machineConfigSelector** must match the name of the custom machine config pool.

For example, because the following custom machine config pool is named **infra**, the custom role must also be **infra**:

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfigPool
metadata:
  name: infra
spec:
  machineConfigSelector:
    matchExpressions:
      - {key: machineconfiguration.openshift.io/role, operator: In, values: [worker,infra]}
# ...
```

If you want to delete the machine configs, delete them in reverse order to avoid exceeding the limit. For example, you delete the **kubelet-3** machine config before deleting the **kubelet-2** machine config.



NOTE

If you have a machine config with a **kubelet-9** suffix, and you create another **KubeletConfig** CR, a new machine config is not created, even if there are fewer than 10 **kubelet** machine configs.

Example KubeletConfig CR

```
$ oc get kubeletconfig
```

```
NAME                AGE
set-kubelet-config  15m
```

Example showing a KubeletConfig machine config

```
$ oc get mc | grep kubelet
```

```
...
99-worker-generated-kubelet-1                 b5c5119de007945b6fe6fb215db3b8e2ceb12511    3.4.0
26m
...
```

The following procedure is an example to show how to configure the maximum number of pods per node, the maximum PIDs per node, and the maximum container log size size on the worker nodes.

Prerequisites

1. Obtain the label associated with the static **MachineConfigPool** CR for the type of node you want to configure. Perform one of the following steps:

a. View the machine config pool:

```
$ oc describe machineconfigpool <name>
```

For example:

```
$ oc describe machineconfigpool worker
```

Example output

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfigPool
metadata:
  creationTimestamp: 2019-02-08T14:52:39Z
  generation: 1
  labels:
    custom-kubelet: set-kubelet-config 1
```

1 If a label has been added it appears under **labels**.

b. If the label is not present, add a key/value pair:

```
$ oc label machineconfigpool worker custom-kubelet=set-kubelet-config
```

Procedure

1. View the available machine configuration objects that you can select:

```
$ oc get machineconfig
```

By default, the two kubelet-related configs are **01-master-kubelet** and **01-worker-kubelet**.

2. Check the current value for the maximum pods per node:

```
$ oc describe node <node_name>
```

For example:

```
$ oc describe node ci-ln-5grqprb-f76d1-ncnqq-worker-a-mdv94
```

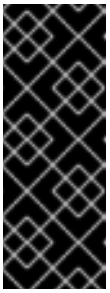
Look for **value: pods: <value>** in the **Allocatable** stanza:

Example output

```
Allocatable:
 attachable-volumes-aws-ebs:  25
 cpu:                         3500m
 hugepages-1Gi:               0
 hugepages-2Mi:               0
 memory:                      15341844Ki
 pods:                        250
```

3. Configure the worker nodes as needed:

   a. Create a YAML file similar to the following that contains the kubelet configuration:



IMPORTANT

Kubelet configurations that target a specific machine config pool also affect any dependent pools. For example, creating a kubelet configuration for the pool containing worker nodes will also apply to any subset pools, including the pool containing infrastructure nodes. To avoid this, you must create a new machine config pool with a selection expression that only includes worker nodes, and have your kubelet configuration target this new pool.

```
apiVersion: machineconfiguration.openshift.io/v1
kind: KubeletConfig
metadata:
  name: set-kubelet-config
spec:
  machineConfigPoolSelector:
    matchLabels:
      custom-kubelet: set-kubelet-config 1
  kubeletConfig: 2
      podPidsLimit: 8192
      containerLogMaxSize: 50Mi
      maxPods: 500
```

1. Enter the label from the machine config pool.
2. Add the kubelet configuration. For example:

- Use **podPidsLimit** to set the maximum number of PIDs in any pod.
- Use **containerLogMaxSize** to set the maximum size of the container log file before it is rotated.
- Use **maxPods** to set the maximum pods per node.

NOTE

The rate at which the kubelet talks to the API server depends on queries per second (QPS) and burst values. The default values, **50** for **kubeAPIQPS** and **100** for **kubeAPIBurst**, are sufficient if there are limited pods running on each node. It is recommended to update the kubelet QPS and burst rates if there are enough CPU and memory resources on the node.

```
apiVersion: machineconfiguration.openshift.io/v1
kind: KubeletConfig
metadata:
  name: set-kubelet-config
spec:
  machineConfigPoolSelector:
    matchLabels:
      custom-kubelet: set-kubelet-config
  kubeletConfig:
    maxPods: <pod_count>
    kubeAPIBurst: <burst_rate>
    kubeAPIQPS: <QPS>
```

b. Update the machine config pool for workers with the label:

```
$ oc label machineconfigpool worker custom-kubelet=set-kubelet-config
```

c. Create the **KubeletConfig** object:

```
$ oc create -f change-maxPods-cr.yaml
```

Verification

1. Verify that the **KubeletConfig** object is created:

```
$ oc get kubeletconfig
```

Example output

```
NAME                AGE
set-kubelet-config  15m
```

Depending on the number of worker nodes in the cluster, wait for the worker nodes to be rebooted one by one. For a cluster with 3 worker nodes, this could take about 10 to 15 minutes.

2. Verify that the changes are applied to the node:

a. Check on a worker node that the **maxPods** value changed:

```
$ oc describe node <node_name>
```

b. Locate the **Allocatable** stanza:

```
 ...
Allocatable:
  attachable-volumes-gce-pd:  127
  cpu:                        3500m
  ephemeral-storage:          123201474766
  hugepages-1Gi:              0
  hugepages-2Mi:              0
  memory:                     14225400Ki
  pods:                       500 (1)
 ...
```

(1) In this example, the **pods** parameter should report the value you set in the **KubeletConfig** object.

3. Verify the change in the **KubeletConfig** object:

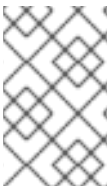
```
$ oc get kubeletconfigs set-kubelet-config -o yaml
```

This should show a status of **True** and **type:Success**, as shown in the following example:

```
spec:
  kubeletConfig:
    containerLogMaxSize: 50Mi
    maxPods: 500
    podPidsLimit: 8192
  machineConfigPoolSelector:
    matchLabels:
      custom-kubelet: set-kubelet-config
status:
  conditions:
  - lastTransitionTime: "2021-06-30T17:04:07Z"
    message: Success
    status: "True"
    type: Success
```

4.2. CREATING A CONTAINERRUNTIMECONFIG CR TO EDIT CRI-O PARAMETERS

You can change some of the settings associated with the OpenShift Container Platform CRI-O runtime for the nodes associated with a specific machine config pool (MCP). Using a **ContainerRuntimeConfig** custom resource (CR), you set the configuration values and add a label to match the MCP. The MCO then rebuilds the **crio.conf** and **storage.conf** configuration files on the associated nodes with the updated values.



NOTE

To revert the changes implemented by using a **ContainerRuntimeConfig** CR, you must delete the CR. Removing the label from the machine config pool does not revert the changes.

You can modify the following settings by using a **ContainerRuntimeConfig** CR:

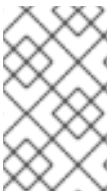
- **Log level**: The **logLevel** parameter sets the CRI-O **log_level** parameter, which is the level of verbosity for log messages. The default is **info** (**log_level = info**). Other options include **fatal**, **panic**, **error**, **warn**, **debug**, and **trace**.
- **Overlay size**: The **overlaySize** parameter sets the CRI-O Overlay storage driver **size** parameter, which is the maximum size of a container image.
- **Container runtime**: The **defaultRuntime** parameter sets the container runtime to either **crun** or **runc**. The default is **crun**.

You should have one **ContainerRuntimeConfig** CR for each machine config pool with all the config changes you want for that pool. If you are applying the same content to all the pools, you only need one **ContainerRuntimeConfig** CR for all the pools.

You should edit an existing **ContainerRuntimeConfig** CR to modify existing settings or add new settings instead of creating a new CR for each change. It is recommended to create a new **ContainerRuntimeConfig** CR only to modify a different machine config pool, or for changes that are intended to be temporary so that you can revert the changes.

You can create multiple **ContainerRuntimeConfig** CRs, as needed, with a limit of 10 per cluster. For the first **ContainerRuntimeConfig** CR, the MCO creates a machine config appended with **containerruntime**. With each subsequent CR, the controller creates a new **containerruntime** machine config with a numeric suffix. For example, if you have a **containerruntime** machine config with a **-2** suffix, the next **containerruntime** machine config is appended with **-3**.

If you want to delete the machine configs, you should delete them in reverse order to avoid exceeding the limit. For example, you should delete the **containerruntime-3** machine config before deleting the **containerruntime-2** machine config.



NOTE

If you have a machine config with a **containerruntime-9** suffix, and you create another **ContainerRuntimeConfig** CR, a new machine config is not created, even if there are fewer than 10 **containerruntime** machine configs.

Example showing multiple ContainerRuntimeConfig CRs

```
$ oc get ctrcfg
```

Example output

```
NAME         AGE
ctr-overlay  15m
ctr-level    5m45s
```

Example showing multiple containerruntime machine configs

```
$ oc get mc | grep container
```

Example output

```
...
```

```
01-master-container-runtime                 b5c5119de007945b6fe6fb215db3b8e2ceb12511   3.4.0
57m
...
01-worker-container-runtime                 b5c5119de007945b6fe6fb215db3b8e2ceb12511   3.4.0
57m
...
99-worker-generated-containerruntime        b5c5119de007945b6fe6fb215db3b8e2ceb12511
3.4.0          26m
99-worker-generated-containerruntime-1      b5c5119de007945b6fe6fb215db3b8e2ceb12511
3.4.0          17m
99-worker-generated-containerruntime-2      b5c5119de007945b6fe6fb215db3b8e2ceb12511
3.4.0          7m26s
...
```

The following example sets the **log_level** field to **debug**, sets the overlay size to 8 GB, and configures runC as the container runtime:

Example ContainerRuntimeConfig CR

```
apiVersion: machineconfiguration.openshift.io/v1
kind: ContainerRuntimeConfig
metadata:
 name: overlay-size
spec:
 machineConfigPoolSelector:
   matchLabels:
     pools.operator.machineconfiguration.openshift.io/worker: '' (1)
 containerRuntimeConfig:
   logLevel: debug (2)
   overlaySize: 8G (3)
   defaultRuntime: "runc" (4)
```

1. Specifies the machine config pool label. For a container runtime config, the role must match the name of the associated machine config pool.
2. Optional: Specifies the level of verbosity for log messages.
3. Optional: Specifies the maximum size of a container image.
4. Optional: Specifies the container runtime to deploy to new containers, either **crun** or **runc**. The default value is **crun**.

Procedure

To change CRI-O settings using the **ContainerRuntimeConfig** CR:

1. Create a YAML file for the **ContainerRuntimeConfig** CR:

```
apiVersion: machineconfiguration.openshift.io/v1
kind: ContainerRuntimeConfig
metadata:
 name: overlay-size
spec:
 machineConfigPoolSelector:
```

```
    matchLabels:
      pools.operator.machineconfiguration.openshift.io/worker: " 1
  containerRuntimeConfig: 2
    logLevel: debug
    overlaySize: 8G
    defaultRuntime: "runc"
```

1 Specify a label for the machine config pool that you want you want to modify.

2 Set the parameters as needed.

2. Create the **ContainerRuntimeConfig** CR:

```
$ oc create -f <file_name>.yaml
```

3. Verify that the CR is created:

```
$ oc get ContainerRuntimeConfig
```

Example output

```
NAME          AGE
overlay-size  3m19s
```

4. Check that a new **containerruntime** machine config is created:

```
$ oc get machineconfigs | grep containerrun
```

Example output

```
99-worker-generated-containerruntime  2c9371fbb673b97a6fe8b1c52691999ed3a1bfc2
3.4.0  31s
```

5. Monitor the machine config pool until all are shown as ready:

```
$ oc get mcp worker
```

Example output

```
NAME    CONFIG              UPDATED  UPDATING  DEGRADED  MACHINECOUNT
READYMACHINECOUNT  UPDATEDMACHINECOUNT  DEGRADEDMACHINECOUNT
AGE
worker  rendered-worker-169  False    True      False     3          1                  1                  0
9h
```

6. Verify that the settings were applied in CRI-O:

   a. Open an **oc debug** session to a node in the machine config pool and run **chroot /host**.

```
$ oc debug node/<node_name>
```

```
sh-4.4# chroot /host
```

b. Verify the changes in the **crio.conf** file:

```
sh-4.4# crio config | grep 'log_level'
```

Example output

```
log_level = "debug"
```

c. Verify the changes in the **storage.conf** file:

```
sh-4.4# head -n 7 /etc/containers/storage.conf
```

Example output

```
[storage]
  driver = "overlay"
  runroot = "/var/run/containers/storage"
  graphroot = "/var/lib/containers/storage"
  [storage.options]
    additionalimagestores = []
    size = "8G"
```

d. Verify the changes in the **crio/crio.conf.d/01-ctrcfg-defaultRuntime** file:

```
sh-5.1# cat /etc/crio/crio.conf.d/01-ctrcfg-defaultRuntime
```

Example output

```
[crio]
  [crio.runtime]
    default_runtime = "runc"
```

4.3. CONFIGURING THE CONTAINER RUNTIME

You can configure the container runtime used with new workloads on your nodes, based on which runtime you or your organization prefers. You can use either crun, which is considered a faster and more lightweight runtime, or runc, which is more widely used than crun.

For information on crun and runc, see "About the container engine and container runtime".

Starting in OpenShift Container Platform 4.18, crun is the default container runtime for new installations. You can change between the runtimes by using a **ContainerRuntimeConfig** object, as described in the following procedure. Changing the container runtime affects new workloads only. Existing workloads continue to use their existing container runtime.

If you updated your cluster from OpenShift Container Platform 4.17, the runc container runtime remains unchanged as the default. During the upgrade, two **MachineConfig** objects, one for the control plane nodes and one for the worker nodes, were created to override the new default runtime. You can migrate the container runtime to crun, on a schedule of your choosing, by removing either or both of the **MachineConfig** objects.

Procedure

- If your cluster is updated from OpenShift Container Platform 4.17, you can use the crun container runtime by deleting the following **MachineConfig** objects:
  - Migrate your worker nodes to crun by running the following command:

```
$ oc delete machineconfig 00-override-worker-generated-crio-default-container-runtime
```

  - Migrate your control plane nodes to crun by running the following command:

```
$ oc delete machineconfig 00-override-master-generated-crio-default-container-runtime
```

- For any OpenShift Container Platform 4.18 or greater cluster, you can configure crun or runc as the container runtime for specific nodes by creating a container runtime configuration:
  1. Create a YAML file for the **ContainerRuntimeConfig** CR:

```
apiVersion: machineconfiguration.openshift.io/v1
kind: ContainerRuntimeConfig
metadata:
 name: configure-runc
spec:
 machineConfigPoolSelector:
   matchLabels:
     pools.operator.machineconfiguration.openshift.io/worker: ''
 containerRuntimeConfig:
   defaultRuntime: "runc"
```

     where:

     - **spec.machineConfigPoolSelector.matchLabels**:: Specifies a label for the machine config pool that you want you want to modify.
     - **spec.containerRuntimeConfig.defaultRuntime**:: Specifies the container runtime to use with new workloads on the nodes in the specified machine config pool, either **crun** or **runc**.

  2. Create the **ContainerRuntimeConfig** CR:

```
$ oc create -f <file_name>.yaml
```

Verification

1. After the nodes return to a ready state, open an **oc debug** session to a node by running the following command:

```
$ oc debug node/<node_name>
```

2. Set /**host** as the root directory within the debug shell by running the following command:

```
sh-5.1# chroot /host
```

3. Check the container runtime by using the following command:

```
sh-5.1# crio status config | grep default_runtime
```

Example output

```
INFO[2026-01-27 23:09:18.413462914Z] Starting CRI-O, version: 1.30.14-
6.rhaos4.17.gitfa27f6f.el9, git: unknown(clean)
    default_runtime = "runc"
```

The **default_runtime** parameter specifies the container runtime that OpenShift Container Platform uses for new workloads on this node, either **crun** or **runc**, depending on what you have configured.

4.4. SETTING THE DEFAULT MAXIMUM CONTAINER ROOT PARTITION SIZE FOR OVERLAY WITH CRI-O

The root partition of each container shows all of the available disk space of the underlying host. Follow this guidance to set a maximum partition size for the root disk of all containers.

To configure the maximum Overlay size, as well as other CRI-O options like the log level, you can create the following **ContainerRuntimeConfig** custom resource definition (CRD):

```
apiVersion: machineconfiguration.openshift.io/v1
kind: ContainerRuntimeConfig
metadata:
 name: overlay-size
spec:
 machineConfigPoolSelector:
   matchLabels:
     custom-crio: overlay-size
 containerRuntimeConfig:
   logLevel: debug
   overlaySize: 8G
```

Procedure

1. Create the configuration object:

```
$ oc apply -f overlaysize.yml
```

2. To apply the new CRI-O configuration to your worker nodes, edit the worker machine config pool:

```
$ oc edit machineconfigpool worker
```

3. Add the **custom-crio** label based on the **matchLabels** name you set in the **ContainerRuntimeConfig** CRD:

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfigPool
metadata:
  creationTimestamp: "2020-07-09T15:46:34Z"
  generation: 3
```

```
  labels:
    custom-crio: overlay-size
    machineconfiguration.openshift.io/mco-built-in: ""
```

4. Save the changes, then view the machine configs:

```
$ oc get machineconfigs
```

New **99-worker-generated-containerruntime** and **rendered-worker-xyz** objects are created:

Example output

```
99-worker-generated-containerruntime  4173030d89fbf4a7a0976d1665491a4d9a6e54f1
3.4.0             7m42s
rendered-worker-xyz                   4173030d89fbf4a7a0976d1665491a4d9a6e54f1    3.4.0
7m36s
```

5. After those objects are created, monitor the machine config pool for the changes to be applied:

```
$ oc get mcp worker
```

The worker nodes show **UPDATING** as **True**, as well as the number of machines, the number updated, and other details:

Example output

```
NAME   CONFIG             UPDATED   UPDATING   DEGRADED   MACHINECOUNT
READYMACHINECOUNT   UPDATEDMACHINECOUNT   DEGRADEDMACHINECOUNT
AGE
worker rendered-worker-xyz False True False     3           2                2                0
20h
```

When complete, the worker nodes transition back to **UPDATING** as **False**, and the **UPDATEDMACHINECOUNT** number matches the **MACHINECOUNT**:

Example output

```
NAME   CONFIG             UPDATED   UPDATING   DEGRADED   MACHINECOUNT
READYMACHINECOUNT   UPDATEDMACHINECOUNT   DEGRADEDMACHINECOUNT
AGE
worker   rendered-worker-xyz   True      False      False      3       3          3          0
20h
```

Looking at a worker machine, you see that the new 8 GB max size configuration is applied to all of the workers:

Example output

```
head -n 7 /etc/containers/storage.conf
[storage]
  driver = "overlay"
  runroot = "/var/run/containers/storage"
  graphroot = "/var/lib/containers/storage"
```

```
[storage.options]
  additionalimagestores = []
  size = "8G"
```

Looking inside a container, you see that the root partition is now 8 GB:

Example output

```
~ $ df -h
Filesystem              Size      Used Available Use% Mounted on
overlay                 8.0G      8.0K      8.0G   0% /
```

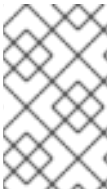
4.5. CREATING A DROP-IN FILE FOR THE DEFAULT CRI-O CAPABILITIES

You can change some of the settings associated with the OpenShift Container Platform CRI-O runtime for the nodes associated with a specific machine config pool (MCP). By using a controller custom resource (CR), you set the configuration values and add a label to match the MCP. The Machine Config Operator (MCO) then rebuilds the **crio.conf** and **default.conf** configuration files on the associated nodes with the updated values.

Earlier versions of OpenShift Container Platform included specific machine configs by default. If you updated to a later version of OpenShift Container Platform, those machine configs were retained to ensure that clusters running on the same OpenShift Container Platform version have the same machine configs.

You can create multiple **ContainerRuntimeConfig** CRs, as needed, with a limit of 10 per cluster. For the first **ContainerRuntimeConfig** CR, the MCO creates a machine config appended with **containerruntime**. With each subsequent CR, the controller creates a **containerruntime** machine config with a numeric suffix. For example, if you have a **containerruntime** machine config with a **-2** suffix, the next **containerruntime** machine config is appended with **-3**.

If you want to delete the machine configs, delete them in reverse order to avoid exceeding the limit. For example, delete the **containerruntime-3** machine config before you delete the **containerruntime-2** machine config.



NOTE

If you have a machine config with a **containerruntime-9** suffix and you create another **ContainerRuntimeConfig** CR, a new machine config is not created, even if there are fewer than 10 **containerruntime** machine configs.

Example of multiple ContainerRuntimeConfig CRs

```
$ oc get ctrcfg
```

Example output

```
NAME         AGE
ctr-overlay  15m
ctr-level    5m45s
```

Example showing multiple containerruntime related system configs

```
$ cat /proc/1/status | grep Cap
```

```
$ capsh --decode=<decode_CapBnd_value> 1
```

1 Replace **<decode_CapBnd_value>** with the specific value you want to decode.

4.6. ADDITIONAL RESOURCES

- About the container engine and container runtime

CHAPTER 5. UPDATED BOOT IMAGES

The Machine Config Operator (MCO) uses a boot image to start a Red Hat Enterprise Linux CoreOS (RHCOS) node. By default, OpenShift Container Platform does not manage the boot image.

This means that the boot image in your cluster is not updated along with your cluster. For example, if your cluster was originally created with OpenShift Container Platform 4.12, the boot image that the cluster uses to create nodes is the same 4.12 version, even if your cluster is at a later version. If the cluster is later upgraded to 4.13 or later, new nodes continue to scale with the same 4.12 image.

This process could cause the following issues:

- Extra time to start nodes
- Certificate expiration issues
- Version skew issues

To avoid these issues, you can configure your cluster to update the boot image whenever you update your cluster. By modifying the **MachineConfiguration** object, you can enable this feature. Currently, the ability to update the boot image is available for only Google Cloud Platform (GCP) and Amazon Web Services (AWS) clusters. It is not supported for clusters managed by the Cluster CAPI Operator.

If you are not using the default user data secret, named **worker-user-data**, in your machine set, or you have modified the **worker-user-data** secret, you should not use managed boot image updates. This is because the Machine Config Operator (MCO) updates the machine set to use a managed version of the secret. By using the managed boot images feature, you are giving up the capability to customize the secret stored in the machine set object.

To view the current boot image used in your cluster, examine a machine set.

NOTE

The location and format of the boot image within the machine set differs, based on the platform. However, the boot image is always listed in the **spec.template.spec.providerSpec.** parameter.

Example GCP machine set with the boot image reference

```
apiVersion: machine.openshift.io/v1beta1
kind: MachineSet
metadata:
  name: ci-ln-hmy310k-72292-5f87z-worker-a
  namespace: openshift-machine-api
spec:
# ...
  template:
# ...
    spec:
# ...
      providerSpec:
# ...
        value:
          disks:
          - autoDelete: true
```

```
        boot: true
        image: projects/rhcos-cloud/global/images/rhcos-412-85-202203181601-0-gcp-x86-64 (1)
# ...
```

(1) This boot image is the same as the originally-installed OpenShift Container Platform version, in this example OpenShift Container Platform 4.12, regardless of the current version of the cluster. The way that the boot image is represented in the machine set depends on the platform, as the structure of the **providerSpec** field differs from platform to platform.

Example AWS machine set with the boot image reference

```
apiVersion: machine.openshift.io/v1beta1
kind: MachineSet
metadata:
  name: ci-ln-hmy310k-72292-5f87z-worker-a
  namespace: openshift-machine-api
spec:
# ...
  template:
# ...
    spec:
# ...
      providerSpec:
        value:
          ami:
            id: ami-0e8fd9094e487d1ff
# ...
```

If you configure your cluster to update your boot images, the boot image referenced in your machine sets matches the current version of the cluster.

5.1. CONFIGURING UPDATED BOOT IMAGES

For supported platforms, the Machine Config Operator (MCO) can manage and update the boot image on each node to ensure the Red Hat Enterprise Linux CoreOS (RHCOS) version of the boot image matches the Red Hat Enterprise Linux CoreOS (RHCOS) version appropriate for your cluster.

Currently, the ability to update the boot image is available for only Google Cloud Platform (GCP) and Amazon Web Services (AWS) clusters. It is not supported for clusters managed by the Cluster CAPI Operator.

Procedure

1. Edit the **MachineConfiguration** object, named **cluster**, to enable the updating of boot images by running the following command:

```
$ oc edit MachineConfiguration cluster
```

- Optional: Configure the boot image update feature for all the machine sets:

```
apiVersion: operator.openshift.io/v1
kind: MachineConfiguration
metadata:
```

```
  name: cluster
spec:
# ...
  managedBootImages:
    machineManagers:
    - resource: machinesets
      apiGroup: machine.openshift.io
      selection:
        mode: All
```

where:

spec.managedBootImages

Configures the boot image management feature.

spec.managedBootImages.machineManagers.selection.mode

Specifies that all the machine sets in the cluster are to be updated.

- Optional: Configure the boot image update feature for specific machine sets:

```
apiVersion: operator.openshift.io/v1
kind: MachineConfiguration
metadata:
  name: cluster
spec:
# ...
  managedBootImages:
    machineManagers:
    - resource: machinesets
      apiGroup: machine.openshift.io
      selection:
        mode: Partial
        partial:
          machineResourceSelector:
            matchLabels:
              update-boot-image: "true"
```

where:

spec.managedBootImages

Configures the boot image management feature.

spec.managedBootImages.machineManagers.selection.partial.machineResourceSelector.matchLabels

Specifies that any machine set with this label is to be updated.

TIP

If an appropriate label is not present on the machine set, add a key-value pair by running a command similar to following:

```
$ oc label machineset.machine ci-ln-hmy310k-72292-5f87z-worker-a update-boot-image=true -n openshift-machine-api
```

Verification

1. View the current state of the boot image updates by viewing the machine configuration object:

```
$ oc get machineconfiguration cluster -n openshift-machine-api -o yaml
```

Example machine set with the boot image reference

```
kind: MachineConfiguration
metadata:
  name: cluster
# ...
status:
  conditions:
  - lastTransitionTime: "2024-09-09T13:51:37Z"
    message: Reconciled 1 of 2 MAPI MachineSets | Reconciled 0 of 0 CAPI MachineSets
      | Reconciled 0 of 0 CAPI MachineDeployments
    reason: BootImageUpdateConfigurationAdded
    status: "True"
    type: BootImageUpdateProgressing
  - lastTransitionTime: "2024-09-09T13:51:37Z"
    message: 0 Degraded MAPI MachineSets | 0 Degraded CAPI MachineSets | 0 CAPI
MachineDeployments
    reason: BootImageUpdateConfigurationAdded
    status: "False"
    type: BootImageUpdateDegraded
```

The **status.conditions.lastTransitionTime.type:BootImageUpdateProgressing** stanza specifies the status of the boot image update. Cluster CAPI Operator machine sets and machine deployments are not currently supported for boot image updates.

The **status.conditions.lastTransitionTime.type:BootImageUpdateConfigurationAdded** stanza specifies if any boot image updates failed. If any of the updates fail, the Machine Config Operator is degraded. In this case, manual intervention might be required.

2. Get the boot image version by running the following command:

```
$ oc get machinesets <machineset_name> -n openshift-machine-api -o yaml
```

Example machine set with the boot image reference

```
apiVersion: machine.openshift.io/v1beta1
kind: MachineSet
metadata:
  labels:
    machine.openshift.io/cluster-api-cluster: ci-ln-77hmkpt-72292-d4pxp
    update-boot-image: "true"
  name: ci-ln-77hmkpt-72292-d4pxp-worker-a
  namespace: openshift-machine-api
spec:
# ...
  template:
# ...
    spec:
# ...
```

```
      providerSpec:
# ...
        value:
          disks:
          - autoDelete: true
            boot: true
            image: projects/rhcos-cloud/global/images/<boot_image>
# ...
```

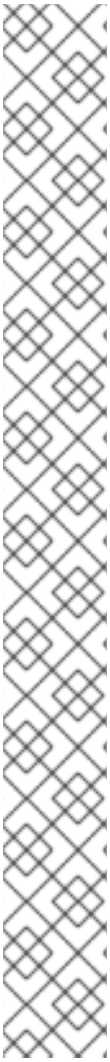
This boot image is the same as the current OpenShift Container Platform version. The location and format of the boot image within the machine set differs, based on the platform. However, the boot image is always listed in the **spec.template.spec.providerSpec.** parameter.

Additional resources

- Enabling features using feature gates

5.2. DISABLING UPDATED BOOT IMAGES

To disable the updated boot image feature, edit the **MachineConfiguration** object so that the **machineManagers** field is an empty array.



NOTE

If you are updating a Google Cloud or Amazon Web Services (AWS) cluster from OpenShift Container Platform 4.18 to 4.19, and you have not configured the **managedBootImages** parameter, the update is blocked with a *This cluster is GCP or AWS but lacks a boot image configuration.* message. The update is blocked intentionally on Google Cloud or AWS clusters in order to alert you that the default updated boot image behavior is changing between version 4.18 and 4.19 to enable updated boot images by default on those platforms .

To allow the update, perform one of the following tasks:

- If you want to allow the feature to be enabled, acknowledge that you are aware of the change in default behavior by patching the **admin-acks** config map by using the following command:

```
$ oc -n openshift-config patch cm admin-acks --patch '{"data":{"ack-4.18-boot-image-opt-out-in-4.19":"true"}}' --type=merge
```

- If you do not want the updated boot image feature enabled, explicitly disable the feature by using the following procedure.

It is important to note that if you use boot images from the AWS Marketplace or the GCP Marketplace, enabling the updated boot image feature overwrites those images with a standard Red Hat Enterprise Linux CoreOS (RHCOS) image. You should explicitly disable this feature and not patch the **admin-acks** config map. If you accidentally enable the updated boot image feature, you can disable it by using the following procedure. Then, replace the marketplace boot images by modifying the compute machine sets, as described in *Modifying a compute machine set* .

If you disable this feature after some nodes have been created with the new boot image version, any existing nodes retain their current boot image. Turning off this feature does not rollback the nodes or

machine sets to the originally-installed boot image. The machine sets retain the boot image version that was present when the feature was enabled and is not updated again when the cluster is upgraded to a new OpenShift Container Platform version in the future.

Procedure

1. Disable updated boot images by editing the **MachineConfiguration** object:

```
$ oc edit MachineConfiguration cluster
```

2. Make the **machineManagers** parameter an empty array:

```
apiVersion: operator.openshift.io/v1
kind: MachineConfiguration
metadata:
  name: cluster
spec:
# ...
  managedBootImages:
    machineManagers: []
```

   Remove the parameters listed under **machineManagers** and add the **[]** characters to disable boot image updates.

Additional resources

- Modifying a compute machine set

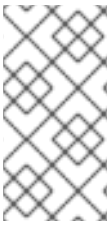
CHAPTER 6. MANAGING UNUSED RENDERED MACHINE CONFIGS

The Machine Config Operator (MCO) does not perform any garbage collection activities. This means that all rendered machine configs remain in the cluster. Each time a user or controller applies a new machine config, the MCO creates new rendered configs for each affected machine config pool. Over time, this can lead to a large number of rendered machine configs, which can make working with machine configs confusing. Having too many rendered machine configs can also contribute to disk space issues and performance issues with etcd.

You can remove old, unused rendered machine configs by using the **oc adm prune renderedmachineconfigs** command with the **--confirm** flag. With this command, you can remove all unused rendered machine configs or only those in a specific machine config pool. You can also remove a specified number of unused rendered machine configs in order to keep some older machine configs, in case you want to check older configurations.

You can use the **oc adm prune renderedmachineconfigs** command without the **--confirm** flag to see which rendered machine configs would be removed.

Use the **list** subcommand to display all the rendered machine configs in the cluster or a specific machine config pool.



NOTE

The **oc adm prune renderedmachineconfigs** command deletes only rendered machine configs that are not in use. If a rendered machine configs are in use by a machine config pool, the rendered machine config is not deleted. In this case, the command output specifies the reason that the rendered machine config was not deleted.

6.1. VIEWING RENDERED MACHINE CONFIGS

You can view a list of rendered machine configs by using the **oc adm prune renderedmachineconfigs** command with the **list** subcommand.

For example, the command in the following procedure would list all rendered machine configs for the **worker** machine config pool.

Procedure

- Optional: List the rendered machine configs by using the following command:

```
$ oc adm prune renderedmachineconfigs list --in-use=false --pool-name=worker
```

where:

list

Displays a list of rendered machine configs in your cluster.

--in-use

Optional: Specifies whether to display only the used machine configs or all machine configs from the specified pool. If **true**, the output lists the rendered machine configs that are being used by a machine config pool. If **false**, the output lists all rendered machine configs in the cluster. The default value is **false**.

--pool-name

Optional: Specifies the machine config pool from which to display the machine configs.

Example output

```
worker

rendered-worker-f38bf61ced3c920cf5a29a200ed43243 -- 2025-01-21 13:45:01 +0000 UTC
(Currently in use: false)
rendered-worker-fc94397dc7c43808c7014683c208956e-- 2025-01-30 17:20:53 +0000 UTC
(Currently in use: false)
rendered-worker-708c652868f7597eaa1e2622edc366ef -- 2025-01-31 18:01:16 +0000 UTC
(Currently in use: true)
```

- List the rendered machine configs that you can remove automatically by running the following command. Any rendered machine config marked with the **as it's currently in use** message in the command output cannot be removed.

```
$ oc adm prune renderedmachineconfigs --pool-name=worker
```

The command runs in dry-run mode, and no machine configs are removed.

where:

--pool-name

Optional: Displays the machine configs in the specified machine config pool.

Example output

```
Dry run enabled - no modifications will be made. Add --confirm to remove rendered machine
configs.
dry-run deleting rendered MachineConfig rendered-worker-
f38bf61ced3c920cf5a29a200ed43243
dry-run deleting MachineConfig rendered-worker-fc94397dc7c43808c7014683c208956e
Skip dry-run deleting rendered MachineConfig rendered-worker-
708c652868f7597eaa1e2622edc366ef as it's currently in use
```

6.2. REMOVING UNUSED RENDERED MACHINE CONFIGS

You can remove unused rendered machine configs by using the **oc adm prune renderedmachineconfigs** command with the **--confirm** command. If any rendered machine config is not deleted, the command output indicates which was not deleted and lists the reason for skipping the deletion.

Procedure

1. Optional: List the rendered machine configs that you can remove automatically by running the following command. Any rendered machine config marked with the **as it's currently in use** message in the command output cannot be removed.

```
$ oc adm prune renderedmachineconfigs --pool-name=worker
```

Example output

```
Dry run enabled - no modifications will be made. Add --confirm to remove rendered machine
configs.
dry-run deleting rendered MachineConfig rendered-worker-
f38bf61ced3c920cf5a29a200ed43243
dry-run deleting MachineConfig rendered-worker-fc94397dc7c43808c7014683c208956e
Skip dry-run deleting rendered MachineConfig rendered-worker-
708c652868f7597eaa1e2622edc366ef as it's currently in use
```

where:

pool-name

Optional: Specifies the machine config pool where you want to delete the machine configs from.

2. Remove the unused rendered machine configs by running the following command. The command in the following procedure would delete the two oldest unused rendered machine configs in the **worker** machine config pool.

```
$ oc adm prune renderedmachineconfigs --pool-name=worker --count=2 --confirm
```

where:

--count

Optional: Specifies the maximum number of unused rendered machine configs you want to delete, starting with the oldest.

--confirm

Indicates that pruning should occur, instead of performing a dry-run.

--pool-name

Optional: Specifies the machine config pool from which you want to delete the machine. If not specified, all the pools are evaluated.

Example output

```
deleting rendered MachineConfig rendered-worker-f38bf61ced3c920cf5a29a200ed43243
deleting rendered MachineConfig rendered-worker-fc94397dc7c43808c7014683c208956e
Skip deleting rendered MachineConfig rendered-worker-
708c652868f7597eaa1e2622edc366ef as it's currently in use
```

CHAPTER 7. RHCOS IMAGE LAYERING

Red Hat Enterprise Linux CoreOS (RHCOS) image layering allows you to easily extend the functionality of your base RHCOS image by *layering* additional images onto the base image. This layering does not modify the base RHCOS image. Instead, it creates a *custom layered image* that includes all RHCOS functionality and adds additional functionality to specific nodes in the cluster.

7.1. ABOUT RHCOS IMAGE LAYERING

Image layering allows you to customize the underlying node operating system on any of your cluster nodes. This helps keep everything up-to-date, including the node operating system and any added customizations such as specialized software.

You create a custom layered image by using a Containerfile and applying it to nodes by using a custom object. At any time, you can remove the custom layered image by deleting that custom object.

With RHCOS image layering, you can install RPMs into your base image, and your custom content will be booted alongside RHCOS. The Machine Config Operator (MCO) can roll out these custom layered images and monitor these custom containers in the same way it does for the default RHCOS image. RHCOS image layering gives you greater flexibility in how you manage your RHCOS nodes.

IMPORTANT

Installing realtime kernel and extensions RPMs as custom layered content is not recommended. This is because these RPMs can conflict with RPMs installed by using a machine config. If there is a conflict, the MCO enters a **degraded** state when it tries to install the machine config RPM. You need to remove the conflicting extension from your machine config before proceeding.

When you apply the custom layered image to your cluster, you assume the responsibility for the package you applied with the custom layered image and any issues that might arise with the package.

There are two methods for deploying a custom layered image onto your nodes:

On-cluster layering

With on-cluster layering, you create a **MachineOSConfig** object where you include the Containerfile and other parameters. The build is performed on your cluster and the resulting custom layered image is automatically pushed to your repository and applied to the machine config pool that you specified in the **MachineOSConfig** object. The entire process is performed completely within your cluster.

Out-of-cluster layering

With out-of-cluster layering, you create a Containerfile that references an OpenShift Container Platform image and the RPM that you want to apply, build the layered image in your own environment, and push the image to your repository. Then, in your cluster, create a **MachineConfig** object for the targeted node pool that points to the new image. The Machine Config Operator overrides the base RHCOS image, as specified by the **osImageURL** value in the associated machine config, and boots the new image.

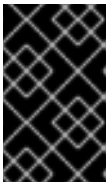
IMPORTANT

For both methods, use the same base RHCOS image installed on the rest of your cluster. Use the **oc adm release info --image-for rhel-coreos** command to obtain the base image used in your cluster.

7.2. EXAMPLE CONTAINERFILES

RHCOS image layering allows you to use the following types of images to create custom layered images:

- **OpenShift Container Platform Hotfixes**. You can work with Customer Experience and Engagement (CEE) to obtain and apply Hotfix packages on top of your RHCOS image. In some instances, you might want a bug fix or enhancement before it is included in an official OpenShift Container Platform release. RHCOS image layering allows you to easily add the Hotfix before it is officially released and remove the Hotfix when the underlying RHCOS image incorporates the fix.



IMPORTANT

Some Hotfixes require a Red Hat Support Exception and are outside of the normal scope of OpenShift Container Platform support coverage or life cycle policies.

Hotfixes are provided to you based on Red Hat Hotfix policy . Apply it on top of the base image and test that new custom layered image in a non-production environment. When you are satisfied that the custom layered image is safe to use in production, you can roll it out on your own schedule to specific node pools. For any reason, you can easily roll back the custom layered image and return to using the default RHCOS.

Example on-cluster Containerfile to apply a Hotfix

```
containerfileArch: noarch
content: |-
  FROM configs AS final
  #Install hotfix package
  RUN dnf update -y https://example.com/files/systemd-252-46.el9_4.x86_64.rpm \
                    https://example.com/files/systemd-journal-remote-252-46.el9_4.x86_64.rpm \
                    https://example.com/files/systemd-libs-252-46.el9_4.x86_64.rpm  \
                    https://example.com/files/systemd-pam-252-46.el9_4.x86_64.rpm \
                    https://example.com/files/systemd-udev-252-46.el9_4.x86_64.rpm \
                    https://example.com/files/systemd-rpm-macros-252-46.el9_4.noarch.rpm && \
     dnf clean all && \
     ostree container commit
```

Example out-of-cluster Containerfile to apply a Hotfix

```
FROM quay.io/openshift-release-dev/ocp-v4.0-art-dev@sha256...
#Install hotfix package
RUN dnf update -y https://example.com/files/systemd-252-46.el9_4.x86_64.rpm \
                  https://example.com/files/systemd-journal-remote-252-46.el9_4.x86_64.rpm \
                  https://example.com/files/systemd-libs-252-46.el9_4.x86_64.rpm  \
                  https://example.com/files/systemd-pam-252-46.el9_4.x86_64.rpm \
                  https://example.com/files/systemd-udev-252-46.el9_4.x86_64.rpm \
                  https://example.com/files/systemd-rpm-macros-252-46.el9_4.noarch.rpm && \
   dnf clean all && \
   ostree container commit
```

- **RHEL packages**. You can download Red Hat Enterprise Linux (RHEL) packages from the Red Hat Customer Portal, such as chrony, firewalld, and iputils.

Example out-of-cluster Containerfile to apply the rsyslog utility

```
# Using a 4.18.0 image
FROM quay.io/openshift-release-dev/ocp-v4.0-art-dev@sha256...
# Install rsyslog package
RUN dnf install -y rsyslog && \
    ostree container commit
# Copy your custom configuration in
ADD remote.conf /etc/rsyslog.d/remote.conf
```

- **Third-party packages**. You can download and install RPMs from third-party organizations, such as the following types of packages:
  - Bleeding edge drivers and kernel enhancements to improve performance or add capabilities.
  - Forensic client tools to investigate possible and actual break-ins.
  - Security agents.
  - Inventory agents that provide a coherent view of the entire cluster.
  - SSH Key management packages.

Example on-cluster Containerfile to apply a third-party package from EPEL

```
FROM configs AS final

#Enable EPEL (more info at https://docs.fedoraproject.org/en-US/epel/ ) and install htop
RUN dnf install -y https://dl.fedoraproject.org/pub/epel/epel-release-latest-9.noarch.rpm && \
    dnf install -y htop && \
    dnf clean all && \
    ostree container commit
```

Example out-of-cluster Containerfile to apply a third-party package from EPEL

```
# Get RHCOS base image of target cluster `oc adm release info --image-for rhel-coreos`
FROM quay.io/openshift-release-dev/ocp-v4.0-art-dev@sha256...

#Enable EPEL (more info at https://docs.fedoraproject.org/en-US/epel/ ) and install htop
RUN dnf install -y https://dl.fedoraproject.org/pub/epel/epel-release-latest-9.noarch.rpm && \
    dnf install -y htop && \
    dnf clean all && \
    ostree container commit
```

This Containerfile installs the RHEL fish program. Because fish requires additional RHEL packages, the image must be built on an entitled RHEL host. For RHEL entitlements to work, you must copy the **etc-pki-entitlement** secret into the **openshift-machine-config-operator** namespace.

Example on-cluster Containerfile to apply a third-party package that has RHEL dependencies

```
FROM configs AS final
```

```
# RHEL entitled host is needed here to access RHEL packages
# Install fish as third party package from EPEL
RUN dnf install -y https://dl.fedoraproject.org/pub/epel/9/Everything/x86_64/Packages/f/fish-3.3.1-3.el9.x86_64.rpm && \
    dnf clean all && \
    ostree container commit
```

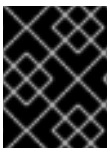
Example out-of-cluster Containerfile to apply a third-party package that has RHEL dependencies

```
# Get RHCOS base image of target cluster `oc adm release info --image-for rhel-coreos`
FROM quay.io/openshift-release-dev/ocp-v4.0-art-dev@sha256...

# RHEL entitled host is needed here to access RHEL packages
# Install fish as third party package from EPEL
RUN dnf install -y https://dl.fedoraproject.org/pub/epel/9/Everything/x86_64/Packages/f/fish-3.3.1-3.el9.x86_64.rpm && \
    dnf clean all && \
    ostree container commit
```

After you create the machine config, the Machine Config Operator (MCO) performs the following steps:

1. Renders a new machine config for the specified pool or pools.
2. Performs cordon and drain operations on the nodes in the pool or pools.
3. Writes the rest of the machine config parameters onto the nodes.
4. Applies the custom layered image to the node.
5. Reboots the node using the new image.



IMPORTANT

It is strongly recommended that you test your images outside of your production environment before rolling out to your cluster.

7.3. USING ON-CLUSTER LAYERING TO APPLY A CUSTOM LAYERED IMAGE

To apply a custom layered image to your cluster by using the on-cluster build process, make a **MachineOSConfig** custom resource (CR) that specifies the following parameters:

- the Containerfile to build
- the machine config pool to associate the build
- where the final image should be pushed and pulled from
- the push and pull secrets to use

You can create only one **MachineOSConfig** CR for each machine config pool.

When you create the object, the Machine Config Operator (MCO) creates a **MachineOSBuild** object

and a builder pod. The build process also creates transient objects, such as config maps, which are cleaned up after the build is complete. The **MachineOSBuild** object and the associated **builder-*** pod use the same naming scheme, **<MachineOSConfig_CR_name>-<hash>**, for example:

Example MachineOSBuild object

```
NAME                                                PREPARED   BUILDING   SUCCEEDED   INTERRUPTED   FAILED
layered-c8765e26ebc87e1e17a7d6e0a78e8bae   False      False      True        False         False
```

Example builder pod

```
NAME                                                READY   STATUS      RESTARTS      AGE
build-layered-c8765e26ebc87e1e17a7d6e0a78e8bae      2/2     Running     0             11m
```

When the build is complete, the MCO pushes the new custom layered image to your repository and rolled out to the nodes in the associated machine config pool. You can see the digested image pull spec for the new custom layered image in the **MachineOSBuild** object and **machine-os-builder** pod.

TIP

You can test a **MachineOSBuild** object to make sure it builds correctly without rolling out the custom layered image to active nodes by using a custom machine config pool that contains non-production nodes. Alternatively, you can use a custom machine config pool that has no nodes. The **MachineOSBuild** object builds even if there are no nodes for the MCO to deploy the custom layered image onto.

You should not need to interact with these new objects or the **machine-os-builder** pod. However, you can use all of these resources for troubleshooting, if necessary.

You need a separate **MachineOSConfig** CR for each machine config pool where you want to use a custom layered image.

Making certain changes to a **MachineOSConfig** object triggers an automatic rebuild of the associated custom layered image. You can mitigate the effects of the rebuild by pausing the machine config pool where the custom layered image is applied as described in "Pausing the machine config pools." While the pools are paused, the MCO does not roll out the newly built image to the nodes after the build is complete. However, the build will still run regardless of whether the pool is paused or not. For example, if you want to remove and replace a **MachineOSCOnfig** object, pausing the machine config pools before making the change prevents the MCO from reverting the associated nodes to the base image, reducing the number of reboots needed.

When a machine config pool is paused, the **oc get machineconfigpools** reports the following status:

Example output

```
NAME     CONFIG                                             UPDATED   UPDATING   DEGRADED
MACHINECOUNT   READYMACHINECOUNT   UPDATEDMACHINECOUNT
DEGRADEDMACHINECOUNT   AGE
master   rendered-master-a0b404d061a6183cc36d302363422aba   True      False      False      3
3              3                   0                   4h14m
worker   rendered-worker-221507009cbcdec0eec8ab3ccd789d18   False     False      False      2
2              2                   0                   4h14m  (1)
```

1 The **worker** machine config pool is paused, as indicated by the three **False** statuses and the **READYMACHINECOUNT** at **0**.

After the changes have been rolled out, you can unpause the machine config pool.

In the case of a build failure, for example due to network issues or an invalid secret, the MCO retries the build three additional times before the job fails. The MCO creates a different build pod for each build attempt. You can use the build pod logs to troubleshoot any build failures. However, the MCO automatically removes these build pods after a short period of time.

Example failed MachineOSBuild object

```
NAME                                PREPARED  BUILDING  SUCCEEDED  INTERRUPTED  FAILED
layered-c8765e26ebc87e1e17a7d6e0a78e8bae  False  False  False  False  True
```

You can manually rebuild your custom layered image by either modifying your **MachineOSConfig** object or applying an annotation to the **MachineOSConfig** object. For more information, see "Rebuilding an on-cluster custom layered image".

If you used a custom machine config pool to apply an on-cluster layered image to a node, you can remove the custom layered image from the node and revert to the base image. For more information, see "Reverting an on-cluster layered node".

You can modify an on-custom layered image as needed, to install additional packages, remove existing packages, change repositories, update secrets, or other similar changes, by editing the **MachineOSConfig** object. For more information, see "Modifying a custom layered image".

7.3.1. On-cluster layering known limitations

Note the following limitations when working with the on-cluster layering feature:

- On-cluster layering is supported only for OpenShift Container Platform clusters on the AMD64 architecture.
- On-cluster layering is not supported on multi-architecture compute machines, or single-node OpenShift clusters.
- If you scale up a machine set that uses a custom layered image, the nodes reboot two times. The first, when the node is initially created with the base image and a second time when the custom layered image is applied.
- Node disruption policies are not supported on nodes with a custom layered image. As a result the following configuration changes cause a node reboot:
  - Modifying the configuration files in the /**var** or /**etc** directory
  - Adding or modifying a systemd service
  - Changing SSH keys
  - Removing mirroring rules from **ICSP**, **ITMS**, and **IDMS** objects
  - Changing the trusted CA, by updating the **user-ca-bundle** configmap in the **openshift-config** namespace

- The images used in creating custom layered images take up space in your push registry. Always be aware of the free space in your registry and prune the images as needed. You can automatically remove an on-cluster, custom layered image from the repository by deleting the **MachineOSBuild** object that created the image. Note that the credentials provided by the registry push secret must also grant permission to delete an image from the registry. For more information, see "Removing an on-cluster custom layered image".

Prerequisites

- You have a copy of the pull secret in the **openshift-machine-config-operator** namespace that the MCO needs to pull the base operating system image.
  For example, if you are using the global pull secret, you can run the following command:

```
$oc create secret docker-registry global-pull-secret-copy \
  --namespace "openshift-machine-config-operator" \
  --from-file=.dockerconfigjson=<(oc get secret/pull-secret -n openshift-config -o go-template='{{index .data ".dockerconfigjson" | base64decode}}')
```

- You have the push secret of the registry that the MCO needs to push the new custom layered image to.
- You have a pull secret that your nodes need to pull the new custom layered image from your registry. This should be a different secret than the one used to push the image to the repository.
- You are familiar with how to configure a Containerfile. Instructions on how to create a Containerfile are beyond the scope of this documentation.
- Optional: You have a separate machine config pool for the nodes where you want to apply the custom layered image. One benefit to having a custom machine config pool for the nodes is that you can easily revert to the base image, if needed. For more information, see "Reverting an on-cluster layered node".

Procedure

1. Create a **MachineOSconfig** object:
   a. Create a YAML file similar to the following:

```
apiVersion: machineconfiguration.openshift.io/v1 1
kind: MachineOSConfig
metadata:
  name: layered 2
spec:
  machineConfigPool:
    name: layered 3
  containerFile: 4
  - containerfileArch: NoArch 5
    content: |-
      FROM configs AS final
      RUN dnf install -y cowsay && \
        dnf clean all && \
        ostree container commit
  imageBuilder: 6
    imageBuilderType: Job
```

```
  baseImagePullSecret: 7
    name: global-pull-secret-copy
  renderedImagePushSpec: image-registry.openshift-image-
registry.svc:5000/openshift/os-image:latest 8
  renderedImagePushSecret: 9
    name: builder-dockercfg-mtcl23
```

1. Specifies the **machineconfiguration.openshift.io/v1** API that is required for **MachineConfig** CRs.
2. Specifies a name for the **MachineOSConfig** object. The name must match the name of the associated machine config pool. This name is used with other on-cluster layering resources. The examples in this documentation use the name **layered**.
3. Specifies the name of the machine config pool associated with the nodes where you want to deploy the custom layered image. The examples in this documentation use the **layered** machine config pool.
4. Specifies the Containerfile to configure the custom layered image.
5. Specifies the architecture this containerfile is to be built for: **ARM64**, **AMD64**, **PPC64LE**, **S390X**, or **NoArch**. The default is **NoArch**, which defines a Containerfile that can be applied to any architecture.
6. Specifies the name of the image builder to use. This must be **Job**, which is a reference to the **job** object that is managing the image build.
7. Optional: Specifies the name of the pull secret that the MCO needs to pull the base operating system image from the registry. By default, the global pull secret is used.
8. Specifies the image registry to push the newly-built custom layered image to. This can be any registry that your cluster has access to in the **host[:port][/namespace]/name** or **svc_name.namespace.svc[:port]/repository/name:<tag>** format. This example uses the internal OpenShift Container Platform registry. You can specify a mirror registry if you cluster is properly configured to use a mirror registry.
9. Specifies the name of the push secret that the MCO needs to push the newly-built custom layered image to that registry.

b. Create the **MachineOSConfig** object:

```
$ oc create -f <file_name>.yaml
```

2. If necessary, when the **MachineOSBuild** object has been created and is in the **READY** state, modify the node spec for the nodes where you want to use the new custom layered image:

a. Check that the **MachineOSBuild** object is **READY**. When the **SUCCEEDED** value is **True**, the build is complete.

```
$ oc get machineosbuild
```

Example output showing that the MachineOSBuild object is ready

```
NAME                                         PREPARED   BUILDING   SUCCEEDED
INTERRUPTED   FAILED
layered-ad5a3cad36303c363cf458ab0524e7c0-builder   False      False      True
False         False
```

b. Edit the nodes where you want to deploy the custom layered image by adding a label for the machine config pool you specified in the **MachineOSConfig** object:

```
$ oc label node <node_name> 'node-role.kubernetes.io/<mcp_name>='
```

where:

node-role.kubernetes.io/<mcp_name>=

Specifies a node selector that identifies the nodes to deploy the custom layered image.

When you save the changes, the MCO drains, cordons, and reboots the nodes. After the reboot, the node will be using the new custom layered image.

Verification

1. Verify that the new pods are ready by running the following command:

```
$ oc get pods -n openshift-machine-config-operator
```

Example output

```
NAME                                          READY   STATUS    RESTARTS   AGE
build-layered-ad5a3cad36303c363cf458ab0524e7c0-hxrws          2/2     Running   0
2m40s (1)
# ...
machine-os-builder-6fb66cfb99-zcpvq                  1/1     Running   0          2m42s (2)
```

(1) This is the build pod where the custom layered image is building, named in the **build-<MachineOSConfig_CR_name>-<hash>** format.

(2) This pod can be used for troubleshooting.

2. Verify that the **MachineOSConfig** object contains a reference to the new custom layered image by running the following command:

```
$ oc get machineosbuilds
```

Example output

```
NAME                                PREPARED   BUILDING   SUCCEEDED   INTERRUPTED
FAILED
layered-ad5a3cad36303c363cf458ab0524e7c0   False      True       False       False
False (1)
```

(1) The **MachineOSBuild** is named in the **<MachineOSConfig_CR_name>-<hash>** format.

3. Verify that the **MachineOSBuild** object contains a reference to the new custom layered image by running the following command:

```
$ oc describe machineosbuild <object_name>
```

Example output

```
Name:         layered-ad5a3cad36303c363cf458ab0524e7c0
# ...
API Version:  machineconfiguration.openshift.io/v1
Kind:         MachineOSBuild
# ...
Spec:
  Config Generation:  1
  Desired Config:
    Name:  rendered-layered-ad5a3cad36303c363cf458ab0524e7c0
  Machine OS Config:
    Name:                  layered
  Rendered Image Pushspec:  image-registry.openshift-image-registry.svc:5000/openshift-machine-config-operator/os-images:layered-ad5a3cad36303c363cf458ab0524e7c0
# ...
    Last Transition Time:  2025-02-12T19:21:28Z
    Message:               Build Ready
    Reason:                Ready
    Status:                True
    Type:                  Succeeded
  Final Image Pullspec:    image-registry.openshift-image-registry.svc:5000/openshift-machine-config-operator/os-images@sha256:312e48825e074b01a913deedd6de68abd44894ede50b2d14f99d722f13cda04b (1)
```

(1) Digested image pull spec for the new custom layered image.

4. Verify that the appropriate nodes are using the new custom layered image:

   a. Start a debug session as root for a control plane node:

```
$ oc debug node/<node_name>
```

   b. Set **/host** as the root directory within the debug shell:

```
sh-4.4# chroot /host
```

   c. Run the **rpm-ostree status** command to view that the custom layered image is in use:

```
sh-5.1# rpm-ostree status
```

Example output

```
# ...
Deployments:
* ostree-unverified-registry:image-registry.openshift-image-registry.svc:5000/openshift-machine-config-operator/os-
```

```
images@sha256:312e48825e074b01a913deedd6de68abd44894ede50b2d14f99d722f13cda04b
                Digest:
sha256:312e48825e074b01a913deedd6de68abd44894ede50b2d14f99d722f13cda04b
(1)
                Version: 418.94.202502100215-0 (2025-02-12T19:20:44Z)
```

(1) Digested image pull spec for the new custom layered image.

Additional resources

- Pausing the machine config pools
- Removing an on-cluster custom layered image
- Modifying a custom layered image
- Rebuilding an on-cluster custom layered image
- Reverting an on-cluster custom layered image

7.3.2. Modifying a custom layered image

You can modify an on-cluster custom layered image, as needed. This allows you to install additional packages, remove existing packages, change the pull or push repositories, update secrets, or other similar changes. You can edit the **MachineOSConfig** object, apply changes to the YAML file that created the **MachineOSConfig** object, or create a new YAML file for that purpose.

If you modify and apply the **MachineOSConfig** object YAML or create a new YAML file, the YAML overwrites any changes you made directly to the **MachineOSConfig** object itself.

Making certain changes to a **MachineOSConfig** object triggers an automatic rebuild of the associated custom layered image. You can mitigate the effects of the rebuild by pausing the machine config pool where the custom layered image is applied as described in "Pausing the machine config pools." While the pools are paused, the MCO does not roll out the newly built image to the nodes after the build is complete. However, the build will still run regardless of whether the pool is paused or not. For example, if you want to remove and replace a **MachineOSCOnfig** object, pausing the machine config pools before making the change prevents the MCO from reverting the associated nodes to the base image, reducing the number of reboots needed.

When a machine config pool is paused, the **oc get machineconfigpools** reports the following status:

Example output

```
NAME     CONFIG                                             UPDATED   UPDATING   DEGRADED
MACHINECOUNT   READYMACHINECOUNT   UPDATEDMACHINECOUNT
DEGRADEDMACHINECOUNT   AGE
master   rendered-master-a0b404d061a6183cc36d302363422aba   True      False      False      3
3              3                   0                   4h14m
worker   rendered-worker-221507009cbcdec0eec8ab3ccd789d18   False     False      False      2
2              2                   0                   4h14m (1)
```

1 The **worker** machine config pool is paused, as indicated by the three **False** statuses and the **READYMACHINECOUNT** at **0**.

After the changes have been rolled out, you can unpause the machine config pool.

Prerequisites

- You have opted in to on-cluster layering by creating a **MachineOSConfig** object.

Procedure

- Modify an object to update the associated custom layered image:

  a. Edit the **MachineOSConfig** object to modify the custom layered image. The following example adds the **rngd** daemon to nodes that already have the tree package that was installed using a custom layered image.

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineOSConfig
metadata:
  name: layered
spec:
  machineConfigPool:
    name: layered
  containerFile:
  - containerfileArch: NoArch
    content: |- 1
      FROM configs AS final
      RUN dnf install -y cowsay && \
        dnf clean all && \
        ostree container commit
  imageBuilder:
    imageBuilderType: Job
  baseImagePullSecret:
    name: global-pull-secret-copy 2
  renderedImagePushSpec: image-registry.openshift-image-
registry.svc:5000/openshift/os-image:latest 3
  renderedImagePushSecret: 4
    name: builder-dockercfg-mtcl23
```

1 Optional: Modify the Containerfile, for example to add or remove packages.

2 Optional: Update the secret needed to pull the base operating system image from the registry.

3 Optional: Modify the image registry to push the newly built custom layered image to.

4 Optional: Update the secret needed to push the newly built custom layered image to the registry.

When you save the changes, the MCO drains, cordons, and reboots the nodes. After the reboot, the node uses the cluster base Red Hat Enterprise Linux CoreOS (RHCOS) image. If your changes modify a secret only, no new build is triggered and no reboot is performed.

Verification

1. Verify that the new **MachineOSBuild** object was created by using the following command:

```
$ oc get machineosbuild
```

Example output

```
NAME                                PREPARED   BUILDING   SUCCEEDED   INTERRUPTED
FAILED
layered-a5457b883f5239cdcb71b57e1a30b6ef   False      False      True        False
False
layered-f91f0f5593dd337d89bf4d38c877590b   False      True       False       False       False
(1)
```

(1) The value **True** in the **BUILDING** column indicates that the **MachineOSBuild** object is building. When the **SUCCEEDED** column reports **True**, the build is complete.

2. You can watch as the new machine config is rolled out to the nodes by using the following command:

```
$ oc get machineconfigpools
```

Example output

```
NAME     CONFIG                                             UPDATED   UPDATING   DEGRADED
MACHINECOUNT   READYMACHINECOUNT   UPDATEDMACHINECOUNT
DEGRADEDMACHINECOUNT   AGE
master   rendered-master-a0b404d061a6183cc36d302363422aba   True      False      False
3              3                   3                     0                      3h38m
worker   rendered-worker-221507009cbcdec0eec8ab3ccd789d18   False     True       False
2              2                   2                     0                      3h38m (1)
```

(1) The value **FALSE** in the **UPDATED** column indicates that the **MachineOSBuild** object is building. When the **UPDATED** column reports **FALSE**, the new custom layered image has rolled out to the nodes.

3. When the node is back in the **Ready** state, check that the changes were applied:

   a. Open an **oc debug** session to the node by running the following command:

```
$ oc debug node/<node_name>
```

   b. Set **/host** as the root directory within the debug shell by running the following command:

```
sh-5.1# chroot /host
```

   c. Use an appropriate command to verify that change was applied. The following examples shows that the **rngd** daemon was installed:

```
sh-5.1# rpm -qa |grep rng-tools
```

-

Example output

```
rng-tools-6.17-3.fc41.x86_64
```

```
sh-5.1# rngd -v
```

Example output

```
rngd 6.16
```

Additional resources

- Pausing the machine config pools

7.3.3. Rebuilding an on-cluster custom layered image

In situations where you want to rebuild an on-cluster custom layered image, you can either modify your **MachineOSConfig** object or add an annotation to the **MachineOSConfig** object. Both of these actions trigger an automatic rebuild of the object. For example, you could perform a rebuild if the you change the Containerfile or need to update the **osimageurl** location in a machine config.

After you add the annotation, the Machine Config Operator (MCO) deletes the current **MachineOSBuild** object and creates a new one in its place. When the build process is complete, the MCO automatically removes the annotation.

Prerequisites

- You have opted-in to {image-mode-os-on-lower} by creating a **MachineOSConfig** object.

Procedure

- Edit the **MachineOSConfig** object to add the **machineconfiguration.openshift.io/rebuild** annotation by using the following command:

```
$ oc edit MachineOSConfig <object_name>
```

Example MachineOSConfig object

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineOSConfig
metadata:
  annotations:
    machineconfiguration.openshift.io/current-machine-os-build: layering-
c26d4a003432df70ee66c83981144cfa
    machineconfiguration.openshift.io/rebuild: "" (1)
# ...
  name: layered
# ...
```

(1) Add this annotation to trigger a rebuild of the custom layered image.

Verification

- Check that the **MachineOSBuild** object is building by using the following command:

```
$ oc get machineosbuild
```

Example output

```
NAME                                PREPARED   BUILDING   SUCCEEDED
INTERRUPTED   FAILED   AGE
layered-d6b929a29c6dbfa8e4007c8069a2fd08   False      True       False      False
False    2m41s 1
```

1 The value **True** in the **BUILDING** column indicates that the **MachineOSBuild** object is building.

- Edit the **MachineOSConfig** object to verify that the MCO removed the **machineconfiguration.openshift.io/rebuild** annotation by using the following command:

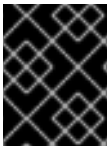
```
$ oc edit MachineOSConfig <object_name>
```

Example MachineOSConfig object

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineOSConfig
metadata:
  annotations:
    machineconfiguration.openshift.io/current-machine-os-build: layering-
c26d4a003432df70ee66c83981144cfa
# ...
  name: layered
# ...
```

7.3.4. Reverting an on-cluster custom layered image

You can revert an on-cluster custom layered image from nodes by removing the label for the machine config pool (MCP) that you specified in the **MachineOSConfig** object. After you remove the label, the Machine Config Operator (MCO) reboots the nodes in that MCP with the cluster base Red Hat Enterprise Linux CoreOS (RHCOS) image, along with any previously-made machine config changes, overriding the custom layered image.



IMPORTANT

If the node where the custom layered image is deployed uses a custom machine config pool, before you remove the label, make sure the node is associated with a second MCP.

You can reapply the custom layered image to the node by using the **oc label node/<node_name> 'node-role.kubernetes.io/<mcp_name>='** label.

Prerequisites

- You have opted in to on-cluster layering by creating a **MachineOSConfig** object.

Procedure

- Remove the label from the node by using the following command:

```
$ oc label node/<node_name> node-role.kubernetes.io/<mcp_name>-
```

When you save the changes, the MCO drains, cordons, and reboots the nodes. After the reboot, the node uses the cluster base Red Hat Enterprise Linux CoreOS (RHCOS) image.

Verification

You can verify that the custom layered image is removed by performing the following checks:

1. Check that the worker machine config pool is updating with the previous machine config:

```
$ oc get mcp
```

Sample output

```
NAME     CONFIG                                             UPDATED   UPDATING   DEGRADED
MACHINECOUNT   READYMACHINECOUNT   UPDATEDMACHINECOUNT
DEGRADEDMACHINECOUNT   AGE
master   rendered-master-8332482204e0b76002f15ecad15b6c2d   True      False      False
3            3                 3                   0                   5h26m
worker   rendered-worker-bde4e4206442c0a48b1a1fb35ba56e85   False     True       False
3            2                 2                   0                   5h26m  1
```

1 The value **FALSE** in the **UPDATED** column indicates that the **MachineOSBuild** object is building. When the **UPDATED** column reports **FALSE**, the base image has rolled out to the nodes.

2. Check the nodes to see that scheduling on the nodes is disabled. This indicates that the change is being applied:

```
$ oc get nodes
```

Example output

```
NAME                                        STATUS                     ROLES                  AGE   VERSION
ip-10-0-148-79.us-west-1.compute.internal   Ready                      worker                 32m
v1.31.3
ip-10-0-155-125.us-west-1.compute.internal  Ready,SchedulingDisabled   worker
35m   v1.31.3
ip-10-0-170-47.us-west-1.compute.internal   Ready                      control-plane,master   42m
v1.31.3
ip-10-0-174-77.us-west-1.compute.internal   Ready                      control-plane,master   42m
v1.31.3
ip-10-0-211-49.us-west-1.compute.internal   Ready                      control-plane,master   42m
v1.31.3
ip-10-0-218-151.us-west-1.compute.internal  Ready                      worker                 31m
v1.31.3
```

3. When the node is back in the **Ready** state, check that the node is using the base image:

   a. Open an **oc debug** session to the node. For example:

   ```
   $ oc debug node/<node_name>
   ```

   b. Set **/host** as the root directory within the debug shell:

   ```
   sh-5.1# chroot /host
   ```

   c. Run an **rpm-ostree status** command to view that the base image is in use:

   ```
   sh-5.1# rpm-ostree status
   ```

   Example output

   ```
   State: idle
   Deployments:
   * ostree-unverified-image:containers-storage:quay.io/openshift-release-dev/ocp-v4.0-art-dev@sha256:76721c875a2b79688be46b1dca654c2c6619a6be28b29a2822cd86c3f9d8e3c1
                    Digest: sha256:76721c875a2b79688be46b1dca654c2c6619a6be28b29a2822cd86c3f9d8e3c1
                 Version: 418.94.202501300706-0 (2025-01-30T07:10:58Z)
   ```

7.3.5. Removing an on-cluster custom layered image

To prevent the custom layered images from taking up excessive space in your registry, you can automatically remove an on-cluster custom layered image from the repository by deleting the **MachineOSBuild** object that created the image.

The credentials provided by the registry push secret that you added to the **MachineOSBuild** object must grant the permission for deleting an image from the registry. If the delete permission is not provided, the image is not removed when you delete the **MachineOSBuild** object.

The custom layered image is not deleted if the image is either currently in use on a node or is desired by the nodes, as indicated by the **machineconfiguration.openshift.io/currentImage** or **machineconfiguration.openshift.io/desiredImage** annotations on the node, which are added to the node when you create the **MachineOSConfig** object.

7.4. USING OUT-OF-CLUSTER LAYERING TO APPLY A CUSTOM LAYERED IMAGE

You can easily configure Red Hat Enterprise Linux CoreOS (RHCOS) image layering on the nodes in specific machine config pools. The Machine Config Operator (MCO) reboots those nodes with the new custom layered image, overriding the base Red Hat Enterprise Linux CoreOS (RHCOS) image.

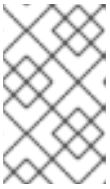
To apply a custom layered image to your cluster, you must have the custom layered image in a repository that your cluster can access. Then, create a **MachineConfig** object that points to the custom layered image. You need a separate **MachineConfig** object for each machine config pool that you want to configure.

IMPORTANT

As soon as you apply an out-of-cluster custom image to your cluster, you effectively *take ownership* of your custom layered images and those nodes. OpenShift Container Platform no longer automatically updates any node that uses the custom layered image. You become responsible for maintaining and updating your nodes as appropriate. If you roll back the custom layer, OpenShift Container Platform resumes automatically updating the node. See the "Updating with a RHCOS custom layered image" for important information about updating nodes that use a custom layered image.

Prerequisites

- You must create a custom layered image that is based on an OpenShift Container Platform image digest, not a tag.



NOTE

You should use the same base RHCOS image that is installed on the rest of your cluster. Use the **oc adm release info --image-for rhel-coreos** command to obtain the base image being used in your cluster.

For example, the following Containerfile creates a custom layered image from an OpenShift Container Platform 4.18 image and overrides the kernel package with one from CentOS 9 Stream:

Example Containerfile for a custom layer image

```
# Using a 4.18.0 image
FROM quay.io/openshift-release-dev/ocp-v4.0-art-dev@sha256... 1
#Install hotfix rpm
RUN rpm-ostree override replace http://mirror.stream.centos.org/9-
stream/BaseOS/x86_64/os/Packages/kernel-{,core-,modules-,modules-core-,modules-extra-
}5.14.0-295.el9.x86_64.rpm && \ 2
    rpm-ostree cleanup -m && \
    ostree container commit
```

1 Specifies the RHCOS base image of your cluster.

2 Replaces the kernel packages.

NOTE

Instructions on how to create a Containerfile are beyond the scope of this documentation.

- Because the process for building a custom layered image is performed outside of the cluster, you must use the **--authfile /path/to/pull-secret** option with Podman or Buildah. Alternatively, to have the pull secret read by these tools automatically, you can add it to one of the default file locations: **~/.docker/config.json**, **$XDG_RUNTIME_DIR/containers/auth.json**, **~/.docker/config.json**, or **~/.dockercfg**. Refer to the **containers-auth.json** man page for more information.

- You must push the custom layered image to a repository that your cluster can access.

Procedure

1. Create a machine config file.

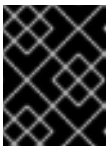
   a. Create a YAML file similar to the following:

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker 1
  name: os-layer-custom
spec:
  osImageURL: quay.io/my-registry/custom-image@sha256... 2
```

   1. Specifies the machine config pool to deploy the custom layered image.
   2. Specifies the path to the custom layered image in the repository.

   b. Create the **MachineConfig** object:

```
$ oc create -f <file_name>.yaml
```



IMPORTANT

It is strongly recommended that you test your images outside of your production environment before rolling out to your cluster.

Verification

You can verify that the custom layered image is applied by performing any of the following checks:

1. Check that the worker machine config pool has rolled out with the new machine config:

   a. Check that the new machine config is created:

```
$ oc get mc
```

Sample output

```
NAME                                               GENERATEDBYCONTROLLER
IGNITIONVERSION   AGE
00-master                                          5bdb57489b720096ef912f738b46330a8f577803
3.4.0             95m
00-worker                                          5bdb57489b720096ef912f738b46330a8f577803
3.4.0             95m
01-master-container-runtime
5bdb57489b720096ef912f738b46330a8f577803   3.4.0             95m
01-master-kubelet                                  5bdb57489b720096ef912f738b46330a8f577803
3.4.0             95m
01-worker-container-runtime
5bdb57489b720096ef912f738b46330a8f577803   3.4.0             95m
01-worker-kubelet                                  5bdb57489b720096ef912f738b46330a8f577803
3.4.0             95m
```

```
99-master-generated-registries
5bdb57489b720096ef912f738b46330a8f577803   3.4.0          95m
99-master-ssh                                             3.2.0          98m
99-worker-generated-registries
5bdb57489b720096ef912f738b46330a8f577803   3.4.0          95m
99-worker-ssh                                             3.2.0          98m
os-layer-custom                                                          10s (1)
rendered-master-15961f1da260f7be141006404d17d39b
5bdb57489b720096ef912f738b46330a8f577803   3.4.0          95m
rendered-worker-5aff604cb1381a4fe07feaf1595a797e
5bdb57489b720096ef912f738b46330a8f577803   3.4.0          95m
rendered-worker-5de4837625b1cbc237de6b22bc0bc873
5bdb57489b720096ef912f738b46330a8f577803   3.4.0          4s (2)
```

(1) New machine config

(2) New rendered machine config

b. Check that the **osImageURL** value in the new machine config points to the expected image:

```
$ oc describe mc rendered-worker-5de4837625b1cbc237de6b22bc0bc873
```

Example output

```
Name:         rendered-worker-5de4837625b1cbc237de6b22bc0bc873
Namespace:
Labels:       <none>
Annotations:  machineconfiguration.openshift.io/generated-by-controller-version:
5bdb57489b720096ef912f738b46330a8f577803
              machineconfiguration.openshift.io/release-image-version: 4.18.0-ec.3
API Version:  machineconfiguration.openshift.io/v1
Kind:         MachineConfig
...
  Os Image URL: quay.io/my-registry/custom-image@sha256...
```

c. Check that the associated machine config pool is updated with the new machine config:

```
$ oc get mcp
```

Sample output

```
NAME     CONFIG                                             UPDATED   UPDATING   DEGRADED
MACHINECOUNT   READYMACHINECOUNT   UPDATEDMACHINECOUNT
DEGRADEDMACHINECOUNT   AGE
master   rendered-master-15961f1da260f7be141006404d17d39b   True      False
False     3              3                   3                     0                    39m
worker   rendered-worker-5de4837625b1cbc237de6b22bc0bc873   True      False
False     3              0                   0                     0                    39m (1)
```

1 When the **UPDATING** field is **True**, the machine config pool is updating with the new machine config. In this case, you will not see the new machine config listed in the

d. Check the nodes to see that scheduling on the nodes is disabled. This indicates that the change is being applied:

```
$ oc get nodes
```

Example output

```
NAME                                         STATUS                     ROLES                  AGE
VERSION
ip-10-0-148-79.us-west-1.compute.internal    Ready                      worker                 32m
v1.31.3
ip-10-0-155-125.us-west-1.compute.internal   Ready,SchedulingDisabled   worker
35m   v1.31.3
ip-10-0-170-47.us-west-1.compute.internal    Ready                      control-plane,master
42m   v1.31.3
ip-10-0-174-77.us-west-1.compute.internal    Ready                      control-plane,master
42m   v1.31.3
ip-10-0-211-49.us-west-1.compute.internal    Ready                      control-plane,master
42m   v1.31.3
ip-10-0-218-151.us-west-1.compute.internal   Ready                      worker                 31m
v1.31.3
```

2. When the node is back in the **Ready** state, check that the node is using the custom layered image:

a. Open an **oc debug** session to the node. For example:

```
$ oc debug node/ip-10-0-155-125.us-west-1.compute.internal
```

b. Set **/host** as the root directory within the debug shell:

```
sh-4.4# chroot /host
```

c. Run the **rpm-ostree status** command to view that the custom layered image is in use:

```
sh-4.4# sudo rpm-ostree status
```

Example output

```
State: idle
Deployments:
* ostree-unverified-registry:quay.io/my-registry/...
                   Digest: sha256:...
```

Additional resources

Updating with a RHCOS custom layered image

7.4.1. Reverting an out-of-cluster node

You can revert an out-of-cluster custom layered image from the nodes in specific machine config pools. The Machine Config Operator (MCO) reboots those nodes with the cluster base Red Hat Enterprise Linux CoreOS (RHCOS) image, overriding the custom layered image.

To remove a Red Hat Enterprise Linux CoreOS (RHCOS) custom layered image from your cluster, you need to delete the machine config that applied the image.

Procedure

- Delete the machine config that applied the custom layered image.

```
$ oc delete mc os-layer-custom
```

  After deleting the machine config, the nodes reboot.

Verification

You can verify that the custom layered image is removed by performing any of the following checks:

1. Check that the worker machine config pool is updating with the previous machine config:

```
$ oc get mcp
```

Sample output

```
NAME     CONFIG                                             UPDATED   UPDATING   DEGRADED
MACHINECOUNT   READYMACHINECOUNT   UPDATEDMACHINECOUNT
DEGRADEDMACHINECOUNT   AGE
master   rendered-master-6faecdfa1b25c114a58cf178fbaa45e2   True      False      False
3            3                 3                   0                      39m
worker   rendered-worker-6b000dbc31aaee63c6a2d56d04cd4c1b   False     True       False
3            0                 0                   0                      39m  1
```

1. When the **UPDATING** field is **True**, the machine config pool is updating with the previous machine config. When the field becomes **False**, the worker machine config pool has rolled out to the previous machine config.

2. Check the nodes to see that scheduling on the nodes is disabled. This indicates that the change is being applied:

```
$ oc get nodes
```

Example output

```
NAME                                        STATUS                     ROLES                  AGE   VERSION
ip-10-0-148-79.us-west-1.compute.internal   Ready                      worker                 32m
v1.31.3
ip-10-0-155-125.us-west-1.compute.internal  Ready,SchedulingDisabled   worker
35m   v1.31.3
ip-10-0-170-47.us-west-1.compute.internal   Ready                      control-plane,master   42m
v1.31.3
ip-10-0-174-77.us-west-1.compute.internal   Ready                      control-plane,master   42m
v1.31.3
```

```
ip-10-0-211-49.us-west-1.compute.internal    Ready                      control-plane,master   42m
v1.31.3
ip-10-0-218-151.us-west-1.compute.internal   Ready                      worker                 31m
v1.31.3
```

3. When the node is back in the **Ready** state, check that the node is using the base image:

   a. Open an **oc debug** session to the node by running the following command:

   ```
   $ oc debug node/<node_name>
   ```

   b. Set **/host** as the root directory within the debug shell by running the following command:

   ```
   sh-5.1# chroot /host
   ```

   c. Run the **rpm-ostree status** command to view that the custom layered image is in use:

   ```
   sh-5.1# sudo rpm-ostree status
   ```

   Example output

   ```
   State: idle
   Deployments:
   * ostree-unverified-registry:podman pull quay.io/openshift-release-dev/ocp-
   release@sha256:e2044c3cfebe0ff3a99fc207ac5efe6e07878ad59fd4ad5e41f88cb016dacd
   73
                      Digest:
   sha256:e2044c3cfebe0ff3a99fc207ac5efe6e07878ad59fd4ad5e41f88cb016dacd73
   ```

7.5. UPDATING WITH A RHCOS CUSTOM LAYERED IMAGE

When you configure Red Hat Enterprise Linux CoreOS (RHCOS) image layering, OpenShift Container Platform no longer automatically updates the node pool that uses the custom layered image. You become responsible to manually update your nodes as appropriate.

To update a node that uses a custom layered image, follow these general steps:

1. The cluster automatically upgrades to version x.y.z+1, except for the nodes that use the custom layered image.

2. You could then create a new Containerfile that references the updated OpenShift Container Platform image and the RPM that you had previously applied.

3. Create a new machine config that points to the updated custom layered image.

Updating a node with a custom layered image is not required. However, if that node gets too far behind the current OpenShift Container Platform version, you could experience unexpected results.

CHAPTER 8. MACHINE CONFIG DAEMON METRICS OVERVIEW

The Machine Config Daemon is a part of the Machine Config Operator. It runs on every node in the cluster. The Machine Config Daemon manages configuration changes and updates on each of the nodes.

8.1. UNDERSTANDING MACHINE CONFIG DAEMON METRICS

Beginning with OpenShift Container Platform 4.3, the Machine Config Daemon provides a set of metrics. These metrics can be accessed using the Prometheus Cluster Monitoring stack.

The following table describes this set of metrics. Some entries contain commands for getting specific logs. However, the most comprehensive set of logs is available using the **oc adm must-gather** command.

NOTE

Metrics marked with * in the **Name** and **Description** columns represent serious errors that might cause performance problems. Such problems might prevent updates and upgrades from proceeding.

Table 8.1. MCO metrics

Name	Format	Description	Notes
mcd_host_os_and_version	**[]string{"os", "version"}**	Shows the OS that MCD is running on, such as RHCOS or RHEL. In case of RHCOS, the version is provided.	
mcd_drain_err*		Logs errors received during failed drain. *	While drains might need multiple tries to succeed, terminal failed drains prevent updates from proceeding. The **drain_time** metric, which shows how much time the drain took, might help with troubleshooting. For further investigation, see the logs by running: **$ oc logs -f -n openshift-machine-config-operator machine-config-daemon-<hash> -c machine-config-daemon**

Name	Format	Description	Notes
mcd_pivot_err*	**[]string{"err", "node", "pivot_target"}**	Logs errors encountered during pivot. *	Pivot errors might prevent OS upgrades from proceeding. For further investigation, run this command to see the logs from the **machine-config-daemon** container: **$ oc logs -f -n openshift-machine-config-operator machine-config-daemon-<hash> -c machine-config-daemon**
mcd_state	**[]string{"state", "reason"}**	State of Machine Config Daemon for the indicated node. Possible states are "Done", "Working", and "Degraded". In case of "Degraded", the reason is included.	For further investigation, see the logs by running: **$ oc logs -f -n openshift-machine-config-operator machine-config-daemon-<hash> -c machine-config-daemon**
mcd_kubelet_state*		Logs kubelet health failures. *	This is expected to be empty, with failure count of 0. If failure count exceeds 2, the error indicating threshold is exceeded. This indicates a possible issue with the health of the kubelet. For further investigation, run this command to access the node and see all its logs: **$ oc debug node/<node> — chroot /host journalctl -u kubelet**

Name	Format	Description	Notes
mcd_reboot_err*	**[]string{"message", "err", "node"}**	Logs the failed reboots and the corresponding errors. *	This is expected to be empty, which indicates a successful reboot. For further investigation, see the logs by running: **$ oc logs -f -n openshift-machine-config-operator machine-config-daemon-<hash> -c machine-config-daemon**
mcd_update_state	**[]string{"config", "err"}**	Logs success or failure of configuration updates and the corresponding errors.	The expected value is **rendered-master/rendered-worker-XXXX**. If the update fails, an error is present. For further investigation, see the logs by running: **$ oc logs -f -n openshift-machine-config-operator machine-config-daemon-<hash> -c machine-config-daemon**

Additional resources

- About OpenShift Container Platform monitoring
- Gathering data about your cluster