



OpenShift Container Platform 4.18

Edge computing

Configure and deploy OpenShift Container Platform clusters at the network edge

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Abstract

This document describes how to configure and deploy OpenShift Container Platform clusters using GitOps ZTP to provision and manage sites at the far edge of the network.

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CHAPTER 1. CHALLENGES OF THE NETWORK FAR EDGE

Edge computing presents complex challenges when managing many sites in geographically displaced locations. Use GitOps Zero Touch Provisioning (ZTP) to provision and manage sites at the far edge of the network.

1.1. OVERCOMING THE CHALLENGES OF THE NETWORK FAR EDGE

Today, service providers want to deploy their infrastructure at the edge of the network. This presents significant challenges:

- How do you handle deployments of many edge sites in parallel?
- What happens when you need to deploy sites in disconnected environments?
- How do you manage the lifecycle of large fleets of clusters?

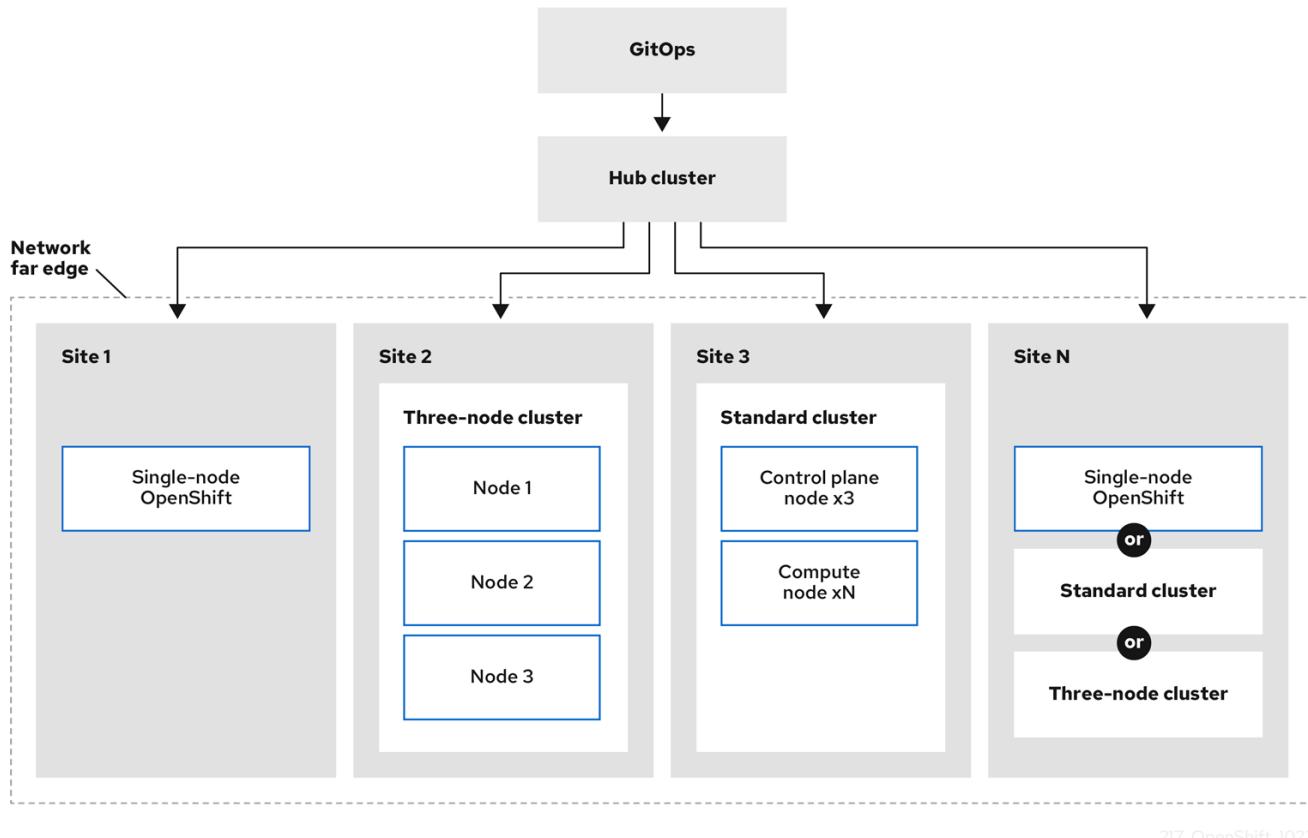
GitOps Zero Touch Provisioning (ZTP) and *GitOps* meets these challenges by allowing you to provision remote edge sites at scale with declarative site definitions and configurations for bare-metal equipment. Template or overlay configurations install OpenShift Container Platform features that are required for CNF workloads. The full lifecycle of installation and upgrades is handled through the GitOps ZTP pipeline.

GitOps ZTP uses GitOps for infrastructure deployments. With GitOps, you use declarative YAML files and other defined patterns stored in Git repositories. Red Hat Advanced Cluster Management (RHACM) uses your Git repositories to drive the deployment of your infrastructure.

GitOps provides traceability, role-based access control (RBAC), and a single source of truth for the desired state of each site. Scalability issues are addressed by Git methodologies and event driven operations through webhooks.

You start the GitOps ZTP workflow by creating declarative site definition and configuration custom resources (CRs) that the GitOps ZTP pipeline delivers to the edge nodes.

The following diagram shows how GitOps ZTP works within the far edge framework.



217_OpenShift_1022

1.2. USING GITOOPS ZTP TO PROVISION CLUSTERS AT THE NETWORK FAR EDGE

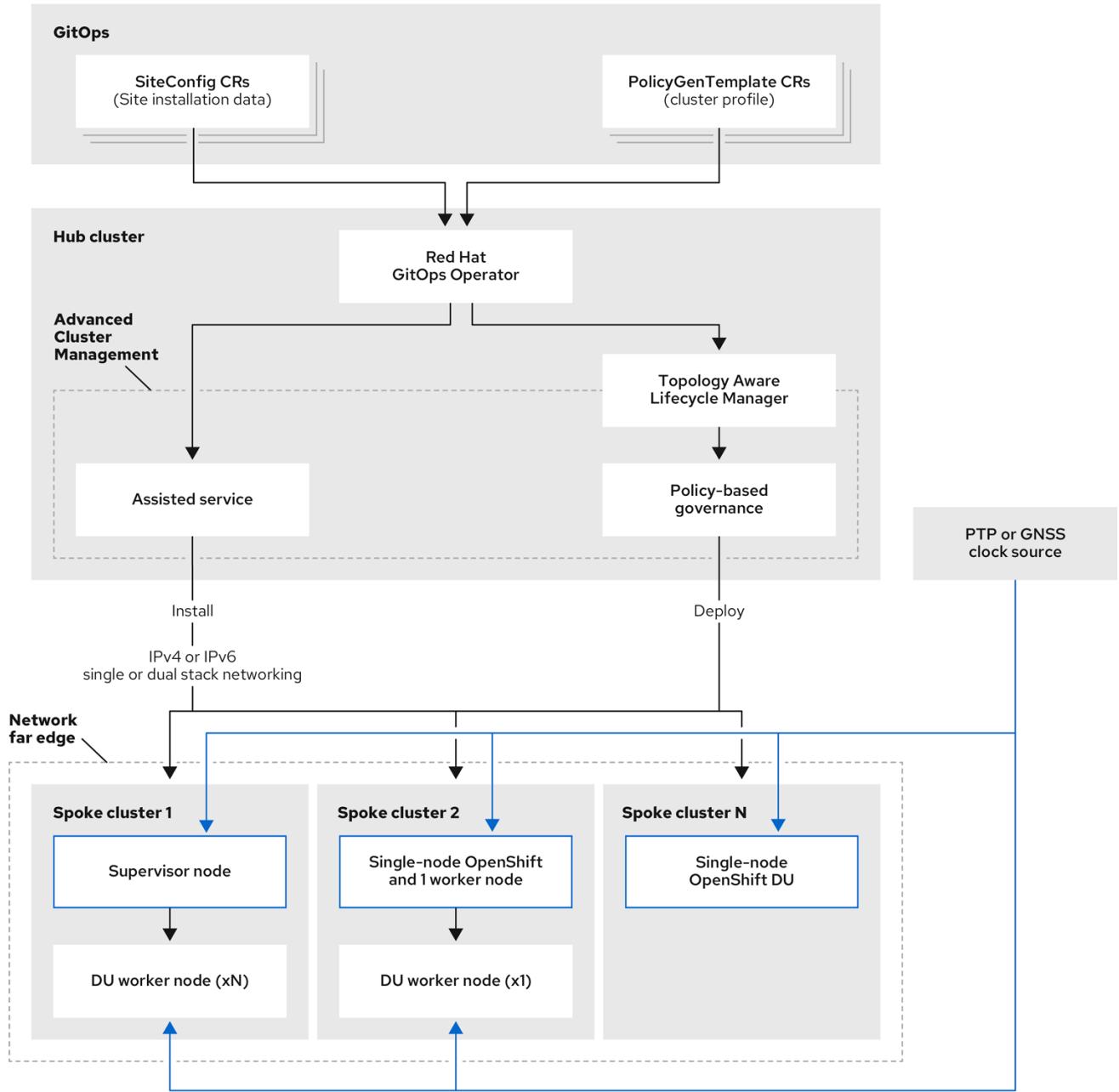
Red Hat Advanced Cluster Management (RHACM) manages clusters in a hub-and-spoke architecture, where a single hub cluster manages many spoke clusters. Hub clusters running RHACM provision and deploy the managed clusters by using GitOps Zero Touch Provisioning (ZTP) and the assisted service that is deployed when you install RHACM.

The assisted service handles provisioning of OpenShift Container Platform on single node clusters, three-node clusters, or standard clusters running on bare metal.

A high-level overview of using GitOps ZTP to provision and maintain bare-metal hosts with OpenShift Container Platform is as follows:

- A hub cluster running RHACM manages an OpenShift image registry that mirrors the OpenShift Container Platform release images. RHACM uses the OpenShift image registry to provision the managed clusters.
- You manage the bare-metal hosts in a YAML format inventory file, versioned in a Git repository.
- You make the hosts ready for provisioning as managed clusters, and use RHACM and the assisted service to install the bare-metal hosts on site.

Installing and deploying the clusters is a two-stage process, involving an initial installation phase, and a subsequent configuration and deployment phase. The following diagram illustrates this workflow:



474_OpenShift_1023

1.3. INSTALLING MANAGED CLUSTERS WITH SITECONFIG RESOURCES AND RHACM

GitOps Zero Touch Provisioning (ZTP) uses **SiteConfig** custom resources (CRs) in a Git repository to manage the processes that install OpenShift Container Platform clusters. The **SiteConfig** CR contains cluster-specific parameters required for installation. It has options for applying select configuration CRs during installation including user defined extra manifests.

The GitOps ZTP plugin processes **SiteConfig** CRs to generate a collection of CRs on the hub cluster. This triggers the assisted service in Red Hat Advanced Cluster Management (RHACM) to install OpenShift Container Platform on the bare-metal host. You can find installation status and error messages in these CRs on the hub cluster.

You can provision single clusters manually or in batches with GitOps ZTP:

Provisioning a single cluster

Create a single **SiteConfig** CR and related installation and configuration CRs for the cluster, and apply them in the hub cluster to begin cluster provisioning. This is a good way to test your CRs before deploying on a larger scale.

Provisioning many clusters

Install managed clusters in batches of up to 400 by defining **SiteConfig** and related CRs in a Git repository. ArgoCD uses the **SiteConfig** CRs to deploy the sites. The RHACM policy generator creates the manifests and applies them to the hub cluster. This starts the cluster provisioning process.



IMPORTANT

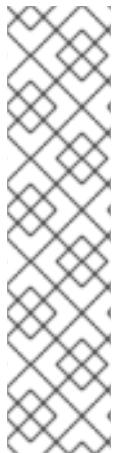
SiteConfig v1 is deprecated starting with OpenShift Container Platform version 4.18. Equivalent and improved functionality is now available through the SiteConfig Operator using the **ClusterInstance** custom resource. For more information, see [Procedure to transition from SiteConfig CRs to the ClusterInstance API](#).

For more information about the SiteConfig Operator, see [SiteConfig](#).

1.4. CONFIGURING MANAGED CLUSTERS WITH POLICIES AND POLICYGENTEMPLATE RESOURCES

GitOps Zero Touch Provisioning (ZTP) uses Red Hat Advanced Cluster Management (RHACM) to configure clusters by using a policy-based governance approach to applying the configuration.

The policy generator or **PolicyGen** is a plugin for the GitOps Operator that enables the creation of RHACM policies from a concise template. The tool can combine multiple CRs into a single policy, and you can generate multiple policies that apply to various subsets of clusters in your fleet.

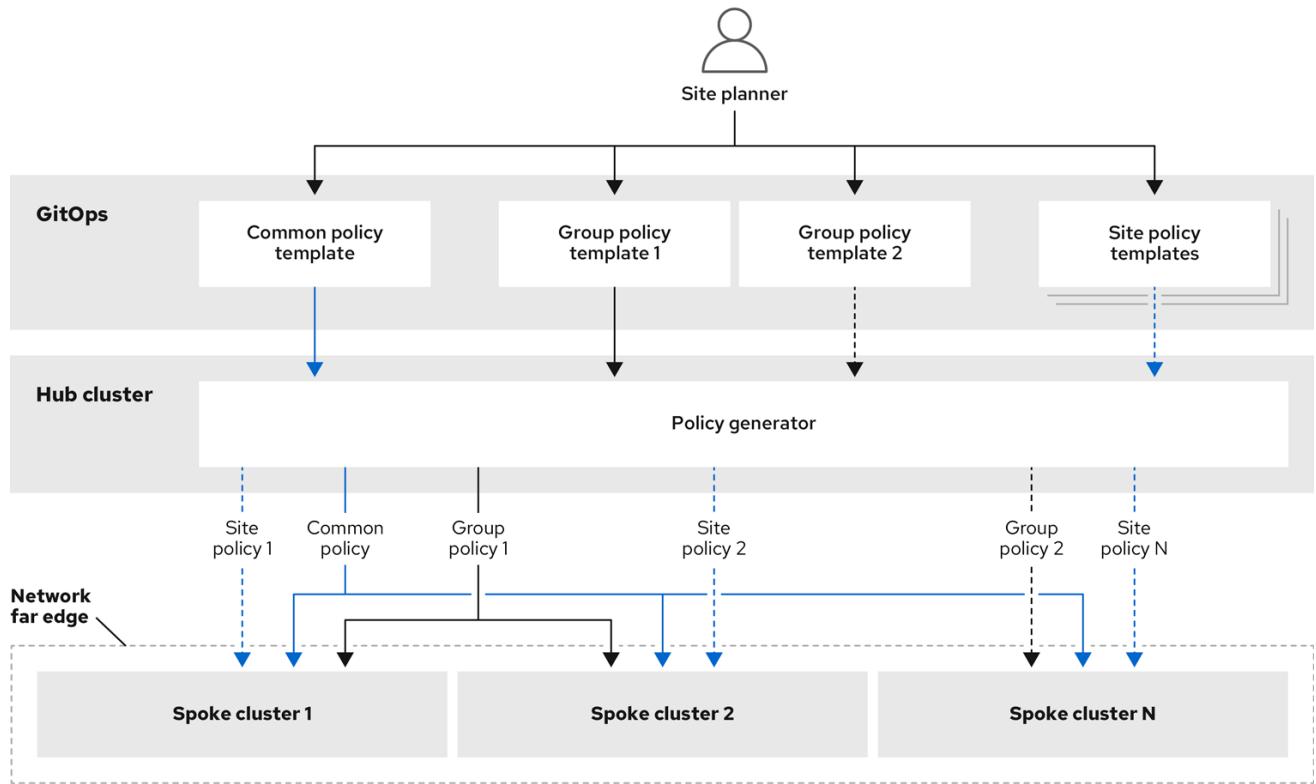


NOTE

For scalability and to reduce the complexity of managing configurations across the fleet of clusters, use configuration CRs with as much commonality as possible.

- Where possible, apply configuration CRs using a fleet-wide common policy.
- The next preference is to create logical groupings of clusters to manage as much of the remaining configurations as possible under a group policy.
- When a configuration is unique to an individual site, use RHACM templating on the hub cluster to inject the site-specific data into a common or group policy. Alternatively, apply an individual site policy for the site.

The following diagram shows how the policy generator interacts with GitOps and RHACM in the configuration phase of cluster deployment.



217_OpenShift_1022

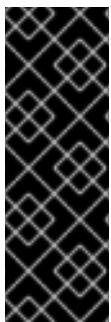
For large fleets of clusters, it is typical for there to be a high-level of consistency in the configuration of those clusters.

The following recommended structuring of policies combines configuration CRs to meet several goals:

- Describe common configurations once and apply to the fleet.
- Minimize the number of maintained and managed policies.
- Support flexibility in common configurations for cluster variants.

Table 1.1. Recommended PolicyGenTemplate policy categories

Policy category	Description
Common	A policy that exists in the common category is applied to all clusters in the fleet. Use common PolicyGenerator CRs to apply common installation settings across all cluster types.
Groups	A policy that exists in the groups category is applied to a group of clusters in the fleet. Use group PolicyGenerator CRs to manage specific aspects of single-node, three-node, and standard cluster installations. Cluster groups can also follow geographic region, hardware variant, etc.
Sites	A policy that exists in the sites category is applied to a specific cluster site. Any cluster can have its own specific policies maintained.



IMPORTANT

Using **PolicyGenTemplate** CRs to manage and deploy policies to managed clusters will be deprecated in an upcoming OpenShift Container Platform release. Equivalent and improved functionality is available using Red Hat Advanced Cluster Management (RHACM) and **PolicyGenerator** CRs.

For more information about **PolicyGenerator** resources, see the RHACM [Integrating Policy Generator](#) documentation.

Additional resources

- Configuring managed cluster policies by using PolicyGenerator resources
- Comparing RHACM PolicyGenerator and PolicyGenTemplate resource patching
- Preparing the GitOps ZTP Git repository

CHAPTER 2. PREPARING THE HUB CLUSTER FOR GITOPS ZTP

To use RHACM in a disconnected environment, create a mirror registry that mirrors the OpenShift Container Platform release images and Operator Lifecycle Manager (OLM) catalog that contains the required Operator images. OLM manages, installs, and upgrades Operators and their dependencies in the cluster. You can also use a disconnected mirror host to serve the RHCOS ISO and RootFS disk images that are used to provision the bare-metal hosts.

2.1. TELCO RAN DU 4.18 VALIDATED SOFTWARE COMPONENTS

The Red Hat telco RAN DU 4.18 solution has been validated using the following Red Hat software products for OpenShift Container Platform managed clusters.

Table 2.1. Telco RAN DU managed cluster validated software components

Component	Software version
Managed cluster version	4.18
Cluster Logging Operator	6.1 ¹
Local Storage Operator	4.18
OpenShift API for Data Protection (OADP)	1.4
PTP Operator	4.18
SR-IOV Operator	4.18
SRIOV-FEC Operator	2.10
Lifecycle Agent	4.18

[1] This table will be updated when the aligned Cluster Logging Operator version 6.2 is released.

2.2. RECOMMENDED HUB CLUSTER SPECIFICATIONS AND MANAGED CLUSTER LIMITS FOR GITOPS ZTP

With GitOps Zero Touch Provisioning (ZTP), you can manage thousands of clusters in geographically dispersed regions and networks. The Red Hat Performance and Scale lab successfully created and managed 3500 virtual single-node OpenShift clusters with a reduced DU profile from a single Red Hat Advanced Cluster Management (RHACM) hub cluster in a lab environment.

In real-world situations, the scaling limits for the number of clusters that you can manage will vary depending on various factors affecting the hub cluster. For example:

Hub cluster resources

Available hub cluster host resources (CPU, memory, storage) are an important factor in determining how many clusters the hub cluster can manage. The more resources allocated to the hub cluster, the more managed clusters it can accommodate.

Hub cluster storage

The hub cluster host storage IOPS rating and whether the hub cluster hosts use NVMe storage can affect hub cluster performance and the number of clusters it can manage.

Network bandwidth and latency

Slow or high-latency network connections between the hub cluster and managed clusters can impact how the hub cluster manages multiple clusters.

Managed cluster size and complexity

The size and complexity of the managed clusters also affects the capacity of the hub cluster. Larger managed clusters with more nodes, namespaces, and resources require additional processing and management resources. Similarly, clusters with complex configurations such as the RAN DU profile or diverse workloads can require more resources from the hub cluster.

Number of managed policies

The number of policies managed by the hub cluster scaled over the number of managed clusters bound to those policies is an important factor that determines how many clusters can be managed.

Monitoring and management workloads

RHACM continuously monitors and manages the managed clusters. The number and complexity of monitoring and management workloads running on the hub cluster can affect its capacity. Intensive monitoring or frequent reconciliation operations can require additional resources, potentially limiting the number of manageable clusters.

RHACM version and configuration

Different versions of RHACM can have varying performance characteristics and resource requirements. Additionally, the configuration settings of RHACM, such as the number of concurrent reconciliations or the frequency of health checks, can affect the managed cluster capacity of the hub cluster.

Use the following representative configuration and network specifications to develop your own Hub cluster and network specifications.



IMPORTANT

The following guidelines are based on internal lab benchmark testing only and do not represent complete bare-metal host specifications.

Table 2.2. Representative three-node hub cluster machine specifications

Requirement	Description
Server hardware	3 x Dell PowerEdge R650 rack servers
NVMe hard disks	<ul style="list-style-type: none"> ● 50 GB disk for /var/lib/etcd ● 2.9 TB disk for /var/lib/containers

Requirement	Description
SSD hard disks	<ul style="list-style-type: none"> • 1 SSD split into 15 200GB thin-provisioned logical volumes provisioned as PV CRs • 1 SSD serving as an extra large PV resource
Number of applied DU profile policies	5



IMPORTANT

The following network specifications are representative of a typical real-world RAN network and were applied to the scale lab environment during testing.

Table 2.3. Simulated lab environment network specifications

Specification	Description
Round-trip time (RTT) latency	50 ms
Packet loss	0.02% packet loss
Network bandwidth limit	20 Mbps

Additional resources

- [Creating and managing single-node OpenShift clusters with RHACM](#)

2.3. INSTALLING GITOPS ZTP IN A DISCONNECTED ENVIRONMENT

Use Red Hat Advanced Cluster Management (RHACM), Red Hat OpenShift GitOps, and Topology Aware Lifecycle Manager (TALM) on the hub cluster in the disconnected environment to manage the deployment of multiple managed clusters.

Prerequisites

- You have installed the OpenShift Container Platform CLI (**oc**).
- You have logged in as a user with **cluster-admin** privileges.
- You have configured a disconnected mirror registry for use in the cluster.



NOTE

The disconnected mirror registry that you create must contain a version of TALM backup and pre-cache images that matches the version of TALM running in the hub cluster. The spoke cluster must be able to resolve these images in the disconnected mirror registry.

Procedure

- Install RHACM in the hub cluster. See [Installing RHACM in a disconnected environment](#).
- Install GitOps and TALM in the hub cluster.

Additional resources

- [Installing OpenShift GitOps](#)
- [Installing TALM](#)
- [Mirroring an Operator catalog](#)

2.4. ADDING RHCOS ISO AND ROOTFS IMAGES TO THE DISCONNECTED MIRROR HOST

Before you begin installing clusters in the disconnected environment with Red Hat Advanced Cluster Management (RHACM), you must first host Red Hat Enterprise Linux CoreOS (RHCOS) images for it to use. Use a disconnected mirror to host the RHCOS images.

Prerequisites

- Deploy and configure an HTTP server to host the RHCOS image resources on the network. You must be able to access the HTTP server from your computer, and from the machines that you create.



IMPORTANT

The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the version that you install. Use the image versions that match your OpenShift Container Platform version if they are available. You require ISO and RootFS images to install RHCOS on the hosts. RHCOS QCOW2 images are not supported for this installation type.

Procedure

1. Log in to the mirror host.
2. Obtain the RHCOS ISO and RootFS images from mirror.openshift.com, for example:
 - a. Export the required image names and OpenShift Container Platform version as environment variables:

```
$ export ISO_IMAGE_NAME=<iso_image_name> ①
```

```
$ export ROOTFS_IMAGE_NAME=<rootfs_image_name> ①
```

```
$ export OCP_VERSION=<ocp_version> ①
```

① ISO image name, for example, **rhcose-4.18.1-x86_64-live.x86_64.iso**

1 RootFS image name, for example, **rhcosh-4.18.1-x86_64-live-rootfs.x86_64.img**

1 OpenShift Container Platform version, for example, **4.18.1**

b. Download the required images:

```
$ sudo wget https://mirror.openshift.com/pub/openshift-v4/dependencies/rhcos/4.18/${OCP_VERSION}/${ISO_IMAGE_NAME} -O /var/www/html/${ISO_IMAGE_NAME}
```

```
$ sudo wget https://mirror.openshift.com/pub/openshift-v4/dependencies/rhcos/4.18/${OCP_VERSION}/${ROOTFS_IMAGE_NAME} -O /var/www/html/${ROOTFS_IMAGE_NAME}
```

Verification steps

- Verify that the images downloaded successfully and are being served on the disconnected mirror host, for example:

```
$ wget http://$(hostname)/${ISO_IMAGE_NAME}
```

Example output

```
Saving to: rhcos-4.18.1-x86_64-live.x86_64.iso
rhcosh-4.18.1-x86_64-live.x86_64.iso- 11%[====>] 10.01M 4.71MB/s
```

Additional resources

- [Creating a mirror registry](#)
- [Mirroring images for a disconnected installation](#)

2.5. ENABLING THE ASSISTED SERVICE

Red Hat Advanced Cluster Management (RHACM) uses the assisted service to deploy OpenShift Container Platform clusters. The assisted service is deployed automatically when you enable the MultiClusterHub Operator on Red Hat Advanced Cluster Management (RHACM). After that, you need to configure the **Provisioning** resource to watch all namespaces and to update the **AgentServiceConfig** custom resource (CR) with references to the ISO and RootFS images that are hosted on the mirror registry HTTP server.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.
- You have RHACM with **MultiClusterHub** enabled.

Procedure

1. Enable the **Provisioning** resource to watch all namespaces and configure mirrors for disconnected environments. For more information, see [Enabling the central infrastructure management service](#).
2. Open the **AgentServiceConfig** CR to update the **spec.oslImages** field by running the following command:

```
$ oc edit AgentServiceConfig
```

3. Update the **spec.oslImages** field in the **AgentServiceConfig** CR:

```
apiVersion: agent-install.openshift.io/v1beta1
kind: AgentServiceConfig
metadata:
  name: agent
spec:
# ...
  oslImages:
    - cpuArchitecture: x86_64
      openshiftVersion: "4.18"
      rootFSUrl: https://<host>/<path>/rhcos-live-rootfs.x86_64.img
      url: https://<host>/<path>/rhcos-live.x86_64.iso
```

where:

<host>

Specifies the fully qualified domain name (FQDN) for the target mirror registry HTTP server.

<path>

Specifies the path to the image on the target mirror registry.

4. Save and quit the editor to apply the changes.

2.6. CONFIGURING THE HUB CLUSTER TO USE A DISCONNECTED MIRROR REGISTRY

You can configure the hub cluster to use a disconnected mirror registry for a disconnected environment.

Prerequisites

- You have a disconnected hub cluster installation with Red Hat Advanced Cluster Management (RHACM) 2.13 installed.
- You have hosted the **rootfs** and **iso** images on an HTTP server. See the *Additional resources* section for guidance about *Mirroring the OpenShift Container Platform image repository*.

**WARNING**

If you enable TLS for the HTTP server, you must confirm the root certificate is signed by an authority trusted by the client and verify the trusted certificate chain between your OpenShift Container Platform hub and managed clusters and the HTTP server. Using a server configured with an untrusted certificate prevents the images from being downloaded to the image creation service. Using untrusted HTTPS servers is not supported.

Procedure

- 1 Create a **ConfigMap** containing the mirror registry config:

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: assisted-installer-mirror-config
  namespace: multicluster-engine 1
  labels:
    app: assisted-service
data:
  ca-bundle.crt: | 2
    -----BEGIN CERTIFICATE-----
    <certificate_contents>
    -----END CERTIFICATE-----

  registries.conf: | 3
    unqualified-search-registries = ["registry.access.redhat.com", "docker.io"]

    [[registry]]
    prefix = ""
    location = "quay.io/example-repository" 4
    mirror-by-digest-only = true

    [[registry.mirror]]
    location = "mirror1.registry.corp.com:5000/example-repository" 5
```

- 1** The **ConfigMap** namespace must be set to **multicluster-engine**.
- 2** The mirror registry's certificate that is used when creating the mirror registry.
- 3** The configuration file for the mirror registry. The mirror registry configuration adds mirror information to the **/etc/containers/registries.conf** file in the discovery image. The mirror information is stored in the **imageContentSources** section of the **install-config.yaml** file when the information is passed to the installation program. The Assisted Service pod that runs on the hub cluster fetches the container images from the configured mirror registry.
- 4** The URL of the mirror registry. You must use the URL from the **imageContentSources** section by running the **oc adm release mirror** command when you configure the mirror registry. For more information, see the *Mirroring the OpenShift Container Platform image repository* section.

- 5 The registries defined in the **registries.conf** file must be scoped by repository, not by registry. In this example, both the **quay.io/example-repository** and the

This updates **mirrorRegistryRef** in the **AgentServiceConfig** custom resource, as shown below:

Example output

```
apiVersion: agent-install.openshift.io/v1beta1
kind: AgentServiceConfig
metadata:
  name: agent
  namespace: multicluster-engine ①
spec:
  databaseStorage:
    volumeName: <db_pv_name>
    accessModes:
      - ReadWriteOnce
  resources:
    requests:
      storage: <db_storage_size>
  filesystemStorage:
    volumeName: <fs_pv_name>
    accessModes:
      - ReadWriteOnce
  resources:
    requests:
      storage: <fs_storage_size>
  mirrorRegistryRef:
    name: assisted-installer-mirror-config ②
  osImages:
    - openshiftVersion: <ocp_version> ③
      url: <iso_url> ④
```

- 1 Set the **AgentServiceConfig** namespace to **multicluster-engine** to match the **ConfigMap** namespace.
- 2 Set **mirrorRegistryRef.name** to match the definition specified in the related **ConfigMap** CR.
- 3 Set the OpenShift Container Platform version to either the x.y or x.y.z format.
- 4 Set the URL for the ISO hosted on the **httpd** server.



IMPORTANT

A valid NTP server is required during cluster installation. Ensure that a suitable NTP server is available and can be reached from the installed clusters through the disconnected network.

Additional resources

- [Mirroring the OpenShift Container Platform image repository](#)

2.7. CONFIGURING THE HUB CLUSTER TO USE UNAUTHENTICATED REGISTRIES

You can configure the hub cluster to use unauthenticated registries. Unauthenticated registries does not require authentication to access and download images.

Prerequisites

- You have installed and configured a hub cluster and installed Red Hat Advanced Cluster Management (RHACM) on the hub cluster.
- You have installed the OpenShift Container Platform CLI (oc).
- You have logged in as a user with **cluster-admin** privileges.
- You have configured an unauthenticated registry for use with the hub cluster.

Procedure

1. Update the **AgentServiceConfig** custom resource (CR) by running the following command:

```
$ oc edit AgentServiceConfig agent
```

2. Add the **unauthenticatedRegistries** field in the CR:

```
apiVersion: agent-install.openshift.io/v1beta1
kind: AgentServiceConfig
metadata:
  name: agent
spec:
  unauthenticatedRegistries:
    - example.registry.com
    - example.registry2.com
    ...
```

Unauthenticated registries are listed under **spec.unauthenticatedRegistries** in the **AgentServiceConfig** resource. Any registry on this list is not required to have an entry in the pull secret used for the spoke cluster installation. **assisted-service** validates the pull secret by making sure it contains the authentication information for every image registry used for installation.



NOTE

Mirror registries are automatically added to the ignore list and do not need to be added under **spec.unauthenticatedRegistries**. Specifying the **PUBLIC_CONTAINER_REGISTRIES** environment variable in the **ConfigMap** overrides the default values with the specified value. The **PUBLIC_CONTAINER_REGISTRIES** defaults are [quay.io](#) and [registry.svc.ci.openshift.org](#).

Verification

Verify that you can access the newly added registry from the hub cluster by running the following commands:

1. Open a debug shell prompt to the hub cluster:

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

2. Test access to the unauthenticated registry by running the following command:

```
sh-4.4# podman login -u kubeadmin -p $(oc whoami -t) <unauthenticated_registry>
```

where:

<unauthenticated_registry>

Is the new registry, for example, **unauthenticated-image-registry.openshift-image-registry.svc:5000**.

Example output

```
Login Succeeded!
```

2.8. CONFIGURING THE HUB CLUSTER WITH ARGOCD

You can configure the hub cluster with a set of ArgoCD applications that generate the required installation and policy custom resources (CRs) for each site with GitOps Zero Touch Provisioning (ZTP).



NOTE

Red Hat Advanced Cluster Management (RHACM) uses **SiteConfig** CRs to generate the Day 1 managed cluster installation CRs for ArgoCD. Each ArgoCD application can manage a maximum of 300 **SiteConfig** CRs.

Prerequisites

- You have a OpenShift Container Platform hub cluster with Red Hat Advanced Cluster Management (RHACM) and Red Hat OpenShift GitOps installed.
- You have extracted the reference deployment from the GitOps ZTP plugin container as described in the "Preparing the GitOps ZTP site configuration repository" section. Extracting the reference deployment creates the **out/argocd/deployment** directory referenced in the following procedure.

Procedure

1. Prepare the ArgoCD pipeline configuration:
 - a. Create a Git repository with the directory structure similar to the example directory. For more information, see "Preparing the GitOps ZTP site configuration repository".
 - b. Configure access to the repository using the ArgoCD UI. Under **Settings** configure the following:
 - **Repositories** - Add the connection information. The URL must end in **.git**, for example, <https://repo.example.com/repo.git> and credentials.
 - **Certificates** - Add the public certificate for the repository, if needed.

- c. Modify the two ArgoCD applications, **out/argocd/deployment/clusters-app.yaml** and **out/argocd/deployment/policies-app.yaml**, based on your Git repository:
- Update the URL to point to the Git repository. The URL ends with **.git**, for example, <https://repo.example.com/repo.git>.
 - The **targetRevision** indicates which Git repository branch to monitor.
 - **path** specifies the path to the **SiteConfig** and **PolicyGenerator** or **PolicyGentemplate** CRs, respectively.
2. To install the GitOps ZTP plugin, patch the ArgoCD instance in the hub cluster with the relevant multicloud engine (MCE) subscription image. Customize the patch file that you previously extracted into the **out/argocd/deployment/** directory for your environment.
- a. Select the **multicloud-operators-subscription** image that matches your RHACM version.
 - For RHACM 2.8 and 2.9, use the **registry.redhat.io/rhacm2/multicloud-operators-subscription-rhel8:v<rhacm_version>** image.
 - For RHACM 2.10 and later, use the **registry.redhat.io/rhacm2/multicloud-operators-subscription-rhel9:v<rhacm_version>** image.



IMPORTANT

The version of the **multicloud-operators-subscription** image must match the RHACM version. Beginning with the MCE 2.10 release, RHEL 9 is the base image for **multicloud-operators-subscription** images.

Click **[Expand for Operator list]** in the "Platform Aligned Operators" table in [OpenShift Operator Life Cycles](#) to view the complete supported Operators matrix for OpenShift Container Platform.

- b. Modify the **out/argocd/deployment/argocd Openshift-gitops-patch.json** file with the **multicloud-operators-subscription** image that matches your RHACM version:

```
{
  "args": [
    "-c",
    "mkdir -p ./config/kustomize/plugin/policy.open-cluster-
management.io/v1/policygenerator && cp ./policy-generator/PolicyGenerator-not-fips-
compliant ./config/kustomize/plugin/policy.open-cluster-
management.io/v1/policygenerator/PolicyGenerator" ①
  ],
  "command": [
    "/bin/bash"
  ],
  "image": "registry.redhat.io/rhacm2/multicloud-operators-subscription-rhel9:v2.10", ②
 ③
  "name": "policy-generator-install",
  "imagePullPolicy": "Always",
  "volumeMounts": [
    {
      "mountPath": "./config",
      "name": "kustomize"
    }
  ]
}
```

```

    ]
}
```

- 1 Optional: For RHEL 9 images, copy the required universal executable in the **/policy-generator/PolicyGenerator-not-fips-compliant** folder for the ArgoCD version.
- 2 Match the **multicluster-operators-subscription** image to the RHACM version.
- 3 In disconnected environments, replace the URL for the **multicluster-operators-subscription** image with the disconnected registry equivalent for your environment.

c. Patch the ArgoCD instance. Run the following command:

```
$ oc patch argocd openshift-gitops \
-n openshift-gitops --type=merge \
--patch-file out/argocd/deployment/argocd Openshift-gitops-patch.json
```

3. In RHACM 2.7 and later, the multicluster engine enables the **cluster-proxy-addon** feature by default. Apply the following patch to disable the **cluster-proxy-addon** feature and remove the relevant hub cluster and managed pods that are responsible for this add-on. Run the following command:

```
$ oc patch multiclusterengines.multicluster.openshift.io multiclusterengine --type=merge \
--patch-file out/argocd/deployment/disable-cluster-proxy-addon.json
```

4. Apply the pipeline configuration to your hub cluster by running the following command:

```
$ oc apply -k out/argocd/deployment
```

5. Optional: If you have existing ArgoCD applications, verify that the **PrunePropagationPolicy=background** policy is set in the **Application** resource by running the following command:

```
$ oc -n openshift-gitops get applications.argoproj.io \
clusters -o jsonpath='{.spec.syncPolicy.syncOptions}' | jq
```

Example output for an existing policy

```
[
  "CreateNamespace=true",
  "PrunePropagationPolicy=background",
  "RespectIgnoreDifferences=true"
]
```

a. If the **spec.syncPolicy.syncOption** field does not contain a **PrunePropagationPolicy** parameter or **PrunePropagationPolicy** is set to the **foreground** value, set the policy to **background** in the **Application** resource. See the following example:

```
kind: Application
spec:
  syncPolicy:
```

```
syncOptions:
- PrunePropagationPolicy=background
```

Setting the **background** deletion policy ensures that the **ManagedCluster** CR and all its associated resources are deleted.

2.9. PREPARING THE GITOPS ZTP SITE CONFIGURATION REPOSITORY

Before you can use the GitOps Zero Touch Provisioning (ZTP) pipeline, you need to prepare the Git repository to host the site configuration data.

Prerequisites

- You have configured the hub cluster GitOps applications for generating the required installation and policy custom resources (CRs).
- You have deployed the managed clusters using GitOps ZTP.

Procedure

1. Create a directory structure with separate paths for the **SiteConfig** and **PolicyGenerator** or **PolicyGentemplate** CRs.



NOTE

Keep **SiteConfig** and **PolicyGenerator** or **PolicyGentemplate** CRs in separate directories. Both the **SiteConfig** and **PolicyGenerator** or **PolicyGentemplate** directories must contain a **kustomization.yaml** file that explicitly includes the files in that directory.

2. Export the **argocd** directory from the **ztp-site-generate** container image using the following commands:

```
$ podman pull registry.redhat.io/openshift4/ztp-site-generate-rhel8:v4.18
```

```
$ mkdir -p ./out
```

```
$ podman run --log-driver=none --rm registry.redhat.io/openshift4/ztp-site-generate-rhel8:v4.18 extract /home/ztp --tar | tar x -C ./out
```

3. Check that the **out** directory contains the following subdirectories:

- **out/extra-manifest** contains the source CR files that **SiteConfig** uses to generate extra manifest **configMap**.
- **out/source-crs** contains the source CR files that **PolicyGenerator** uses to generate the Red Hat Advanced Cluster Management (RHACM) policies.
- **out/argocd/deployment** contains patches and YAML files to apply on the hub cluster for use in the next step of this procedure.

- **out/argocd/example** contains the examples for **SiteConfig** and **PolicyGenerator** or **PolicyGentemplate** files that represent the recommended configuration.
4. Copy the **out/source-crs** folder and contents to the **PolicyGenerator** or **PolicyGentemplate** directory.
 5. The out/extra-manifests directory contains the reference manifests for a RAN DU cluster. Copy the **out/extra-manifests** directory into the **SiteConfig** folder. This directory should contain CRs from the **ztp-site-generate** container only. Do not add user-provided CRs here. If you want to work with user-provided CRs you must create another directory for that content. For example:

```
example/
  └── acmpolicygenerator
      └── kustomization.yaml
          └── source-crs/
  └── policygentemplates ①
      └── kustomization.yaml
          └── source-crs/
  └── siteconfig
      └── extra-manifests
          └── kustomization.yaml
```

- 1 Using **PolicyGenTemplate** CRs to manage and deploy policies to manage clusters will be deprecated in a future OpenShift Container Platform release. Equivalent and improved functionality is available by using Red Hat Advanced Cluster Management (RHACM) and **PolicyGenerator** CRs.
6. Commit the directory structure and the **kustomization.yaml** files and push to your Git repository. The initial push to Git should include the **kustomization.yaml** files.

You can use the directory structure under **out/argocd/example** as a reference for the structure and content of your Git repository. That structure includes **SiteConfig** and **PolicyGenerator** or **PolicyGentemplate** reference CRs for single-node, three-node, and standard clusters. Remove references to cluster types that you are not using.

For all cluster types, you must:

- Add the **source-crs** subdirectory to the **acmpolicygenerator** or **policygentemplates** directory.
- Add the **extra-manifests** directory to the **siteconfig** directory.

The following example describes a set of CRs for a network of single-node clusters:

```
example/
  └── acmpolicygenerator
      ├── acm-common-ranGen.yaml
      ├── acm-example-sno-site.yaml
      ├── acm-group-du-sno-ranGen.yaml
      ├── group-du-sno-validator-ranGen.yaml
      └── kustomization.yaml
  └── source-crs/
      └── ns.yaml
  └── siteconfig
      └── example-sno.yaml
  └── extra-manifests/ ①
```

```

└── custom-manifests/
    └── 2
        ├── KlusterletAddonConfigOverride.yaml
        └── kustomization.yaml

```

- 1 Contains reference manifests from the **ztp-container**.
- 2 Contains custom manifests.



IMPORTANT

Using **PolicyGenTemplate** CRs to manage and deploy policies to managed clusters will be deprecated in an upcoming OpenShift Container Platform release. Equivalent and improved functionality is available using Red Hat Advanced Cluster Management (RHACM) and **PolicyGenerator** CRs.

For more information about **PolicyGenerator** resources, see the RHACM [Integrating Policy Generator](#) documentation.

Additional resources

- [Configuring managed cluster policies by using PolicyGenerator resources](#)
- [Comparing RHACM PolicyGenerator and PolicyGenTemplate resource patching](#)

2.10. PREPARING THE GITOOPS ZTP SITE CONFIGURATION REPOSITORY FOR VERSION INDEPENDENCE

You can use GitOps ZTP to manage source custom resources (CRs) for managed clusters that are running different versions of OpenShift Container Platform. This means that the version of OpenShift Container Platform running on the hub cluster can be independent of the version running on the managed clusters.



NOTE

The following procedure assumes you are using **PolicyGenerator** resources instead of **PolicyGenTemplate** resources for cluster policies management.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in as a user with **cluster-admin** privileges.

Procedure

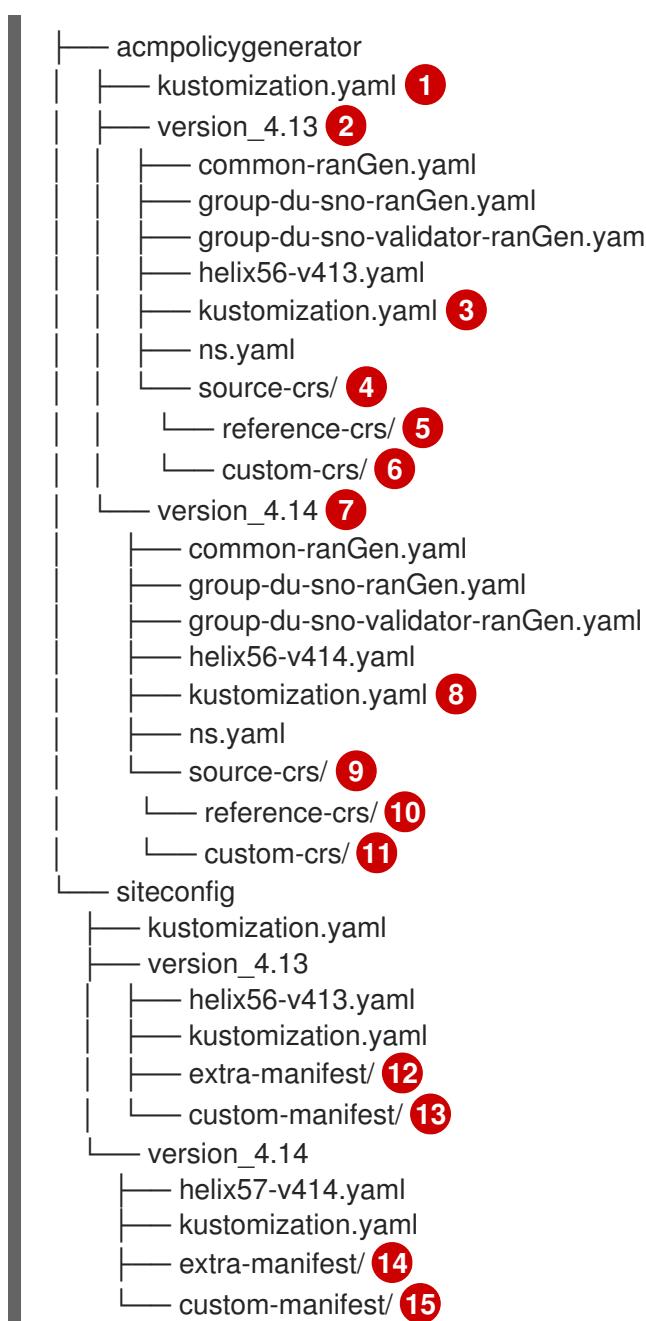
1. Create a directory structure with separate paths for the **SiteConfig** and **PolicyGenerator** CRs.
2. Within the **PolicyGenerator** directory, create a directory for each OpenShift Container Platform version you want to make available. For each version, create the following resources:
 - **kustomization.yaml** file that explicitly includes the files in that directory

- **source-crs** directory to contain reference CR configuration files from the **ztp-site-generate** container

If you want to work with user-provided CRs, you must create a separate directory for them.

- In the **/siteconfig** directory, create a subdirectory for each OpenShift Container Platform version you want to make available. For each version, create at least one directory for reference CRs to be copied from the container. There is no restriction on the naming of directories or on the number of reference directories. If you want to work with custom manifests, you must create a separate directory for them.

The following example describes a structure using user-provided manifests and CRs for different versions of OpenShift Container Platform:



① Create a top-level **kustomization** YAML file.

② ⑦ Create the version-specific directories within the custom **/acmpolicygenerator** directory.

③ ⑧ Create a **kustomization.yaml** file for each version.

④ ⑨

Create a **source-crs** directory for each version to contain reference CRs from the **ztp-site-generate** container.

- 5 10** Create the **reference-crs** directory for policy CRs that are extracted from the ZTP container.
- 6 11** Optional: Create a **custom-crs** directory for user-provided CRs.
- 12 14** Create a directory within the custom **/siteconfig** directory to contain extra manifests from the **ztp-site-generate** container.
- 13 15** Create a folder to hold user-provided manifests.



NOTE

In the previous example, each version subdirectory in the custom **/siteconfig** directory contains two further subdirectories, one containing the reference manifests copied from the container, the other for custom manifests that you provide. The names assigned to those directories are examples. If you use user-provided CRs, the last directory listed under **extraManifests.searchPaths** in the **SiteConfig** CR must be the directory containing user-provided CRs.

4. Edit the **SiteConfig** CR to include the search paths of any directories you have created. The first directory that is listed under **extraManifests.searchPaths** must be the directory containing the reference manifests. Consider the order in which the directories are listed. In cases where directories contain files with the same name, the file in the final directory takes precedence.

Example SiteConfig CR

```
extraManifests:
  searchPaths:
    - extra-manifest/ ①
    - custom-manifest/ ②
```

- 1** The directory containing the reference manifests must be listed first under **extraManifests.searchPaths**.
 - 2** If you are using user-provided CRs, the last directory listed under **extraManifests.searchPaths** in the **SiteConfig** CR must be the directory containing those user-provided CRs.
5. Edit the top-level **kustomization.yaml** file to control which OpenShift Container Platform versions are active. The following is an example of a **kustomization.yaml** file at the top level:

```
resources:
  - version_4.13 ①
  #- version_4.14 ②
```

- 1** Activate version 4.13.
- 2** Use comments to deactivate a version.

2.11. CONFIGURING THE HUB CLUSTER FOR BACKUP AND RESTORE

You can use GitOps ZTP to configure a set of policies to back up **BareMetalHost** resources. This allows you to recover data from a failed hub cluster and deploy a replacement cluster using Red Hat Advanced Cluster Management (RHACM).

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in as a user with **cluster-admin** privileges.

Procedure

1. Create a policy to add the **cluster.open-cluster-management.io/backup=cluster-activation** label to all **BareMetalHost** resources that have the **infraenvs.agent-install.openshift.io** label. Save the policy as **BareMetalHostBackupPolicy.yaml**.

The following example adds the **cluster.open-cluster-management.io/backup** label to all **BareMetalHost** resources that have the **infraenvs.agent-install.openshift.io** label:

Example Policy

```
apiVersion: policy.open-cluster-management.io/v1
kind: Policy
metadata:
  name: bmh-cluster-activation-label
  annotations:
    policy.open-cluster-management.io/description: Policy used to add the cluster.open-cluster-management.io/backup=cluster-activation label to all BareMetalHost resources
spec:
  disabled: false
  policy-templates:
    - objectDefinition:
        apiVersion: policy.open-cluster-management.io/v1
        kind: ConfigurationPolicy
        metadata:
          name: set-bmh-backup-label
        spec:
          object-templates-raw:
            {{- /* Set cluster-activation label on all BMH resources */ -}}
            {{- $infra_label := "infraenvs.agent-install.openshift.io" -}}
            {{- range $bmh := (lookup "metal3.io/v1alpha1" "BareMetalHost" "") -}}
              $infra_label).items }}
            - complianceType: musthave
              objectDefinition:
                kind: BareMetalHost
                apiVersion: metal3.io/v1alpha1
                metadata:
                  name: {{ $bmh.metadata.name }}
                  namespace: {{ $bmh.metadata.namespace }}
                  labels:
                    cluster.open-cluster-management.io/backup: cluster-activation ①
            {{- end -}}
            remediationAction: enforce
            severity: high
```

```

---
apiVersion: cluster.open-cluster-management.io/v1beta1
kind: Placement
metadata:
  name: bmh-cluster-activation-label-pr
spec:
  predicates:
    - requiredClusterSelector:
        labelSelector:
          matchExpressions:
            - key: name
              operator: In
              values:
                - local-cluster
---
apiVersion: policy.open-cluster-management.io/v1
kind: PlacementBinding
metadata:
  name: bmh-cluster-activation-label-binding
placementRef:
  name: bmh-cluster-activation-label-pr
  apiGroup: cluster.open-cluster-management.io
  kind: Placement
subjects:
  - name: bmh-cluster-activation-label
    apiGroup: policy.open-cluster-management.io
    kind: Policy
---
apiVersion: cluster.open-cluster-management.io/v1beta2
kind: ManagedClusterSetBinding
metadata:
  name: default
  namespace: default
spec:
  clusterSet: default

```

- 1** If you apply the **cluster.open-cluster-management.io/backup: cluster-activation** label to **BareMetalHost** resources, the RHACM cluster backs up those resources. You can restore the **BareMetalHost** resources if the active cluster becomes unavailable, when restoring the hub activation resources.

2. Apply the policy by running the following command:

```
$ oc apply -f BareMetalHostBackupPolicy.yaml
```

Verification

1. Find all **BareMetalHost** resources with the label **infraenvs.agent-install.openshift.io** by running the following command:

```
$ oc get BareMetalHost -A -l infraenvs.agent-install.openshift.io
```

Example output

NAMESPACE	NAME	STATE	CONSUMER	ONLINE	ERROR	AGE
baremetal-ns	baremetal-name			false		50s

2. Verify that the policy has applied the label **cluster.open-cluster-management.io/backup=cluster-activation** to all these resources, by running the following command:

```
$ oc get BareMetalHost -A -l infraenvs.agent-install.openshift.io,cluster.open-cluster-management.io/backup=cluster-activation
```

Example output

NAMESPACE	NAME	STATE	CONSUMER	ONLINE	ERROR	AGE
baremetal-ns	baremetal-name			false		50s

The output must show the same list as in the previous step, which listed all **BareMetalHost** resources with the label **infraenvs.agent-install.openshift.io**. This confirms that all the **BareMetalHost** resources with the **infraenvs.agent-install.openshift.io** label also have the **cluster.open-cluster-management.io/backup: cluster-activation** label.

The following example shows a **BareMetalHost** resource with the **infraenvs.agent-install.openshift.io** label. The resource must also have the **cluster.open-cluster-management.io/backup: cluster-activation** label, which was added by the policy created in step 1.

```
apiVersion: metal3.io/v1alpha1
kind: BareMetalHost
metadata:
  labels:
    cluster.open-cluster-management.io/backup: cluster-activation
    infraenvs.agent-install.openshift.io: value
  name: baremetal-name
  namespace: baremetal-ns
```

You can now use Red Hat Advanced Cluster Management to restore a managed cluster.



IMPORTANT

When you restore **BareMetalHosts** resources as part of restoring the cluster activation data, you must restore the **BareMetalHosts** status. The following RHACM **Restore** resource example restores activation resources, including **BareMetalHosts**, and also restores the status for the **BareMetalHosts** resources:

```
apiVersion: cluster.open-cluster-management.io/v1beta1
kind: Restore
metadata:
  name: restore-acm-bmh
  namespace: open-cluster-management-backup
spec:
  cleanupBeforeRestore: CleanupRestored
  veleroManagedClustersBackupName: latest 1
  veleroCredentialsBackupName: latest
  veleroResourcesBackupName: latest
  restoreStatus:
    includedResources:
      - BareMetalHosts 2
```

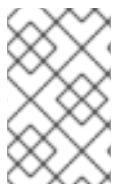
- 1** Set **veleroManagedClustersBackupName: latest** to restore activation resources.
- 2** Restores the status for **BareMetalHosts** resources.

Additional resources

- [Restoring managed cluster activation data](#)
- [Active-passive configuration](#)
- [Restoring activation resources](#)

CHAPTER 3. UPDATING GITOPS ZTP

You can update the GitOps Zero Touch Provisioning (ZTP) infrastructure independently from the hub cluster, Red Hat Advanced Cluster Management (RHACM), and the managed OpenShift Container Platform clusters.



NOTE

You can update the Red Hat OpenShift GitOps Operator when new versions become available. When updating the GitOps ZTP plugin, review the updated files in the reference configuration and ensure that the changes meet your requirements.



IMPORTANT

Using **PolicyGenTemplate** CRs to manage and deploy policies to managed clusters will be deprecated in an upcoming OpenShift Container Platform release. Equivalent and improved functionality is available using Red Hat Advanced Cluster Management (RHACM) and **PolicyGenerator** CRs.

For more information about **PolicyGenerator** resources, see the RHACM [Integrating Policy Generator](#) documentation.

Additional resources

- Configuring managed cluster policies by using PolicyGenerator resources
- Comparing RHACM PolicyGenerator and PolicyGenTemplate resource patching

3.1. OVERVIEW OF THE GITOPS ZTP UPDATE PROCESS

You can update GitOps Zero Touch Provisioning (ZTP) for a fully operational hub cluster running an earlier version of the GitOps ZTP infrastructure. The update process avoids impact on managed clusters.



NOTE

Any changes to policy settings, including adding recommended content, results in updated policies that must be rolled out to the managed clusters and reconciled.

At a high level, the strategy for updating the GitOps ZTP infrastructure is as follows:

1. Label all existing clusters with the **ztp-done** label.
2. Stop the ArgoCD applications.
3. Install the new GitOps ZTP tools.
4. Update required content and optional changes in the Git repository.
5. Enable pulling the ISO images for the desired OpenShift Container Platform version.
6. Update and restart the application configuration.

3.2. PREPARING FOR THE UPGRADE

Use the following procedure to prepare your site for the GitOps Zero Touch Provisioning (ZTP) upgrade.

Procedure

1. Get the latest version of the GitOps ZTP container that has the custom resources (CRs) used to configure Red Hat OpenShift GitOps for use with GitOps ZTP.
2. Extract the **argocd/deployment** directory by using the following commands:

```
$ mkdir -p ./update
```

```
$ podman run --log-driver=none --rm registry.redhat.io/openshift4/ztp-site-generate-rhel8:v4.18 extract /home/ztp --tar | tar x -C ./update
```

The **/update** directory contains the following subdirectories:

- **update/extra-manifest**: contains the source CR files that the **SiteConfig** CR uses to generate the extra manifest **configMap**.
 - **update/source-crs**: contains the source CR files that the **PolicyGenerator** or **PolicyGentemplate** CR uses to generate the Red Hat Advanced Cluster Management (RHACM) policies.
 - **update/argocd/deployment**: contains patches and YAML files to apply on the hub cluster for use in the next step of this procedure.
 - **update/argocd/example**: contains example **SiteConfig** and **PolicyGenerator** or **PolicyGentemplate** files that represent the recommended configuration.
3. Update the **clusters-app.yaml** and **policies-app.yaml** files to reflect the name of your applications and the URL, branch, and path for your Git repository.
If the upgrade includes changes that results in obsolete policies, the obsolete policies should be removed prior to performing the upgrade.
 4. Diff the changes between the configuration and deployment source CRs in the **/update** folder and Git repo where you manage your fleet site CRs. Apply and push the required changes to your site repository.



IMPORTANT

When you update GitOps ZTP to the latest version, you must apply the changes from the **update/argocd/deployment** directory to your site repository. Do not use older versions of the **argocd/deployment/** files.

3.3. LABELING THE EXISTING CLUSTERS

To ensure that existing clusters remain untouched by the tool updates, label all existing managed clusters with the **ztp-done** label.

**NOTE**

This procedure only applies when updating clusters that were not provisioned with Topology Aware Lifecycle Manager (TALM). Clusters that you provision with TALM are automatically labeled with **ztp-done**.

Procedure

- Find a label selector that lists the managed clusters that were deployed with GitOps Zero Touch Provisioning (ZTP), such as **local-cluster!=true**:

```
$ oc get managedcluster -l 'local-cluster!=true'
```

- Ensure that the resulting list contains all the managed clusters that were deployed with GitOps ZTP, and then use that selector to add the **ztp-done** label:

```
$ oc label managedcluster -l 'local-cluster!=true' ztp-done=
```

3.4. STOPPING THE EXISTING GITOPS ZTP APPLICATIONS

Removing the existing applications ensures that any changes to existing content in the Git repository are not rolled out until the new version of the tools is available.

Use the application files from the **deployment** directory. If you used custom names for the applications, update the names in these files first.

Procedure

- Perform a non-cascaded delete on the **clusters** application to leave all generated resources in place:

```
$ oc delete -f update/argocd/deployment/clusters-app.yaml
```

- Perform a cascaded delete on the **policies** application to remove all previous policies:

```
$ oc patch -f policies-app.yaml -p '{"metadata": {"finalizers": ["resources-finalizer.argocd.argoproj.io"]}}' --type merge
```

```
$ oc delete -f update/argocd/deployment/policies-app.yaml
```

3.5. REQUIRED CHANGES TO THE GIT REPOSITORY

When upgrading the **ztp-site-generate** container from an earlier release of GitOps Zero Touch Provisioning (ZTP) to 4.10 or later, there are additional requirements for the contents of the Git repository. Existing content in the repository must be updated to reflect these changes.

**NOTE**

The following procedure assumes you are using **PolicyGenerator** resources instead of **PolicyGentemplate** resources for cluster policies management.

- Make required changes to **PolicyGenerator** files:

All **PolicyGenerator** files must be created in a **Namespace** prefixed with **ztp**. This ensures that the GitOps ZTP application is able to manage the policy CRs generated by GitOps ZTP without conflicting with the way Red Hat Advanced Cluster Management (RHACM) manages the policies internally.

- Add the **kustomization.yaml** file to the repository:

All **SiteConfig** and **PolicyGenerator** CRs must be included in a **kustomization.yaml** file under their respective directory trees. For example:

```

    acmpolicygenerator
    └── site1-ns.yaml
    └── site1.yaml
    └── site2-ns.yaml
    └── site2.yaml
    └── common-ns.yaml
    └── common-ranGen.yaml
    └── group-du-sno-ranGen-ns.yaml
    └── group-du-sno-ranGen.yaml
    └── kustomization.yaml
  └── siteconfig
    └── site1.yaml
    └── site2.yaml
    └── kustomization.yaml

```



NOTE

The files listed in the **generator** sections must contain either **SiteConfig** or **{policy-gen-cr}** CRs only. If your existing YAML files contain other CRs, for example, **Namespace**, these other CRs must be pulled out into separate files and listed in the **resources** section.

The **PolicyGenerator** kustomization file must contain all **PolicyGenerator** YAML files in the **generator** section and **Namespace** CRs in the **resources** section. For example:

```

apiVersion: kustomize.config.k8s.io/v1beta1
kind: Kustomization

generators:
- acm-common-ranGen.yaml
- acm-group-du-sno-ranGen.yaml
- site1.yaml
- site2.yaml

resources:
- common-ns.yaml
- acm-group-du-sno-ranGen-ns.yaml
- site1-ns.yaml
- site2-ns.yaml

```

The **SiteConfig** kustomization file must contain all **SiteConfig** YAML files in the **generator** section and any other CRs in the resources:

```

apiVersion: kustomize.config.k8s.io/v1beta1
kind: Kustomization

```

```
generators:
- site1.yaml
- site2.yaml
```

- Remove the **pre-sync.yaml** and **post-sync.yaml** files.

In OpenShift Container Platform 4.10 and later, the **pre-sync.yaml** and **post-sync.yaml** files are no longer required. The **update/deployment/kustomization.yaml** CR manages the policies deployment on the hub cluster.



NOTE

There is a set of **pre-sync.yaml** and **post-sync.yaml** files under both the **SiteConfig** and **{policy-gen-cr}** trees.

- Review and incorporate recommended changes

Each release may include additional recommended changes to the configuration applied to deployed clusters. Typically these changes result in lower CPU use by the OpenShift platform, additional features, or improved tuning of the platform.

Review the reference **SiteConfig** and **PolicyGenerator** CRs applicable to the types of cluster in your network. These examples can be found in the **argocd/example** directory extracted from the GitOps ZTP container.

3.6. INSTALLING THE NEW GITOPS ZTP APPLICATIONS

Using the extracted **argocd/deployment** directory, and after ensuring that the applications point to your site Git repository, apply the full contents of the deployment directory. Applying the full contents of the directory ensures that all necessary resources for the applications are correctly configured.

Procedure

1. To install the GitOps ZTP plugin, patch the ArgoCD instance in the hub cluster with the relevant multicloud engine (MCE) subscription image. Customize the patch file that you previously extracted into the **out/argocd/deployment/** directory for your environment.
 - a. Select the **multicloud-operators-subscription** image that matches your RHACM version.
 - For RHACM 2.8 and 2.9, use the **registry.redhat.io/rhacm2/multicloud-operators-subscription-rhel8:v<rhacm_version>** image.
 - For RHACM 2.10 and later, use the **registry.redhat.io/rhacm2/multicloud-operators-subscription-rhel9:v<rhacm_version>** image.



IMPORTANT

The version of the **multicloud-operators-subscription** image must match the RHACM version. Beginning with the MCE 2.10 release, RHEL 9 is the base image for **multicloud-operators-subscription** images.

Click **[Expand for Operator list]** in the "Platform Aligned Operators" table in [OpenShift Operator Life Cycles](#) to view the complete supported Operators matrix for OpenShift Container Platform.

- b. Modify the **out/argocd/deployment/argocd Openshift-gitops-patch.json** file with the **multicloud-operators-subscription** image that matches your RHACM version:

```
{
  "args": [
    "-c",
    "mkdir -p ./config/kustomize/plugin/policy.open-cluster-
management.io/v1/policygenerator && cp ./policy-generator/PolicyGenerator-not-fips-
compliant ./config/kustomize/plugin/policy.open-cluster-
management.io/v1/policygenerator/PolicyGenerator" ①
  ],
  "command": [
    "/bin/bash"
  ],
  "image": "registry.redhat.io/rhacm2/multicloud-operators-subscription-rhel9:v2.10", ②
  ③
  "name": "policy-generator-install",
  "imagePullPolicy": "Always",
  "volumeMounts": [
    {
      "mountPath": "./config",
      "name": "kustomize"
    }
  ]
}
```

- ① Optional: For RHEL 9 images, copy the required universal executable in the **/policy-
generator/PolicyGenerator-not-fips-compliant** folder for the ArgoCD version.
- ② Match the **multicloud-operators-subscription** image to the RHACM version.
- ③ In disconnected environments, replace the URL for the **multicloud-operators-
subscription** image with the disconnected registry equivalent for your environment.

- c. Patch the ArgoCD instance. Run the following command:

```
$ oc patch argocd openshift-gitops \
-n openshift-gitops --type=merge \
--patch-file out/argocd/deployment/argocd-openshift-gitops-patch.json
```

2. In RHACM 2.7 and later, the multicloud engine enables the **cluster-proxy-addon** feature by default. Apply the following patch to disable the **cluster-proxy-addon** feature and remove the relevant hub cluster and managed pods that are responsible for this add-on. Run the following command:

```
$ oc patch multiclusterengines.multicloud.openshift.io multiclusterengine --type=merge --
patch-file out/argocd/deployment/disable-cluster-proxy-addon.json
```

3. Apply the pipeline configuration to your hub cluster by running the following command:

```
$ oc apply -k out/argocd/deployment
```

3.7. PULLING ISO IMAGES FOR THE DESIRED OPENSHIFT CONTAINER PLATFORM VERSION

To pull ISO images for the desired OpenShift Container Platform version, update the **AgentServiceConfig** custom resource (CR) with references to the desired ISO and RootFS images that are hosted on the mirror registry HTTP server.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.
- You have RHACM with **MultiClusterHub** enabled.
- You have enabled the assisted service.

Procedure

1. Open the **AgentServiceConfig** CR to update the **spec.oslImages** field by running the following command:

```
$ oc edit AgentServiceConfig
```

2. Update the **spec.oslImages** field in the **AgentServiceConfig** CR:

```
apiVersion: agent-install.openshift.io/v1beta1
kind: AgentServiceConfig
metadata:
  name: agent
spec:
# ...
  oslImages:
    - cpuArchitecture: x86_64
      openshiftVersion: "4.18"
      rootFSUrl: https://<host>/<path>/rhcos-live-rootfs.x86_64.img
      url: https://<host>/<path>/rhcos-live.x86_64.iso
```

where:

<host>

Specifies the fully qualified domain name (FQDN) for the target mirror registry HTTP server.

<path>

Specifies the path to the image on the target mirror registry.

3. Save and quit the editor to apply the changes.

Additional resources

- [Enabling the assisted service](#)

3.8. ROLLING OUT THE GITOPS ZTP CONFIGURATION CHANGES

If any configuration changes were included in the upgrade due to implementing recommended changes, the upgrade process results in a set of policy CRs on the hub cluster in the **Non-Compliant** state. With the GitOps Zero Touch Provisioning (ZTP) version 4.10 and later **ztp-site-generate** container, these policies are set to **inform** mode and are not pushed to the managed clusters without an additional step by the user. This ensures that potentially disruptive changes to the clusters can be managed in terms of when the changes are made, for example, during a maintenance window, and how many clusters are updated concurrently.

To roll out the changes, create one or more **ClusterGroupUpgrade** CRs as detailed in the TALM documentation. The CR must contain the list of **Non-Compliant** policies that you want to push out to the managed clusters as well as a list or selector of which clusters should be included in the update.

Additional resources

- For information about the Topology Aware Lifecycle Manager (TALM), see [About the Topology Aware Lifecycle Manager configuration](#).
- For information about creating **ClusterGroupUpgrade** CRs, see [About the auto-created ClusterGroupUpgrade CR for GitOps ZTP](#).

CHAPTER 4. INSTALLING MANAGED CLUSTERS WITH RHACM AND SITECONFIG RESOURCES

You can provision OpenShift Container Platform clusters at scale with Red Hat Advanced Cluster Management (RHACM) using the assisted service and the GitOps plugin policy generator with core-reduction technology enabled. The GitOps Zero Touch Provisioning (ZTP) pipeline performs the cluster installations. GitOps ZTP can be used in a disconnected environment.



IMPORTANT

Using **PolicyGenTemplate** CRs to manage and deploy policies to managed clusters will be deprecated in an upcoming OpenShift Container Platform release. Equivalent and improved functionality is available using Red Hat Advanced Cluster Management (RHACM) and **PolicyGenerator** CRs.

For more information about **PolicyGenerator** resources, see the RHACM [Integrating Policy Generator](#) documentation.

Additional resources

- [Configuring managed cluster policies by using PolicyGenerator resources](#)
- [Comparing RHACM PolicyGenerator and PolicyGenTemplate resource patching](#)

4.1. GITOPS ZTP AND TOPOLOGY AWARE LIFECYCLE MANAGER

GitOps Zero Touch Provisioning (ZTP) generates installation and configuration CRs from manifests stored in Git. These artifacts are applied to a centralized hub cluster where Red Hat Advanced Cluster Management (RHACM), the assisted service, and the Topology Aware Lifecycle Manager (TALM) use the CRs to install and configure the managed cluster. The configuration phase of the GitOps ZTP pipeline uses the TALM to orchestrate the application of the configuration CRs to the cluster. There are several key integration points between GitOps ZTP and the TALM.

Inform policies

By default, GitOps ZTP creates all policies with a remediation action of **inform**. These policies cause RHACM to report on compliance status of clusters relevant to the policies but does not apply the desired configuration. During the GitOps ZTP process, after OpenShift installation, the TALM steps through the created **inform** policies and enforces them on the target managed cluster(s). This applies the configuration to the managed cluster. Outside of the GitOps ZTP phase of the cluster lifecycle, this allows you to change policies without the risk of immediately rolling those changes out to affected managed clusters. You can control the timing and the set of remediated clusters by using TALM.

Automatic creation of ClusterGroupUpgrade CRs

To automate the initial configuration of newly deployed clusters, TALM monitors the state of all **ManagedCluster** CRs on the hub cluster. Any **ManagedCluster** CR that does not have a **ztp-done** label applied, including newly created **ManagedCluster** CRs, causes the TALM to automatically create a **ClusterGroupUpgrade** CR with the following characteristics:

- The **ClusterGroupUpgrade** CR is created and enabled in the **ztp-install** namespace.
- **ClusterGroupUpgrade** CR has the same name as the **ManagedCluster** CR.
- The cluster selector includes only the cluster associated with that **ManagedCluster** CR.

- The set of managed policies includes all policies that RHACM has bound to the cluster at the time the **ClusterGroupUpgrade** is created.
- Pre-caching is disabled.
- Timeout set to 4 hours (240 minutes).

The automatic creation of an enabled **ClusterGroupUpgrade** ensures that initial zero-touch deployment of clusters proceeds without the need for user intervention. Additionally, the automatic creation of a **ClusterGroupUpgrade** CR for any **ManagedCluster** without the **ztp-done** label allows a failed GitOps ZTP installation to be restarted by simply deleting the **ClusterGroupUpgrade** CR for the cluster.

Waves

Each policy generated from a **PolicyGenerator** or **PolicyGentemplate** CR includes a **ztp-deploy-wave** annotation. This annotation is based on the same annotation from each CR which is included in that policy. The wave annotation is used to order the policies in the auto-generated **ClusterGroupUpgrade** CR. The wave annotation is not used other than for the auto-generated **ClusterGroupUpgrade** CR.



NOTE

All CRs in the same policy must have the same setting for the **ztp-deploy-wave** annotation. The default value of this annotation for each CR can be overridden in the **PolicyGenerator** or **PolicyGentemplate**. The wave annotation in the source CR is used for determining and setting the policy wave annotation. This annotation is removed from each built CR which is included in the generated policy at runtime.

The TALM applies the configuration policies in the order specified by the wave annotations. The TALM waits for each policy to be compliant before moving to the next policy. It is important to ensure that the wave annotation for each CR takes into account any prerequisites for those CRs to be applied to the cluster. For example, an Operator must be installed before or concurrently with the configuration for the Operator. Similarly, the **CatalogSource** for an Operator must be installed in a wave before or concurrently with the Operator Subscription. The default wave value for each CR takes these prerequisites into account.

Multiple CRs and policies can share the same wave number. Having fewer policies can result in faster deployments and lower CPU usage. It is a best practice to group many CRs into relatively few waves.

To check the default wave value in each source CR, run the following command against the **out/source-crs** directory that is extracted from the **ztp-site-generate** container image:

```
$ grep -r "ztp-deploy-wave" out/source-crs
```

Phase labels

The **ClusterGroupUpgrade** CR is automatically created and includes directives to annotate the **ManagedCluster** CR with labels at the start and end of the GitOps ZTP process.

When GitOps ZTP configuration postinstallation commences, the **ManagedCluster** has the **ztp-running** label applied. When all policies are remediated to the cluster and are fully compliant, these directives cause the TALM to remove the **ztp-running** label and apply the **ztp-done** label.

For deployments that make use of the **informDuValidator** policy, the **ztp-done** label is applied when the cluster is fully ready for deployment of applications. This includes all reconciliation and resulting

effects of the GitOps ZTP applied configuration CRs. The **ztp-done** label affects automatic **ClusterGroupUpgrade** CR creation by TALM. Do not manipulate this label after the initial GitOps ZTP installation of the cluster.

Linked CRs

The automatically created **ClusterGroupUpgrade** CR has the owner reference set as the **ManagedCluster** from which it was derived. This reference ensures that deleting the **ManagedCluster** CR causes the instance of the **ClusterGroupUpgrade** to be deleted along with any supporting resources.

4.2. OVERVIEW OF DEPLOYING MANAGED CLUSTERS WITH GITOPS ZTP

Red Hat Advanced Cluster Management (RHACM) uses GitOps Zero Touch Provisioning (ZTP) to deploy single-node OpenShift Container Platform clusters, three-node clusters, and standard clusters. You manage site configuration data as OpenShift Container Platform custom resources (CRs) in a Git repository. GitOps ZTP uses a declarative GitOps approach for a develop once, deploy anywhere model to deploy the managed clusters.

The deployment of the clusters includes:

- Installing the host operating system (RHCOS) on a blank server
- Deploying OpenShift Container Platform
- Creating cluster policies and site subscriptions
- Making the necessary network configurations to the server operating system
- Deploying profile Operators and performing any needed software-related configuration, such as performance profile, PTP, and SR-IOV

Overview of the managed site installation process

After you apply the managed site custom resources (CRs) on the hub cluster, the following actions happen automatically:

1. A Discovery image ISO file is generated and booted on the target host.
2. When the ISO file successfully boots on the target host it reports the host hardware information to RHACM.
3. After all hosts are discovered, OpenShift Container Platform is installed.
4. When OpenShift Container Platform finishes installing, the hub installs the **klusterlet** service on the target cluster.
5. The requested add-on services are installed on the target cluster.

The Discovery image ISO process is complete when the **Agent** CR for the managed cluster is created on the hub cluster.



IMPORTANT

The target bare-metal host must meet the networking, firmware, and hardware requirements listed in [Recommended single-node OpenShift cluster configuration for vDU application workloads](#).

4.3. CREATING THE MANAGED BARE-METAL HOST SECRETS

Add the required **Secret** custom resources (CRs) for the managed bare-metal host to the hub cluster. You need a secret for the GitOps Zero Touch Provisioning (ZTP) pipeline to access the Baseboard Management Controller (BMC) and a secret for the assisted installer service to pull cluster installation images from the registry.



NOTE

The secrets are referenced from the **SiteConfig** CR by name. The namespace must match the **SiteConfig** namespace.

Procedure

1. Create a YAML secret file containing credentials for the host Baseboard Management Controller (BMC) and a pull secret required for installing OpenShift and all add-on cluster Operators:
 - a. Save the following YAML as the file **example-sno-secret.yaml**:

```
apiVersion: v1
kind: Secret
metadata:
  name: example-sno-bmc-secret
  namespace: example-sno 1
data: 2
  password: <base64_password>
  username: <base64_username>
type: Opaque
---
apiVersion: v1
kind: Secret
metadata:
  name: pull-secret
  namespace: example-sno 3
data:
  .dockerconfigjson: <pull_secret> 4
type: kubernetes.io/dockerconfigjson
```

- 1** Must match the namespace configured in the related **SiteConfig** CR
- 2** Base64-encoded values for **password** and **username**
- 3** Must match the namespace configured in the related **SiteConfig** CR
- 4** Base64-encoded pull secret

2. Add the relative path to **example-sno-secret.yaml** to the **kustomization.yaml** file that you use to install the cluster.

4.4. CONFIGURING DISCOVERY ISO KERNEL ARGUMENTS FOR INSTALLATIONS USING GITOPS ZTP

The GitOps Zero Touch Provisioning (ZTP) workflow uses the Discovery ISO as part of the OpenShift Container Platform installation process on managed bare-metal hosts. You can edit the **InfraEnv** resource to specify kernel arguments for the Discovery ISO. This is useful for cluster installations with specific environmental requirements. For example, configure the **rd.net.timeout.carrier** kernel argument for the Discovery ISO to facilitate static networking for the cluster or to receive a DHCP address before downloading the root file system during installation.



NOTE

In OpenShift Container Platform 4.18, you can only add kernel arguments. You can not replace or delete kernel arguments.

Prerequisites

- You have installed the OpenShift CLI (oc).
- You have logged in to the hub cluster as a user with cluster-admin privileges.

Procedure

1. Create the **InfraEnv** CR and edit the **spec.kernelArguments** specification to configure kernel arguments.
 - a. Save the following YAML in an **InfraEnv-example.yaml** file:



NOTE

The **InfraEnv** CR in this example uses template syntax such as `{{ .Cluster.ClusterName }}` that is populated based on values in the **SiteConfig** CR. The **SiteConfig** CR automatically populates values for these templates during deployment. Do not edit the templates manually.

```
apiVersion: agent-install.openshift.io/v1beta1
kind: InfraEnv
metadata:
  annotations:
    argocd.argoproj.io/sync-wave: "1"
  name: "{{ .Cluster.ClusterName }}"
  namespace: "{{ .Cluster.ClusterName }}"
spec:
  clusterRef:
    name: "{{ .Cluster.ClusterName }}"
    namespace: "{{ .Cluster.ClusterName }}"
  kernelArguments:
    - operation: append ①
      value: audit=0 ②
    - operation: append
```

```

    value: trace=1
    sshAuthorizedKey: "{{ .Site.SshPublicKey }}"
    proxy: "{{ .Cluster.ProxySettings }}"
    pullSecretRef:
      name: "{{ .Site.PullSecretRef.Name }}"
    ignitionConfigOverride: "{{ .Cluster.IgnitionConfigOverride }}"
    nmStateConfigLabelSelector:
      matchLabels:
        nmstate-label: "{{ .Cluster.ClusterName }}"
    additionalNTPSources: "{{ .Cluster.AdditionalNTPSources }}"

```

- 1** Specify the append operation to add a kernel argument.
 - 2** Specify the kernel argument you want to configure. This example configures the audit kernel argument and the trace kernel argument.
2. Commit the **InfraEnv-example.yaml** CR to the same location in your Git repository that has the **SiteConfig** CR and push your changes. The following example shows a sample Git repository structure:
- ```

~/example-ztp/install
 └── site-install
 ├── siteconfig-example.yaml
 └── InfraEnv-example.yaml
 ...

```
3. Edit the **spec.clusters.crTemplates** specification in the **SiteConfig** CR to reference the **InfraEnv-example.yaml** CR in your Git repository:

```

clusters:
crTemplates:
 InfraEnv: "InfraEnv-example.yaml"

```

When you are ready to deploy your cluster by committing and pushing the **SiteConfig** CR, the build pipeline uses the custom **InfraEnv-example** CR in your Git repository to configure the infrastructure environment, including the custom kernel arguments.

## Verification

To verify that the kernel arguments are applied, after the Discovery image verifies that OpenShift Container Platform is ready for installation, you can SSH to the target host before the installation process begins. At that point, you can view the kernel arguments for the Discovery ISO in the **/proc/cmdline** file.

1. Begin an SSH session with the target host:

```
$ ssh -i /path/to/privatekey core@<host_name>
```

2. View the system's kernel arguments by using the following command:

```
$ cat /proc/cmdline
```

## 4.5. DEPLOYING A MANAGED CLUSTER WITH SITECONFIG AND GITOPS ZTP

Use the following procedure to create a **SiteConfig** custom resource (CR) and related files and initiate the GitOps Zero Touch Provisioning (ZTP) cluster deployment.



### IMPORTANT

SiteConfig v1 is deprecated starting with OpenShift Container Platform version 4.18. Equivalent and improved functionality is now available through the SiteConfig Operator using the **ClusterInstance** custom resource. For more information, see [Procedure to transition from SiteConfig CRs to the ClusterInstance API](#).

For more information about the SiteConfig Operator, see [SiteConfig](#).

### Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.
- You configured the hub cluster for generating the required installation and policy CRs.
- You created a Git repository where you manage your custom site configuration data. The repository must be accessible from the hub cluster and you must configure it as a source repository for the ArgoCD application. See "Preparing the GitOps ZTP site configuration repository" for more information.



### NOTE

When you create the source repository, ensure that you patch the ArgoCD application with the **argocd/deployment/argocd Openshift-Gitops-Patch.json** patch-file that you extract from the **ztp-site-generate** container. See "Configuring the hub cluster with ArgoCD".

- To be ready for provisioning managed clusters, you require the following for each bare-metal host:

#### Network connectivity

Your network requires DNS. Managed cluster hosts should be reachable from the hub cluster. Ensure that Layer 3 connectivity exists between the hub cluster and the managed cluster host.

#### Baseboard Management Controller (BMC) details

GitOps ZTP uses BMC username and password details to connect to the BMC during cluster installation. The GitOps ZTP plugin manages the **ManagedCluster** CRs on the hub cluster based on the **SiteConfig** CR in your site Git repo. You create individual **BMCSecret** CRs for each host manually.

### Procedure

1. Create the required managed cluster secrets on the hub cluster. These resources must be in a namespace with a name matching the cluster name. For example, in **out/argocd/example/siteconfig/example-sno.yaml**, the cluster name and namespace is **example-sno**.

- Export the cluster namespace by running the following command:

```
$ export CLUSTERNS=example-sno
```

- Create the namespace:

```
$ oc create namespace $CLUSTERNS
```

- Create pull secret and BMC **Secret** CRs for the managed cluster. The pull secret must contain all the credentials necessary for installing OpenShift Container Platform and all required Operators. See "Creating the managed bare-metal host secrets" for more information.



### NOTE

The secrets are referenced from the **SiteConfig** custom resource (CR) by name.  
The namespace must match the **SiteConfig** namespace.

- Create a **SiteConfig** CR for your cluster in your local clone of the Git repository:

- Choose the appropriate example for your CR from the **out/argocd/example/siteconfig/** folder. The folder includes example files for single node, three-node, and standard clusters:
  - **example-sno.yaml**
  - **example-3node.yaml**
  - **example-standard.yaml**
- Change the cluster and host details in the example file to match the type of cluster you want. For example:

#### Example single-node OpenShift SiteConfig CR

```
example-node1-bmh-secret & assisted-deployment-pull-secret need to be created
under same namespace example-sno

apiVersion: ran.openshift.io/v1
kind: SiteConfig
metadata:
 name: "example-sno"
 namespace: "example-sno"
spec:
 baseDomain: "example.com"
 pullSecretRef:
 name: "assisted-deployment-pull-secret"
 clusterImageSetNameRef: "openshift-4.18"
 sshPublicKey: "ssh-rsa AAAA..."
clusters:
 - clusterName: "example-sno"
 networkType: "OVNKubernetes"
 # installConfigOverrides is a generic way of passing install-config
 # parameters through the siteConfig. The 'capabilities' field configures
 # the composable openshift feature. In this 'capabilities' setting, we
 # remove all the optional set of components.
 # Notes:
```

```

- OperatorLifecycleManager is needed for 4.15 and later
- NodeTuning is needed for 4.13 and later, not for 4.12 and earlier
- Ingress is needed for 4.16 and later
installConfigOverrides: |
{
 "capabilities": {
 "baselineCapabilitySet": "None",
 "additionalEnabledCapabilities": [
 "NodeTuning",
 "OperatorLifecycleManager",
 "Ingress"
]
 }
}

It is strongly recommended to include crun manifests as part of the additional
install-time manifests for 4.13+.
The crun manifests can be obtained from source-crs/optional-extra-manifest/ and
added to the git repo ie.sno-extra-manifest.
extraManifestPath: sno-extra-manifest
clusterLabels:
 # These example cluster labels correspond to the bindingRules in the
PolicyGenTemplate examples
 du-profile: "latest"
 # These example cluster labels correspond to the bindingRules in the
PolicyGenTemplate examples in ../policygentemplates:
 # ../policygentemplates/common-ranGen.yaml will apply to all clusters with
'common: true'
 common: true
 # ../policygentemplates/group-du-sno-ranGen.yaml will apply to all clusters with
'group-du-sno: ""'
 group-du-sno: ""
 # ../policygentemplates/example-sno-site.yaml will apply to all clusters with 'sites:
"example-sno"'
 # Normally this should match or contain the cluster name so it only applies to a
single cluster
 sites: "example-sno"
 clusterNetwork:
 - cidr: 1001:1::/48
 hostPrefix: 64
 machineNetwork:
 - cidr: 1111:2222:3333:4444::/64
 serviceNetwork:
 - 1001:2::/112
 additionalNTPSources:
 - 1111:2222:3333:4444::2
 # Initiates the cluster for workload partitioning. Setting specific reserved/isolated
CPUSets is done via PolicyTemplate
 # please see Workload Partitioning Feature for a complete guide.
 cpuPartitioningMode: AllNodes
 # Optionally; This can be used to override the KlusterletAddonConfig that is created
for this cluster:
 #crTemplates:
 # KlusterletAddonConfig: "KlusterletAddonConfigOverride.yaml"
 nodes:
 - hostName: "example-node1.example.com"
 role: "master"

```

```

Optionally; This can be used to configure desired BIOS setting on a host:
#biosConfigRef:
filePath: "example-hw.profile"
bmcAddress: "idrac-
virtualmedia+https://[1111:2222:3333:4444::bbbb:1]/redfish/v1/Systems/System.Embedded.1"
bmcCredentialsName:
 name: "example-node1-bmh-secret"
bootMACAddress: "AA:BB:CC:DD:EE:11"
Use UEFI SecureBoot to enable secure boot.
bootMode: "UEFISecureBoot"
rootDeviceHints:
 deviceName: "/dev/disk/by-path/pci-0000:01:00.0-scsi-0:2:0:0"
#crTemplates:
BareMetalHost: "bmhOverride.yaml"
disk partition at `/var/lib/containers` with ignitionConfigOverride. Some values
must be updated. See DiskPartitionContainer.md for more details
ignitionConfigOverride: |
{
 "ignition": {
 "version": "3.2.0"
 },
 "storage": {
 "disks": [
 {
 "device": "/dev/disk/by-id/wwn-0x6b07b250ebb9d0002a33509f24af1f62",
 "partitions": [
 {
 "label": "var-lib-containers",
 "sizeMiB": 0,
 "startMiB": 250000
 }
],
 "wipeTable": false
 }
],
 "filesystems": [
 {
 "device": "/dev/disk/by-partlabel/var-lib-containers",
 "format": "xfs",
 "mountOptions": [
 "defaults",
 "prjquota"
],
 "path": "/var/lib/containers",
 "wipeFilesystem": true
 }
]
 },
 "systemd": {
 "units": [
 {
 "contents": "# Generated by Butane\n[Unit]\nRequires=systemd-fsck@dev-disk-by\\x2dpartlabel-var\\x2dlib\\x2dcontainers.service\nAfter=systemd-fsck@dev-disk-by\\x2dpartlabel-var\\x2dlib\\x2dcontainers.service\n\n[Mount]\nWhere=/var/lib/containers\nWhat=/dev/disk/b"
 }
]
 }
}

```

```

y-partlabel/var-lib-
containers\nType=xfs\nOptions=defaults,prjquota\n\n[Install]\nRequiredBy=local-
fs.target",
 "enabled": true,
 "name": "var-lib-containers.mount"
}
]
}
}

nodeNetwork:
interfaces:
- name: eno1
 macAddress: "AA:BB:CC:DD:EE:11"
config:
interfaces:
- name: eno1
 type: ethernet
 state: up
 ipv4:
 enabled: false
 ipv6:
 enabled: true
 address:
 # For SNO sites with static IP addresses, the node-specific,
 # API and Ingress IPs should all be the same and configured on
 # the interface
 - ip: 1111:2222:3333:4444::aaaa:1
 prefix-length: 64
dns-resolver:
config:
search:
- example.com
server:
- 1111:2222:3333:4444::2
routes:
config:
- destination: ::/0
 next-hop-interface: eno1
 next-hop-address: 1111:2222:3333:4444::1
 table-id: 254

```



## NOTE

For more information about BMC addressing, see the "Additional resources" section. The **installConfigOverrides** and **ignitionConfigOverride** fields are expanded in the example for ease of readability.



## NOTE

To override the default **BareMetalHost** CR for a node, you can reference the override CR in the node-level **crTemplates** field in the **SiteConfig** CR. Ensure that you set the **argocd.argoproj.io/sync-wave: "3"** annotation in your override **BareMetalHost** CR.

- c. You can inspect the default set of extra-manifest **MachineConfig** CRs in **out/argocd/extra-manifest**. It is automatically applied to the cluster when it is installed.
- d. Optional: To provision additional install-time manifests on the provisioned cluster, create a directory in your Git repository, for example, **sno-extra-manifest**, and add your custom manifest CRs to this directory. If your **SiteConfig.yaml** refers to this directory in the **extraManifestPath** field, any CRs in this referenced directory are appended to the default set of extra manifests.



## ENABLING THE CRUN OCI CONTAINER RUNTIME

For optimal cluster performance, enable crun for master and worker nodes in single-node OpenShift, single-node OpenShift with additional worker nodes, three-node OpenShift, and standard clusters.

Enable crun in a **ContainerRuntimeConfig** CR as an additional Day 0 install-time manifest to avoid the cluster having to reboot.

The **enable-crun-master.yaml** and **enable-crun-worker.yaml** CR files are in the **out/source-crs/optional-extra-manifest**/ folder that you can extract from the **ztp-site-generate** container. For more information, see "Customizing extra installation manifests in the GitOps ZTP pipeline".

4. Add the **SiteConfig** CR to the **kustomization.yaml** file in the **generators** section, similar to the example shown in **out/argocd/example/siteconfig/kustomization.yaml**.
5. Commit the **SiteConfig** CR and associated **kustomization.yaml** changes in your Git repository and push the changes.

The ArgoCD pipeline detects the changes and begins the managed cluster deployment.

### Verification

- Verify that the custom roles and labels are applied after the node is deployed:

```
$ oc describe node example-node.example.com
```

### Example output

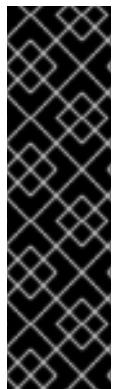
```
Name: example-node.example.com
Roles: control-plane,example-label,master,worker
Labels: beta.kubernetes.io/arch=amd64
 beta.kubernetes.io/os=linux
 custom-label/parameter1=true
 kubernetes.io/arch=amd64
 kubernetes.io/hostname=cnfdf03.telco5gran.eng.rdu2.redhat.com
 kubernetes.io/os=linux
 node-role.kubernetes.io/control-plane=
 node-role.kubernetes.io/example-label= ①
 node-role.kubernetes.io/master=
 node-role.kubernetes.io/worker=
 node.openshift.io/os_id=rhcos
```

- 1 The custom label is applied to the node.

## Additional resources

- [Single-node OpenShift SiteConfig CR installation reference](#)

### 4.5.1. Accelerated provisioning of GitOps ZTP



#### IMPORTANT

Accelerated provisioning of GitOps ZTP 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](#).

You can reduce the time taken for cluster installation by using accelerated provisioning of GitOps ZTP for single-node OpenShift. Accelerated ZTP speeds up installation by applying Day 2 manifests derived from policies at an earlier stage.



#### IMPORTANT

Accelerated provisioning of GitOps ZTP is supported only when installing single-node OpenShift with Assisted Installer. Otherwise this installation method will fail.

#### 4.5.1.1. Activating accelerated ZTP

You can activate accelerated ZTP using the **spec.clusters.clusterLabels.accelerated-ztp** label, as in the following example:

##### Example Accelerated ZTP SiteConfig CR.

```
apiVersion: ran.openshift.io/v2
kind: SiteConfig
metadata:
 name: "example-sno"
 namespace: "example-sno"
spec:
 baseDomain: "example.com"
 pullSecretRef:
 name: "assisted-deployment-pull-secret"
 clusterImageSetNameRef: "openshift-4.18"
 sshPublicKey: "ssh-rsa AAAA..."
 clusters:
 # ...
 clusterLabels:
 common: true
 group-du-sno: ""
 sites : "example-sno"
 accelerated-ztp: full
```

You can use **accelerated-ztp: full** to fully automate the accelerated process. GitOps ZTP updates the **AgentClusterInstall** resource with a reference to the accelerated GitOps ZTP **ConfigMap**, and includes resources extracted from policies by TALM, and accelerated ZTP job manifests.

If you use **accelerated-ztp: partial**, GitOps ZTP does not include the accelerated job manifests, but includes policy-derived objects created during the cluster installation of the following **kind** types:

- **PerformanceProfile.performance.openshift.io**
- **Tuned.tuned.openshift.io**
- **Namespace**
- **CatalogSource.operators.coreos.com**
- **ContainerRuntimeConfig.machineconfiguration.openshift.io**

This partial acceleration can reduce the number of reboots done by the node when applying resources of the kind **Performance Profile**, **Tuned**, and **ContainerRuntimeConfig**. TALM installs the Operator subscriptions derived from policies after RHACM completes the import of the cluster, following the same flow as standard GitOps ZTP.

The benefits of accelerated ZTP increase with the scale of your deployment. Using **accelerated-ztp: full** gives more benefit on a large number of clusters. With a smaller number of clusters, the reduction in installation time is less significant. Full accelerated ZTP leaves behind a namespace and a completed job on the spoke that need to be manually removed.

One benefit of using **accelerated-ztp: partial** is that you can override the functionality of the on-spoke job if something goes wrong with the stock implementation or if you require a custom functionality.

#### 4.5.1.2. The accelerated ZTP process

Accelerated ZTP uses an additional **ConfigMap** to create the resources derived from policies on the spoke cluster. The standard **ConfigMap** includes manifests that the GitOps ZTP workflow uses to customize cluster installs.

TALM detects that the **accelerated-ztp** label is set and then creates a second **ConfigMap**. As part of accelerated ZTP, the **SiteConfig** generator adds a reference to that second **ConfigMap** using the naming convention **<spoke-cluster-name>-aztp**.

After TALM creates that second **ConfigMap**, it finds all policies bound to the managed cluster and extracts the GitOps ZTP profile information. TALM adds the GitOps ZTP profile information to the **<spoke-cluster-name>-aztp ConfigMap** custom resource (CR) and applies the CR to the hub cluster API.

#### 4.5.2. Configuring IPsec encryption for single-node OpenShift clusters using GitOps ZTP and SiteConfig resources

You can enable IPsec encryption in managed single-node OpenShift clusters that you install using GitOps ZTP and Red Hat Advanced Cluster Management (RHACM). You can encrypt traffic between the managed cluster and IPsec endpoints external to the managed cluster. All network traffic between nodes on the OVN-Kubernetes cluster network is encrypted with IPsec in Transport mode.



## IMPORTANT

You can also configure IPsec encryption for single-node OpenShift clusters with an additional worker node by following this procedure. It is recommended to use the **MachineConfig** custom resource (CR) to configure IPsec encryption for single-node OpenShift clusters and single-node OpenShift clusters with an additional worker node because of their low resource availability.

### Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.
- You have configured RHACM and the hub cluster for generating the required installation and policy custom resources (CRs) for managed clusters.
- You have created a Git repository where you manage your custom site configuration data. The repository must be accessible from the hub cluster and be defined as a source repository for the Argo CD application.
- You have installed the **butane** utility version 0.20.0 or later.
- You have a PKCS#12 certificate for the IPsec endpoint and a CA cert in PEM format.

### Procedure

- 1 Extract the latest version of the **ztp-site-generate** container source and merge it with your repository where you manage your custom site configuration data.
- 2 Configure **optional-extra-manifest/ipsec/ipsec-endpoint-config.yaml** with the required values that configure IPsec in the cluster. For example:

```
interfaces:
- name: hosta_conn
 type: ipsec
 libreswan:
 left: '%defaultroute'
 leftid: '%fromcert'
 leftmodecfgclient: false
 leftcert: left_server ①
 lefrsasigkey: '%cert'
 right: <external_host> ②
 rightid: '%fromcert'
 rightrsasigkey: '%cert'
 rightsubnet: <external_address> ③
 ikev2: insist ④
 type: tunnel
```

- 1 The value of this field must match with the name of the certificate used on the remote system.
- 2 Replace **<external\_host>** with the external host IP address or DNS hostname.
- 3 Replace **<external\_address>** with the IP subnet of the external host on the other side of the IPsec tunnel.

- 4** Use the IKEv2 VPN encryption protocol only. Do not use IKEv1, which is deprecated.

3. Add the following certificates to the **optional-extra-manifest/ipsec** folder:

- **left\_server.p12**: The certificate bundle for the IPsec endpoints
- **ca.pem**: The certificate authority that you signed your certificates with  
The certificate files are required for the Network Security Services (NSS) database on each host. These files are imported as part of the Butane configuration in later steps.

4. Open a shell prompt at the **optional-extra-manifest/ipsec** folder of the Git repository where you maintain your custom site configuration data.

5. Run the **optional-extra-manifest/ipsec/build.sh** script to generate the required Butane and **MachineConfig** CRs files.

If the PKCS#12 certificate is protected with a password, set the **-W** argument.

### Example output

```

out
└── argocd
 └── example
 └── optional-extra-manifest
 └── ipsec
 ├── 99-ipsec-master-endpoint-config.bu ①
 ├── 99-ipsec-master-endpoint-config.yaml ②
 ├── 99-ipsec-worker-endpoint-config.bu ③
 ├── 99-ipsec-worker-endpoint-config.yaml ④
 ├── build.sh
 ├── ca.pem ⑤
 ├── left_server.p12 ⑥
 ├── enable-ipsec.yaml
 ├── ipsec-endpoint-config.yaml
 └── README.md

```

**1 2 3 4** The **ipsec/build.sh** script generates the Butane and endpoint configuration CRs.

**5 6** You provide **ca.pem** and **left\_server.p12** certificate files that are relevant to your network.

6. Create a **custom-manifest**/ folder in the repository where you manage your custom site configuration data. Add the **enable-ipsec.yaml** and **99-ipsec-\*** YAML files to the directory. For example:

```

siteconfig
└── site1-sno-du.yaml
└── extra-manifest/
└── custom-manifest
 ├── enable-ipsec.yaml
 ├── 99-ipsec-worker-endpoint-config.yaml
 └── 99-ipsec-master-endpoint-config.yaml

```

- In your **SiteConfig** CR, add the **custom-manifest/** directory to the **extraManifests.searchPaths** field. For example:

```

clusters:
- clusterName: "site1-sno-du"
 networkType: "OVNKubernetes"
 extraManifests:
 searchPaths:
 - extra-manifest/
 - custom-manifest/

```

- Commit the **SiteConfig** CR changes and updated files in your Git repository and push the changes to provision the managed cluster and configure IPsec encryption.
- The Argo CD pipeline detects the changes and begins the managed cluster deployment.

During cluster provisioning, the GitOps ZTP pipeline appends the CRs in the **custom-manifest/** directory to the default set of extra manifests stored in the **extra-manifest/** directory.

## Verification

For information about verifying the IPsec encryption, see "Verifying the IPsec encryption".

## Additional resources

- [Verifying the IPsec encryption](#)
- [Configuring IPsec encryption](#)
- [Encryption protocol and IPsec mode](#)
- [Installing managed clusters with RHACM and SiteConfig resources](#)

### 4.5.3. Configuring IPsec encryption for multi-node clusters using GitOps ZTP and SiteConfig resources

You can enable IPsec encryption in managed multi-node clusters that you install using GitOps ZTP and Red Hat Advanced Cluster Management (RHACM). You can encrypt traffic between the managed cluster and IPsec endpoints external to the managed cluster. All network traffic between nodes on the OVN-Kubernetes cluster network is encrypted with IPsec in Transport mode.

## Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.
- You have configured RHACM and the hub cluster for generating the required installation and policy custom resources (CRs) for managed clusters.
- You have created a Git repository where you manage your custom site configuration data. The repository must be accessible from the hub cluster and be defined as a source repository for the Argo CD application.
- You have installed the **butane** utility version 0.20.0 or later.
- You have a PKCS#12 certificate for the IPsec endpoint and a CA cert in PEM format.

- You have installed the NMState Operator.

## Procedure

1. Extract the latest version of the **ztp-site-generate** container source and merge it with your repository where you manage your custom site configuration data.
2. Configure the **optional-extra-manifest/ipsec/ipsec-config-policy.yaml** file with the required values that configure IPsec in the cluster.

### ConfigurationPolicy object for creating an IPsec configuration

```

apiVersion: policy.open-cluster-management.io/v1
kind: ConfigurationPolicy
metadata:
 name: policy-config
spec:
 namespaceSelector:
 include: ["default"]
 exclude: []
 matchExpressions: []
 matchLabels: {}
 remediationAction: inform
 severity: low
 evaluationInterval:
 compliant:
 noncompliant:
 object-templates-raw: |
 {{- range (lookup "v1" "Node" "" "") .items --}}
 - complianceType: musthave
 objectDefinition:
 kind: NodeNetworkConfigurationPolicy
 apiVersion: nmstate.io/v1
 metadata:
 name: {{ .metadata.name }}-ipsec-policy
 spec:
 nodeSelector:
 kubernetes.io/hostname: {{ .metadata.name }}
 desiredState:
 interfaces:
 - name: hosta_conn
 type: ipsec
 libreswan:
 left: '%defaultroute'
 leftid: '%fromcert'
 leftmodecfgclient: false
 leftcert: left_server 1
 lefrtsasigkey: '%cert'
 right: <external_host> 2
 rightid: '%fromcert'
 rightrsasigkey: '%cert'
 rightsubnet: <external_address> 3
 ikev2: insist 4
 type: tunnel

```

- 1 The value of this field must match with the name of the certificate used on the remote system.
- 2 Replace `<external_host>` with the external host IP address or DNS hostname.
- 3 Replace `<external_address>` with the IP subnet of the external host on the other side of the IPsec tunnel.
- 4 Use the IKEv2 VPN encryption protocol only. Do not use IKEv1, which is deprecated.

3. Add the following certificates to the **optional-extra-manifest/ipsec** folder:

- **left\_server.p12**: The certificate bundle for the IPsec endpoints
- **ca.pem**: The certificate authority that you signed your certificates with  
The certificate files are required for the Network Security Services (NSS) database on each host. These files are imported as part of the Butane configuration in later steps.

4. Open a shell prompt at the **optional-extra-manifest/ipsec** folder of the Git repository where you maintain your custom site configuration data.
5. Run the **optional-extra-manifest/ipsec/import-certs.sh** script to generate the required Butane and **MachineConfig** CRs to import the external certs.  
If the PKCS#12 certificate is protected with a password, set the **-W** argument.

### Example output

```

out
└── argocd
 └── example
 └── optional-extra-manifest
 └── ipsec
 ├── 99-ipsec-master-import-certs.bu ①
 ├── 99-ipsec-master-import-certs.yaml ②
 ├── 99-ipsec-worker-import-certs.bu ③
 ├── 99-ipsec-worker-import-certs.yaml ④
 ├── import-certs.sh
 ├── ca.pem ⑤
 ├── left_server.p12 ⑥
 ├── enable-ipsec.yaml
 ├── ipsec-config-policy.yaml
 └── README.md

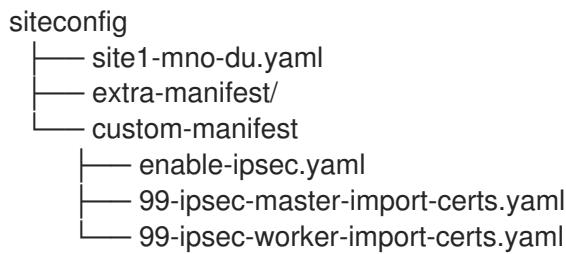
```

① ② ③ ④ The **ipsec/import-certs.sh** script generates the Butane and endpoint configuration CRs.

⑤ ⑥ Add the **ca.pem** and **left\_server.p12** certificate files that are relevant to your network.

6. Create a **custom-manifest/** folder in the repository where you manage your custom site configuration data and add the **enable-ipsec.yaml** and **99-ipsec-\*** YAML files to the directory.

### Example siteconfig directory



- In your **SiteConfig** CR, add the **custom-manifest/** directory to the **extraManifests.searchPaths** field, as in the following example:

```

clusters:
- clusterName: "site1-mno-du"
 networkType: "OVNKubernetes"
 extraManifests:
 searchPaths:
 - extra-manifest/
 - custom-manifest/

```

- Include the **ipsec-config-policy.yaml** config policy file in the **source-crs** directory in GitOps and reference the file in one of the **PolicyGenerator** CRs.
- Commit the **SiteConfig** CR changes and updated files in your Git repository and push the changes to provision the managed cluster and configure IPsec encryption.  
The Argo CD pipeline detects the changes and begins the managed cluster deployment.

During cluster provisioning, the GitOps ZTP pipeline appends the CRs in the **custom-manifest/** directory to the default set of extra manifests stored in the **extra-manifest/** directory.

## Verification

For information about verifying the IPsec encryption, see "Verifying the IPsec encryption".

## Additional resources

- [Verifying the IPsec encryption](#)
- [Configuring IPsec encryption](#)
- [Encryption protocol and IPsec mode](#)
- [Installing managed clusters with RHACM and SiteConfig resources](#)

### 4.5.4. Verifying the IPsec encryption

You can verify that the IPsec encryption is successfully applied in a managed OpenShift Container Platform cluster.

## Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.
- You have configured the IPsec encryption.

## Procedure

- Start a debug pod for the managed cluster by running the following command:

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

- Check that the IPsec policy is applied in the cluster node by running the following command:

```
sh-5.1# ip xfrm policy
```

### Example output

```
src 172.16.123.0/24 dst 10.1.232.10/32
 dir out priority 1757377 ptype main
 tmpl src 10.1.28.190 dst 10.1.232.10
 proto esp reqid 16393 mode tunnel
src 10.1.232.10/32 dst 172.16.123.0/24
 dir fwd priority 1757377 ptype main
 tmpl src 10.1.232.10 dst 10.1.28.190
 proto esp reqid 16393 mode tunnel
src 10.1.232.10/32 dst 172.16.123.0/24
 dir in priority 1757377 ptype main
 tmpl src 10.1.232.10 dst 10.1.28.190
 proto esp reqid 16393 mode tunnel
```

- Check that the IPsec tunnel is up and connected by running the following command:

```
sh-5.1# ip xfrm state
```

### Example output

```
src 10.1.232.10 dst 10.1.28.190
 proto esp spi 0xa62a05aa reqid 16393 mode tunnel
 replay-window 0 flag af-unspec esn
 auth-trunc hmac(sha1) 0x8c59f680c8ea1e667b665d8424e2ab749cec12dc 96
 enc cbc(aes)
 0x2818a489fe84929c8ab72907e9ce2f0eac6f16f2258bd22240f4087e0326badb
 anti-replay esn context:
 seq-hi 0x0, seq 0x0, oseq-hi 0x0, oseq 0x0
 replay_window 128, bitmap-length 4
 00000000 00000000 00000000 00000000
src 10.1.28.190 dst 10.1.232.10
 proto esp spi 0x8e96e9f9 reqid 16393 mode tunnel
 replay-window 0 flag af-unspec esn
 auth-trunc hmac(sha1) 0xd960ddc0a6baaccb343396a51295e08cf8aadd 96
 enc cbc(aes)
 0x0273c02e05b4216d5e652de3fc9b3528fea94648bc2b88fa01139fdf0beb27ab
 anti-replay esn context:
 seq-hi 0x0, seq 0x0, oseq-hi 0x0, oseq 0x0
 replay_window 128, bitmap-length 4
 00000000 00000000 00000000 00000000
```

<sup>4</sup> Bind a known IP in the external host subnet by running the following command. For example:

4. Ping a known IP in the external host subnet by running the following command. For example, ping an IP address in the **rightsubnet** range that you set in the **ipsec/ipsec-endpoint-config.yaml** file:

```
sh-5.1# ping 172.16.110.8
```

### Example output

```
PING 172.16.110.8 (172.16.110.8) 56(84) bytes of data.
64 bytes from 172.16.110.8: icmp_seq=1 ttl=64 time=153 ms
64 bytes from 172.16.110.8: icmp_seq=2 ttl=64 time=155 ms
```

## 4.5.5. Single-node OpenShift SiteConfig CR installation reference

Table 4.1. SiteConfig CR installation options for single-node OpenShift clusters

| SiteConfig CR field                         | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|---------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>spec.cpuPartitioningMode</b>             | Configure workload partitioning by setting the value for <b>cpuPartitioningMode</b> to <b>AllNodes</b> . To complete the configuration, specify the <b>isolated</b> and <b>reserved</b> CPUs in the <b>PerformanceProfile</b> CR.                                                                                                                                                                                                                                                                                                                          |
| <b>metadata.name</b>                        | Set <b>name</b> to <b>assisted-deployment-pull-secret</b> and create the <b>assisted-deployment-pull-secret</b> CR in the same namespace as the <b>SiteConfig</b> CR.                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>spec.clusterImageSetNameRef</b>          | Configure the image set available on the hub cluster for all the clusters in the site. To see the list of supported versions on your hub cluster, run <b>oc get clusterimagesets</b> .                                                                                                                                                                                                                                                                                                                                                                     |
| <b>installConfigOverrides</b>               | <p>Set the <b>installConfigOverrides</b> field to enable or disable optional components prior to cluster installation.</p> <p> <b>IMPORTANT</b></p> <p>Use the reference configuration as specified in the example <b>SiteConfig</b> CR. Adding additional components back into the system might require additional reserved CPU capacity.</p>                                                                                                                          |
| <b>spec.clusters.clusterImageSetNameRef</b> | Specifies the cluster image set used to deploy an individual cluster. If defined, it overrides the <b>spec.clusterImageSetNameRef</b> at site level.                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>spec.clusters.clusterLabels</b>          | <p>Configure cluster labels to correspond to the binding rules in the <b>PolicyGenerator</b> or <b>PolicyGentemplate</b> CRs that you define. <b>PolicyGenerator</b> CRs use the <b>policyDefaults.placement.labelSelector</b> field. <b>PolicyGentemplate</b> CRs use the <b>spec.bindingRules</b> field.</p> <p>For example, <b>acmpolicygenerator/acm-common-ranGen.yaml</b> applies to all clusters with <b>common: true</b> set, <b>acmpolicygenerator/acm-group-du-sno-ranGen.yaml</b> applies to all clusters with <b>group-du-sno: ""</b> set.</p> |

| SiteConfig CR field                                    | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|--------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>spec.clusters.crTemplates.KlusterletAddonConfig</b> | <p>Optional. Set <b>KlusterletAddonConfig</b> to <b>KlusterletAddonConfigOverride.yaml</b> to override the default `KlusterletAddonConfig` that is created for the cluster.</p>                                                                                                                                                                                                                                                                                                                                    |
| <b>spec.clusters.diskEncryption</b>                    | <p>Configure this field to enable disk encryption with Trusted Platform Module (TPM) and Platform Configuration Registers (PCRs) protection. For more information, see "About disk encryption with TPM and PCR protection".</p> <p> <b>NOTE</b></p> <p>Configuring disk encryption by using the <b>diskEncryption</b> field in the <b>SiteConfig</b> CR is a Technology Preview feature in OpenShift Container Platform 4.18.</p> |
| <b>spec.clusters.diskEncryption.type</b>               | <p>Set the disk encryption type to <b>tpm2</b>.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>spec.clusters.diskEncryption.tpm2</b>               | <p>Configure the Platform Configuration Registers (PCRs) protection for disk encryption.</p>                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>spec.clusters.diskEncryption.tpm2.pcrList</b>       | <p>Configure the list of Platform Configuration Registers (PCRs) to be used for disk encryption. You must use PCR registers 1 and 7.</p>                                                                                                                                                                                                                                                                                                                                                                           |
| <b>spec.clusters.nodes.hostName</b>                    | <p>For single-node deployments, define a single host. For three-node deployments, define three hosts. For standard deployments, define three hosts with <b>role: master</b> and two or more hosts defined with <b>role: worker</b>.</p>                                                                                                                                                                                                                                                                            |
| <b>spec.clusters.nodes.nodeLabels</b>                  | <p>Specify custom roles for your nodes in your managed clusters. These are additional roles are not used by any OpenShift Container Platform components, only by the user. When you add a custom role, it can be associated with a custom machine config pool that references a specific configuration for that role. Adding custom labels or roles during installation makes the deployment process more effective and prevents the need for additional reboots after the installation is complete.</p>           |
| <b>spec.clusters.nodes.automatedCleaningMode</b>       | <p>Optional. Uncomment and set the value to <b>metadata</b> to enable the removal of the disk's partitioning table only, without fully wiping the disk. The default value is <b>disabled</b>.</p>                                                                                                                                                                                                                                                                                                                  |
| <b>spec.clusters.nodes.bmcAddress</b>                  | <p>BMC address that you use to access the host. Applies to all cluster types. GitOps ZTP supports iPXE and virtual media booting by using Redfish or IPMI protocols. To use iPXE booting, you must use RHACM 2.8 or later. For more information about BMC addressing, see the "Additional resources" section.</p>                                                                                                                                                                                                  |

| SiteConfig CR field                                           | Description                                                                                                                                                                                                                                                                                                                         |
|---------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>spec.clusters.nodes.bmcAddress</b>                         | BMC address that you use to access the host. Applies to all cluster types. GitOps ZTP supports iPXE and virtual media booting by using Redfish or IPMI protocols. To use iPXE booting, you must use RHACM 2.8 or later. For more information about BMC addressing, see the "Additional resources" section.                          |
|                                                               |  <b>NOTE</b><br>In far edge Telco use cases, only virtual media is supported for use with GitOps ZTP.                                                                                                                                              |
| <b>spec.clusters.nodes.bmcCredentialsName</b>                 | Configure the <b>bmh-secret</b> CR that you separately create with the host BMC credentials. When creating the <b>bmh-secret</b> CR, use the same namespace as the <b>SiteConfig</b> CR that provisions the host.                                                                                                                   |
| <b>spec.clusters.nodes.bootMode</b>                           | Set the boot mode for the host to <b>UEFI</b> . The default value is <b>UEFI</b> . Use <b>UEFISecureBoot</b> to enable secure boot on the host.                                                                                                                                                                                     |
| <b>spec.clusters.nodes.rootDeviceHints</b>                    | Specifies the device for deployment. Identifiers that are stable across reboots are recommended. For example, <b>wwn: &lt;disk_wwn&gt;</b> or <b>deviceName: /dev/disk/by-path/&lt;device_path&gt;. &lt;by-path&gt;</b> values are preferred. For a detailed list of stable identifiers, see the "About root device hints" section. |
| <b>spec.clusters.nodes.ignitionConfigOverride</b>             | Optional. Use this field to assign partitions for persistent storage. Adjust disk ID and size to the specific hardware.                                                                                                                                                                                                             |
| <b>spec.clusters.nodes.nodeNetwork</b>                        | Configure the network settings for the node.                                                                                                                                                                                                                                                                                        |
| <b>spec.clusters.nodes.nodeNetwork.config.interfaces.ipv6</b> | Configure the IPv6 address for the host. For single-node OpenShift clusters with static IP addresses, the node-specific API and Ingress IPs should be the same.                                                                                                                                                                     |

## Additional resources

- [About disk encryption with TPM and PCR protection](#) .
- [Customizing extra installation manifests in the GitOps ZTP pipeline](#)
- [Preparing the GitOps ZTP site configuration repository](#)
- [Configuring the hub cluster with ArgoCD](#)
- [Signalling GitOps ZTP cluster deployment completion with validator inform policies](#)
- [Creating the managed bare-metal host secrets](#)
- [BMC addressing](#)
- [About root device hints](#)

## 4.6. MANAGING HOST FIRMWARE SETTINGS WITH GITOPS ZTP

Hosts require the correct firmware configuration to ensure high performance and optimal efficiency. You can deploy custom host firmware configurations for managed clusters with GitOps ZTP.

Tune hosts with specific hardware profiles in your lab and ensure they are optimized for your requirements. When you have completed host tuning to your satisfaction, you extract the host profile and save it in your GitOps ZTP repository. Then, you use the host profile to configure firmware settings in the managed cluster hosts that you deploy with GitOps ZTP.

You specify the required hardware profiles in **SiteConfig** custom resources (CRs) that you use to deploy the managed clusters. The GitOps ZTP pipeline generates the required **HostFirmwareSettings (HFS)** and **BareMetalHost (BMH)** CRs that are applied to the hub cluster.

Use the following best practices to manage your host firmware profiles.

### Identify critical firmware settings with hardware vendors

Work with hardware vendors to identify and document critical host firmware settings required for optimal performance and compatibility with the deployed host platform.

### Use common firmware configurations across similar hardware platforms

Where possible, use a standardized host firmware configuration across similar hardware platforms to reduce complexity and potential errors during deployment.

### Test firmware configurations in a lab environment

Test host firmware configurations in a controlled lab environment before deploying in production to ensure that settings are compatible with hardware, firmware, and software.

### Manage firmware profiles in source control

Manage host firmware profiles in Git repositories to track changes, ensure consistency, and facilitate collaboration with vendors.

### Additional resources

- [Recommended firmware configuration for vDU cluster hosts](#)

### 4.6.1. Retrieving the host firmware schema for a managed cluster

You can discover the host firmware schema for managed clusters. The host firmware schema for bare-metal hosts is populated with information that the Ironic API returns. The API returns information about host firmware interfaces, including firmware setting types, allowable values, ranges, and flags.

### Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have installed Red Hat Advanced Cluster Management (RHACM) and logged in to the hub cluster as a user with **cluster-admin** privileges.
- You have provisioned a cluster that is managed by RHACM.

### Procedure

- Discover the host firmware schema for the managed cluster. Run the following command:
- ```
$ oc get firmwareschema -n <managed_cluster_namespace> -o yaml
```

Example output

```

apiVersion: v1
items:
- apiVersion: metal3.io/v1alpha1
kind: FirmwareSchema
metadata:
  creationTimestamp: "2024-09-11T10:29:43Z"
  generation: 1
  name: schema-40562318
  namespace: compute-1
  ownerReferences:
    - apiVersion: metal3.io/v1alpha1
      kind: HostFirmwareSettings
      name: compute-1.example.com
      uid: 65d0e89b-1cd8-4317-966d-2fbbbe033fe9
  resourceVersion: "280057624"
  uid: 511ad25d-f1c9-457b-9a96-776605c7b887
spec:
  schema:
    AccessControlService:
      allowable_values:
        - Enabled
        - Disabled
      attribute_type: Enumeration
      read_only: false
    # ...
  
```

4.6.2. Retrieving the host firmware settings for a managed cluster

You can retrieve the host firmware settings for managed clusters. This is useful when you have deployed changes to the host firmware and you want to monitor the changes and ensure that they are applied successfully.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have installed Red Hat Advanced Cluster Management (RHACM) and logged in to the hub cluster as a user with **cluster-admin** privileges.
- You have provisioned a cluster that is managed by RHACM.

Procedure

1. Retrieve the host firmware settings for the managed cluster. Run the following command:

```
$ oc get hostfirmwaresettings -n <cluster_namespace> <node_name> -o yaml
```

Example output

```

apiVersion: v1
items:
  
```

```

- apiVersion: metal3.io/v1alpha1
kind: HostFirmwareSettings
metadata:
  creationTimestamp: "2024-09-11T10:29:43Z"
  generation: 1
  name: compute-1.example.com
  namespace: kni-qe-24
  ownerReferences:
    - apiVersion: metal3.io/v1alpha1
      blockOwnerDeletion: true
      controller: true
      kind: BareMetalHost
      name: compute-1.example.com
      uid: 0baddbb7-bb34-4224-8427-3d01d91c9287
  resourceVersion: "280057626"
  uid: 65d0e89b-1cd8-4317-966d-2fbbbe033fe9
spec:
  settings: {}
status:
  conditions:
    - lastTransitionTime: "2024-09-11T10:29:43Z"
      message: ""
      observedGeneration: 1
      reason: Success
      status: "True" 1
      type: ChangeDetected
    - lastTransitionTime: "2024-09-11T10:29:43Z"
      message: Invalid BIOS setting
      observedGeneration: 1
      reason: ConfigurationError
      status: "False" 2
      type: Valid
  lastUpdated: "2024-09-11T10:29:43Z"
  schema:
    name: schema-40562318
    namespace: compute-1
  settings: 3
    AccessControlService: Enabled
    AcpiHpet: Enabled
    AcpiRootBridgePxm: Enabled
    # ...

```

- 1** Indicates that a change in the host firmware settings has been detected
- 2** Indicates that the host has an invalid firmware setting
- 3** The complete list of configured host firmware settings is returned under the **status.settings** field

2. Optional: Check the status of the **HostFirmwareSettings (hfs)** custom resource in the cluster:

```
$ oc get hfs -n <managed_cluster_namespace> <managed_cluster_name> -o jsonpath='{.status.conditions[?(@.type=="ChangeDetected")].status}'
```

Example output

True

3. Optional: Check for invalid firmware settings in the cluster host. Run the following command:

```
$ oc get hfs -n <managed_cluster_namespace> <managed_cluster_name> -o jsonpath='{.status.conditions[?(@.type=="Valid")].status}'
```

Example output

False

4.6.3. Deploying user-defined firmware to cluster hosts with GitOps ZTP

You can deploy user-defined firmware settings to cluster hosts by configuring the **SiteConfig** custom resource (CR) to include a hardware profile that you want to apply during cluster host provisioning. You can configure hardware profiles to apply to hosts in the following scenarios:

- All hosts site-wide
- Only cluster hosts that meet certain criteria
- Individual cluster hosts



IMPORTANT

You can configure host hardware profiles to be applied in a hierarchy. Cluster-level settings override site-wide settings. Node level profiles override cluster and site-wide settings.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have installed Red Hat Advanced Cluster Management (RHACM) and logged in to the hub cluster as a user with **cluster-admin** privileges.
- You have provisioned a cluster that is managed by RHACM.
- You created a Git repository where you manage your custom site configuration data. The repository must be accessible from the hub cluster and be defined as a source repository for the Argo CD application.

Procedure

1. Create the host firmware profile that contain the firmware settings you want to apply. For example, create the following YAML file:

host-firmware.profile

BootMode: Uefi
 LogicalProc: Enabled
 ProcVirtualization: Enabled

- Save the hardware profile YAML file relative to the **kustomization.yaml** file that you use to define how to provision the cluster, for example:

```
example-ztp/install
└── site-install
    ├── siteconfig-example.yaml
    ├── kustomization.yaml
    └── host-firmware.profile
```

- Edit the **SiteConfig** CR to include the firmware profile that you want to apply in the cluster. For example:

```
apiVersion: ran.openshift.io/v1
kind: SiteConfig
metadata:
  name: "site-plan-cluster"
  namespace: "example-cluster-namespace"
spec:
  baseDomain: "example.com"
  # ...
  biosConfigRef:
    filePath: "./host-firmware.profile" ①
```

- ① Applies the hardware profile to all cluster hosts site-wide



NOTE

Where possible, use a single **SiteConfig** CR per cluster.

- Optional. To apply a hardware profile to hosts in a specific cluster, update **clusters.biosConfigRef.filePath** with the hardware profile that you want to apply. For example:

```
clusters:
- clusterName: "cluster-1"
  # ...
  biosConfigRef:
    filePath: "./host-firmware.profile" ①
```

- ① Applies to all hosts in the **cluster-1** cluster

- Optional. To apply a hardware profile to a specific host in the cluster, update **clusters.nodes.biosConfigRef.filePath** with the hardware profile that you want to apply. For example:

```
clusters:
- clusterName: "cluster-1"
  # ...
  nodes:
```

```

- hostName: "compute-1.example.com"
# ...
bootMode: "UEFI"
biosConfigRef:
filePath: "./host-firmware.profile" ①

```

- ① Applies the firmware profile to the **compute-1.example.com** host in the cluster

6. Commit the **SiteConfig** CR and associated **kustomization.yaml** changes in your Git repository and push the changes.

The ArgoCD pipeline detects the changes and begins the managed cluster deployment.



NOTE

Cluster deployment proceeds even if an invalid firmware setting is detected. To apply a correction using GitOps ZTP, re-deploy the cluster with the corrected hardware profile.

Verification

- Check that the firmware settings have been applied in the managed cluster host. For example, run the following command:

```
$ oc get hfs -n <managed_cluster_namespace> <managed_cluster_name> -o
jsonpath='{.status.conditions[?(@.type=="Valid")].status}'
```

Example output

```
True
```

4.7. MONITORING MANAGED CLUSTER INSTALLATION PROGRESS

The ArgoCD pipeline uses the **SiteConfig** CR to generate the cluster configuration CRs and syncs it with the hub cluster. You can monitor the progress of the synchronization in the ArgoCD dashboard.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.

Procedure

When the synchronization is complete, the installation generally proceeds as follows:

1. The Assisted Service Operator installs OpenShift Container Platform on the cluster. You can monitor the progress of cluster installation from the RHACM dashboard or from the command line by running the following commands:
 - a. Export the cluster name:

```
$ export CLUSTER=<clusterName>
```

- b. Query the **AgentClusterInstall** CR for the managed cluster:

```
$ oc get agentclusterinstall -n $CLUSTER $CLUSTER -o jsonpath='{.status.conditions[?(@.type=="Completed")]}' | jq
```

- c. Get the installation events for the cluster:

```
$ curl -sk $(oc get agentclusterinstall -n $CLUSTER $CLUSTER -o jsonpath='{.status.debugInfo.eventsURL}') | jq '.[-2,-1]'
```

4.8. TROUBLESHOOTING GITOPS ZTP BY VALIDATING THE INSTALLATION CRS

The ArgoCD pipeline uses the **SiteConfig** and **PolicyGenerator** or **PolicyGentemplate** custom resources (CRs) to generate the cluster configuration CRs and Red Hat Advanced Cluster Management (RHACM) policies. Use the following steps to troubleshoot issues that might occur during this process.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.

Procedure

1. Check that the installation CRs were created by using the following command:

```
$ oc get AgentClusterInstall -n <cluster_name>
```

If no object is returned, use the following steps to troubleshoot the ArgoCD pipeline flow from **SiteConfig** files to the installation CRs.

2. Verify that the **ManagedCluster** CR was generated using the **SiteConfig** CR on the hub cluster:

```
$ oc get managedcluster
```

3. If the **ManagedCluster** is missing, check if the **clusters** application failed to synchronize the files from the Git repository to the hub cluster:

```
$ oc get applications.argoproj.io -n openshift-gitops clusters -o yaml
```

- a. To identify error logs for the managed cluster, inspect the **status.operationState.syncResult.resources** field. For example, if an invalid value is assigned to the **extraManifestPath** in the **SiteConfig** CR, an error similar to the following is generated:

```
syncResult:
resources:
- group: ran.openshift.io
  kind: SiteConfig
message: The Kubernetes API could not find ran.openshift.io/SiteConfig for requested resource spoke-sno/spoke-sno. Make sure the "SiteConfig" CRD is installed on the destination cluster
```

- b. To see a more detailed **SiteConfig** error, complete the following steps:
 - i. In the Argo CD dashboard, click the **SiteConfig** resource that Argo CD is trying to sync.
 - ii. Check the **DESIRED MANIFEST** tab to find the **siteConfigError** field.

siteConfigError: >- Error: could not build the entire SiteConfig defined by /tmp/kust-plugin-config-1081291903: stat sno-extra-manifest: no such file or directory

- c. Check the **Status.Sync** field. If there are log errors, the **Status.Sync** field could indicate an **Unknown** error:

```

Status:
Sync:
Compared To:
Destination:
  Namespace: clusters-sub
  Server: https://kubernetes.default.svc
Source:
  Path: sites-config
  Repo URL: https://git.com/ran-sites/siteconfigs/.git
  Target Revision: master
Status: Unknown

```

4.9. TROUBLESHOOTING GITOPS ZTP VIRTUAL MEDIA BOOTING ON SUPERMICRO SERVERS

SuperMicro X11 servers do not support virtual media installations when the image is served using the **https** protocol. As a result, single-node OpenShift deployments for this environment fail to boot on the target node. To avoid this issue, log in to the hub cluster and disable Transport Layer Security (TLS) in the **Provisioning** resource. This ensures the image is not served with TLS even though the image address uses the **https** scheme.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.

Procedure

1. Disable TLS in the **Provisioning** resource by running the following command:

```
$ oc patch provisioning provisioning-configuration --type merge -p '{"spec": {"disableVirtualMediaTLS": true}}'
```

2. Continue the steps to deploy your single-node OpenShift cluster.

4.10. REMOVING A MANAGED CLUSTER SITE FROM THE GITOPS ZTP PIPELINE

You can remove a managed site and the associated installation and configuration policy CRs from the GitOps Zero Touch Provisioning (ZTP) pipeline.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.

Procedure

1. Remove a site and the associated CRs by removing the associated **SiteConfig** and **PolicyGenerator** or **PolicyGentemplate** files from the **kustomization.yaml** file.
2. Add the following **syncOptions** field to your **SiteConfig** application.

```
kind: Application
spec:
  syncPolicy:
    syncOptions:
      - PrunePropagationPolicy=background
```

When you run the GitOps ZTP pipeline again, the generated CRs are removed.

3. Optional: If you want to permanently remove a site, you should also remove the **SiteConfig** and site-specific **PolicyGenerator** or **PolicyGentemplate** files from the Git repository.
4. Optional: If you want to remove a site temporarily, for example when redeploying a site, you can leave the **SiteConfig** and site-specific **PolicyGenerator** or **PolicyGentemplate** CRs in the Git repository.

Additional resources

- For information about removing a cluster, see [Removing a cluster from management](#).

4.11. REMOVING OBSOLETE CONTENT FROM THE GITOPS ZTP PIPELINE

If a change to the **PolicyGenerator** or **PolicyGentemplate** configuration results in obsolete policies, for example, if you rename policies, use the following procedure to remove the obsolete policies.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.

Procedure

1. Remove the affected **PolicyGenerator** or **PolicyGentemplate** files from the Git repository, commit and push to the remote repository.
2. Wait for the changes to synchronize through the application and the affected policies to be removed from the hub cluster.
3. Add the updated **PolicyGenerator** or **PolicyGentemplate** files back to the Git repository, and then commit and push to the remote repository.



NOTE

Removing GitOps Zero Touch Provisioning (ZTP) policies from the Git repository, and as a result also removing them from the hub cluster, does not affect the configuration of the managed cluster. The policy and CRs managed by that policy remains in place on the managed cluster.

4. Optional: As an alternative, after making changes to **PolicyGenerator** or **PolicyGentemplate** CRs that result in obsolete policies, you can remove these policies from the hub cluster manually. You can delete policies from the RHACM console using the **Governance** tab or by running the following command:

```
$ oc delete policy -n <namespace> <policy_name>
```

4.12. TEARING DOWN THE GITOPS ZTP PIPELINE

You can remove the ArgoCD pipeline and all generated GitOps Zero Touch Provisioning (ZTP) artifacts.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.

Procedure

1. Detach all clusters from Red Hat Advanced Cluster Management (RHACM) on the hub cluster.
2. Delete the **kustomization.yaml** file in the **deployment** directory using the following command:

```
$ oc delete -k out/argocd/deployment
```

3. Commit and push your changes to the site repository.

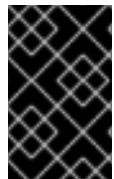
CHAPTER 5. MANUALLY INSTALLING A SINGLE-NODE OPENSIFT CLUSTER WITH GITOPS ZTP

You can deploy a managed single-node OpenShift cluster by using Red Hat Advanced Cluster Management (RHACM) and the assisted service.



NOTE

If you are creating multiple managed clusters, use the **SiteConfig** method described in [Deploying far edge sites with ZTP](#).



IMPORTANT

The target bare-metal host must meet the networking, firmware, and hardware requirements listed in [Recommended cluster configuration for vDU application workloads](#).

5.1. GENERATING GITOPS ZTP INSTALLATION AND CONFIGURATION CRS MANUALLY

Use the **generator** entrypoint for the **ztp-site-generate** container to generate the site installation and configuration custom resource (CRs) for a cluster based on **SiteConfig** and **PolicyGenerator** CRs.



IMPORTANT

SiteConfig v1 is deprecated starting with OpenShift Container Platform version 4.18. Equivalent and improved functionality is now available through the SiteConfig Operator using the **ClusterInstance** custom resource. For more information, see [Procedure to transition from SiteConfig CRs to the ClusterInstance API](#).

For more information about the SiteConfig Operator, see [SiteConfig](#).

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.

Procedure

1. Create an output folder by running the following command:

```
$ mkdir -p ./out
```

2. Export the **argocd** directory from the **ztp-site-generate** container image:

```
$ podman run --log-driver=none --rm registry.redhat.io/openshift4/ztp-site-generate-rhel8:v4.18 extract /home/ztp --tar | tar x -C ./out
```

The **./out** directory has the reference **PolicyGenerator** and **SiteConfig** CRs in the **out/argocd/example/** folder.

Example output

```

out
└── argocd
    └── example
        ├── acmpolicygenerator
        │   ├── {policy-prefix}common-ranGen.yaml
        │   ├── {policy-prefix}example-sno-site.yaml
        │   ├── {policy-prefix}group-du-sno-ranGen.yaml
        │   ├── {policy-prefix}group-du-sno-validator-ranGen.yaml
        │   ...
        │   └── kustomization.yaml
        └── siteconfig
            ├── example-sno.yaml
            ├── KlusterletAddonConfigOverride.yaml
            └── kustomization.yaml

```

3. Create an output folder for the site installation CRs:

```
$ mkdir -p ./site-install
```

4. Modify the example **SiteConfig** CR for the cluster type that you want to install. Copy **example-sno.yaml** to **site-1-sno.yaml** and modify the CR to match the details of the site and bare-metal host that you want to install, for example:

```

# example-node1-bmh-secret & assisted-deployment-pull-secret need to be created under
# same namespace example-sno
---
apiVersion: ran.openshift.io/v1
kind: SiteConfig
metadata:
  name: "example-sno"
  namespace: "example-sno"
spec:
  baseDomain: "example.com"
  pullSecretRef:
    name: "assisted-deployment-pull-secret"
  clusterImageSetNameRef: "openshift-4.18"
  sshPublicKey: "ssh-rsa AAAA..."
clusters:
  - clusterName: "example-sno"
    networkType: "OVNKubernetes"
    # installConfigOverrides is a generic way of passing install-config
    # parameters through the siteConfig. The 'capabilities' field configures
    # the composable openshift feature. In this 'capabilities' setting, we
    # remove all the optional set of components.
    # Notes:
    # - OperatorLifecycleManager is needed for 4.15 and later
    # - NodeTuning is needed for 4.13 and later, not for 4.12 and earlier
    # - Ingress is needed for 4.16 and later
  installConfigOverrides: |
    {
      "capabilities": {
        "baselineCapabilitySet": "None",

```

```

    "additionalEnabledCapabilities": [
        "NodeTuning",
        "OperatorLifecycleManager",
        "Ingress"
    ]
}
}

# It is strongly recommended to include crun manifests as part of the additional install-time manifests for 4.13+.

# The crun manifests can be obtained from source-crs/optional-extra-manifest/ and added to the git repo ie.sno-extra-manifest.

# extraManifestPath: sno-extra-manifest

clusterLabels:
    # These example cluster labels correspond to the bindingRules in the PolicyGenTemplate examples
    du-profile: "latest"
    # These example cluster labels correspond to the bindingRules in the PolicyGenTemplate examples in ../policygentemplates:
    # ../policygentemplates/common-ranGen.yaml will apply to all clusters with 'common: true'
    common: true
    # ../policygentemplates/group-du-sno-ranGen.yaml will apply to all clusters with 'group-du-sno: ""'
    group-du-sno: ""
    # ../policygentemplates/example-sno-site.yaml will apply to all clusters with 'sites: "example-sno"'
    # Normally this should match or contain the cluster name so it only applies to a single cluster
    sites: "example-sno"
clusterNetwork:
    - cidr: 1001:1::/48
        hostPrefix: 64
machineNetwork:
    - cidr: 1111:2222:3333:4444::/64
serviceNetwork:
    - 1001:2::/112
additionalINTPSources:
    - 1111:2222:3333:4444::2
    # Initiates the cluster for workload partitioning. Setting specific reserved/isolated CPUSets is done via PolicyTemplate
    # please see Workload Partitioning Feature for a complete guide.
cpuPartitioningMode: AllNodes
    # Optionally; This can be used to override the KlusterletAddonConfig that is created for this cluster:
    #crTemplates:
    # KlusterletAddonConfig: "KlusterletAddonConfigOverride.yaml"
nodes:
    - hostName: "example-node1.example.com"
        role: "master"
        # Optionally; This can be used to configure desired BIOS setting on a host:
        #biosConfigRef:
        # filePath: "example-hw.profile"
        bmcAddress: "idrac"
virtualmedia+https://[1111:2222:3333:4444::bbbb:1]/redfish/v1/Systems/System.Embedded.1"

bmcCredentialsName:

```

```

name: "example-node1-bmh-secret"
bootMACAddress: "AA:BB:CC:DD:EE:11"
# Use UEFI Secure Boot to enable secure boot.
bootMode: "UEFI Secure Boot"
rootDeviceHints:
  deviceName: "/dev/disk/by-path/pci-0000:01:00.0-scsi-0:2:0:0"
#crTemplates:
# BareMetalHost: "bmhOverride.yaml"
# disk partition at `/var/lib/containers` with ignitionConfigOverride. Some values must
be updated. See DiskPartitionContainer.md for more details
ignitionConfigOverride: |
{
  "ignition": {
    "version": "3.2.0"
  },
  "storage": {
    "disks": [
      {
        "device": "/dev/disk/by-id/wwn-0x6b07b250ebb9d0002a33509f24af1f62",
        "partitions": [
          {
            "label": "var-lib-containers",
            "sizeMiB": 0,
            "startMiB": 250000
          }
        ],
        "wipeTable": false
      }
    ],
    "filesystems": [
      {
        "device": "/dev/disk/by-partlabel/var-lib-containers",
        "format": "xfs",
        "mountOptions": [
          "defaults",
          "prjquota"
        ],
        "path": "/var/lib/containers",
        "wipeFilesystem": true
      }
    ]
  },
  "systemd": {
    "units": [
      {
        "contents": "# Generated by Butane\n[Unit]\nRequires=systemd-fsck@dev-disk-\nby\\x2dpartlabel-var\\x2dlib\\x2dcontainers.service\nAfter=systemd-fsck@dev-disk-\nby\\x2dpartlabel-\nvar\\x2dlib\\x2dcontainers.service\n\n[Mount]\nWhere=/var/lib/containers\nWhat=/dev/disk/by-\npartlabel/var-lib-\ncontainers\nType=xfs\nOptions=defaults,prjquota\n\n[Install]\nRequiredBy=local-fs.target",
        "enabled": true,
        "name": "var-lib-containers.mount"
      }
    ]
  }
}

```

```

    }

nodeNetwork:
  interfaces:
    - name: eno1
      macAddress: "AA:BB:CC:DD:EE:11"
  config:
    interfaces:
      - name: eno1
        type: ethernet
        state: up
      ipv4:
        enabled: false
      ipv6:
        enabled: true
        address:
          # For SNO sites with static IP addresses, the node-specific,
          # API and Ingress IPs should all be the same and configured on
          # the interface
          - ip: 1111:2222:3333:4444::aaaa:1
            prefix-length: 64
  dns-resolver:
    config:
      search:
        - example.com
      server:
        - 1111:2222:3333:4444::2
  routes:
    config:
      - destination: ::/0
        next-hop-interface: eno1
        next-hop-address: 1111:2222:3333:4444::1
        table-id: 254

```



NOTE

Once you have extracted reference CR configuration files from the **out/extra-manifest** directory of the **ztp-site-generate** container, you can use **extraManifests.searchPaths** to include the path to the git directory containing those files. This allows the GitOps ZTP pipeline to apply those CR files during cluster installation. If you configure a **searchPaths** directory, the GitOps ZTP pipeline does not fetch manifests from the **ztp-site-generate** container during site installation.

- Generate the Day 0 installation CRs by processing the modified **SiteConfig** CR **site-1-sno.yaml** by running the following command:

```
$ podman run -it --rm -v `pwd`/out/argocd/example/siteconfig:/resources:Z -v `pwd`/site-install:/output:Z,U registry.redhat.io/openshift4/ztp-site-generate-rhel8:v4.18 generator install site-1-sno.yaml /output
```

Example output

```

site-install
└── site-1-sno

```

```

└── site-1_agentclusterinstall_example-sno.yaml
└── site-1-sno_baremetalhost_example-node1.example.com.yaml
└── site-1-sno_clusterdeployment_example-sno.yaml
└── site-1-sno_configmap_example-sno.yaml
└── site-1-sno_infraenv_example-sno.yaml
└── site-1-sno_klusterletaddonconfig_example-sno.yaml
└── site-1-sno_machineconfig_02-master-workload-partitioning.yaml
└── site-1-sno_machineconfig_predefined-extra-manifests-master.yaml
└── site-1-sno_machineconfig_predefined-extra-manifests-worker.yaml
└── site-1-sno_managedcluster_example-sno.yaml
└── site-1-sno_namespace_example-sno.yaml
└── site-1-sno_nmstateconfig_example-node1.example.com.yaml

```

6. Optional: Generate just the Day 0 **MachineConfig** installation CRs for a particular cluster type by processing the reference **SiteConfig** CR with the **-E** option. For example, run the following commands:

- Create an output folder for the **MachineConfig** CRs:

```
$ mkdir -p ./site-machineconfig
```

- Generate the **MachineConfig** installation CRs:

```
$ podman run -it --rm -v `pwd`/out/argocd/example/siteconfig:/resources:Z -v `pwd`/site-machineconfig:/output:Z,U registry.redhat.io/openshift4/ztp-site-generate-rhel8:v4.18 generator install -E site-1-sno.yaml /output
```

Example output

```

site-machineconfig
└── site-1-sno
    └── site-1-sno_machineconfig_02-master-workload-partitioning.yaml
    └── site-1-sno_machineconfig_predefined-extra-manifests-master.yaml
    └── site-1-sno_machineconfig_predefined-extra-manifests-worker.yaml

```

7. Generate and export the Day 2 configuration CRs using the reference **PolicyGenerator** CRs from the previous step. Run the following commands:

- Create an output folder for the Day 2 CRs:

```
$ mkdir -p ./ref
```

- Generate and export the Day 2 configuration CRs:

```
$ podman run -it --rm -v `pwd`/out/argocd/example/acmpolicygenerator:/resources:Z -v `pwd`/ref:/output:Z,U registry.redhat.io/openshift4/ztp-site-generate-rhel8:v4.18 generator config -N ./output
```

The command generates example group and site-specific **PolicyGenerator** CRs for single-node OpenShift, three-node clusters, and standard clusters in the **./ref** folder.

Example output

```
ref
```

```

└── customResource
    ├── common
    ├── example-multinode-site
    ├── example-sno
    ├── group-du-3node
    ├── group-du-3node-validator
        └── Multiple-validatorCRs
    ├── group-du-sno
    ├── group-du-sno-validator
    ├── group-du-standard
    └── group-du-standard-validator
        └── Multiple-validatorCRs

```

8. Use the generated CRs as the basis for the CRs that you use to install the cluster. You apply the installation CRs to the hub cluster as described in "Installing a single managed cluster". The configuration CRs can be applied to the cluster after cluster installation is complete.

Verification

- Verify that the custom roles and labels are applied after the node is deployed:

```
$ oc describe node example-node.example.com
```

Example output

```

Name: example-node.example.com
Roles: control-plane,example-label,master,worker
Labels: beta.kubernetes.io/arch=amd64
        beta.kubernetes.io/os=linux
        custom-label/parameter1=true
        kubernetes.io/arch=amd64
        kubernetes.io/hostname=cnfdf03.telco5gran.eng.rdu2.redhat.com
        kubernetes.io/os=linux
        node-role.kubernetes.io/control-plane=
        node-role.kubernetes.io/example-label= ①
        node-role.kubernetes.io/master=
        node-role.kubernetes.io/worker=
        node.openshift.io/os_id=rhcos

```

- ① The custom label is applied to the node.

Additional resources

- [Workload partitioning](#)
- [BMC addressing](#)
- [About root device hints](#)
- [Single-node OpenShift SiteConfig CR installation reference](#)

5.2. CREATING THE MANAGED BARE-METAL HOST SECRETS

Add the required **Secret** custom resources (CRs) for the managed bare-metal host to the hub cluster. You need a secret for the GitOps Zero Touch Provisioning (ZTP) pipeline to access the Baseboard Management Controller (BMC) and a secret for the assisted installer service to pull cluster installation images from the registry.



NOTE

The secrets are referenced from the **SiteConfig** CR by name. The namespace must match the **SiteConfig** namespace.

Procedure

1. Create a YAML secret file containing credentials for the host Baseboard Management Controller (BMC) and a pull secret required for installing OpenShift and all add-on cluster Operators:
 - a. Save the following YAML as the file **example-sno-secret.yaml**:

```
apiVersion: v1
kind: Secret
metadata:
  name: example-sno-bmc-secret
  namespace: example-sno 1
  data: 2
  password: <base64_password>
  username: <base64_username>
type: Opaque
---
apiVersion: v1
kind: Secret
metadata:
  name: pull-secret
  namespace: example-sno 3
  data:
    .dockerconfigjson: <pull_secret> 4
type: kubernetes.io/dockerconfigjson
```

- 1** Must match the namespace configured in the related **SiteConfig** CR
- 2** Base64-encoded values for **password** and **username**
- 3** Must match the namespace configured in the related **SiteConfig** CR
- 4** Base64-encoded pull secret

2. Add the relative path to **example-sno-secret.yaml** to the **kustomization.yaml** file that you use to install the cluster.

5.3. CONFIGURING DISCOVERY ISO KERNEL ARGUMENTS FOR MANUAL INSTALLATIONS USING GITOPS ZTP

The GitOps Zero Touch Provisioning (ZTP) workflow uses the Discovery ISO as part of the OpenShift Container Platform installation process on managed bare-metal hosts. You can edit the **InfraEnv**

resource to specify kernel arguments for the Discovery ISO. This is useful for cluster installations with specific environmental requirements. For example, configure the **rd.net.timeout.carrier** kernel argument for the Discovery ISO to facilitate static networking for the cluster or to receive a DHCP address before downloading the root file system during installation.



NOTE

In OpenShift Container Platform 4.18, you can only add kernel arguments. You can not replace or delete kernel arguments.

Prerequisites

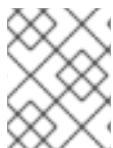
- You have installed the OpenShift CLI (oc).
- You have logged in to the hub cluster as a user with cluster-admin privileges.
- You have manually generated the installation and configuration custom resources (CRs).

Procedure

- 1 Edit the **spec.kernelArguments** specification in the **InfraEnv** CR to configure kernel arguments:

```
apiVersion: agent-install.openshift.io/v1beta1
kind: InfraEnv
metadata:
  name: <cluster_name>
  namespace: <cluster_name>
spec:
  kernelArguments:
    - operation: append ①
      value: audit=0 ②
    - operation: append
      value: trace=1
  clusterRef:
    name: <cluster_name>
    namespace: <cluster_name>
  pullSecretRef:
    name: pull-secret
```

- 1 Specify the append operation to add a kernel argument.
- 2 Specify the kernel argument you want to configure. This example configures the audit kernel argument and the trace kernel argument.



NOTE

The **SiteConfig** CR generates the **InfraEnv** resource as part of the day-0 installation CRs.

Verification

To verify that the kernel arguments are applied, after the Discovery image verifies that OpenShift

Container Platform is ready for installation, you can SSH to the target host before the installation process begins. At that point, you can view the kernel arguments for the Discovery ISO in the `/proc/cmdline` file.

1. Begin an SSH session with the target host:

```
$ ssh -i /path/to/privatekey core@<host_name>
```

2. View the system's kernel arguments by using the following command:

```
$ cat /proc/cmdline
```

5.4. INSTALLING A SINGLE MANAGED CLUSTER

You can manually deploy a single managed cluster using the assisted service and Red Hat Advanced Cluster Management (RHACM).

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.
- You have created the baseboard management controller (BMC) **Secret** and the image pull-secret **Secret** custom resources (CRs). See "Creating the managed bare-metal host secrets" for details.
- Your target bare-metal host meets the networking and hardware requirements for managed clusters.

Procedure

1. Create a **ClusterImageSet** for each specific cluster version to be deployed, for example `clusterImageSet-4.18.yaml`. A **ClusterImageSet** has the following format:

```
apiVersion: hive.openshift.io/v1
kind: ClusterImageSet
metadata:
  name: openshift-4.18.0 1
spec:
  releaseImage: quay.io/openshift-release-dev/ocp-release:4.18.0-x86_64 2
```

- 1 The descriptive version that you want to deploy.
- 2 Specifies the **releaseImage** to deploy and determines the operating system image version. The discovery ISO is based on the image version as set by **releaseImage**, or the latest version if the exact version is unavailable.

2. Apply the **clusterImageSet** CR:

```
$ oc apply -f clusterImageSet-4.18.yaml
```

3. Create the **Namespace** CR in the `cluster-namespace.yaml` file:

```

apiVersion: v1
kind: Namespace
metadata:
  name: <cluster_name> ①
  labels:
    name: <cluster_name> ②

```

① ② The name of the managed cluster to provision.

4. Apply the **Namespace** CR by running the following command:

```
$ oc apply -f cluster-namespace.yaml
```

5. Apply the generated day-0 CRs that you extracted from the **ztp-site-generate** container and customized to meet your requirements:

```
$ oc apply -R ./site-install/site-sno-1
```

Additional resources

- [Connectivity prerequisites for managed cluster networks](#)
- [Deploying LVM Storage on single-node OpenShift clusters](#)
- [Configuring LVM Storage using PolicyGenerator CRs](#)

5.5. MONITORING THE MANAGED CLUSTER INSTALLATION STATUS

Ensure that cluster provisioning was successful by checking the cluster status.

Prerequisites

- All of the custom resources have been configured and provisioned, and the **Agent** custom resource is created on the hub for the managed cluster.

Procedure

1. Check the status of the managed cluster:

```
$ oc get managedcluster
```

True indicates the managed cluster is ready.

2. Check the agent status:

```
$ oc get agent -n <cluster_name>
```

3. Use the **describe** command to provide an in-depth description of the agent's condition. Statuses to be aware of include **BackendError**, **InputError**, **ValidationsFailing**, **InstallationFailed**, and **AgentIsConnected**. These statuses are relevant to the **Agent** and **AgentClusterInstall** custom resources.

```
$ oc describe agent -n <cluster_name>
```

- Check the cluster provisioning status:

```
$ oc get agentclusterinstall -n <cluster_name>
```

- Use the **describe** command to provide an in-depth description of the cluster provisioning status:

```
$ oc describe agentclusterinstall -n <cluster_name>
```

- Check the status of the managed cluster's add-on services:

```
$ oc get managedclusteraddon -n <cluster_name>
```

- Retrieve the authentication information of the **kubeconfig** file for the managed cluster:

```
$ oc get secret -n <cluster_name> <cluster_name>-admin-kubeconfig -o jsonpath={.data.kubeconfig} | base64 -d > <directory>/<cluster_name>-kubeconfig
```

5.6. TROUBLESHOOTING THE MANAGED CLUSTER

Use this procedure to diagnose any installation issues that might occur with the managed cluster.

Procedure

- Check the status of the managed cluster:

```
$ oc get managedcluster
```

Example output

NAME	HUB ACCEPTED	MANAGED CLUSTER URLs	JOINED	AVAILABLE
AGE				
SNO-cluster	true		True	True
				2d19h

If the status in the **AVAILABLE** column is **True**, the managed cluster is being managed by the hub.

If the status in the **AVAILABLE** column is **Unknown**, the managed cluster is not being managed by the hub. Use the following steps to continue checking to get more information.

- Check the **AgentClusterInstall** install status:

```
$ oc get clusterdeployment -n <cluster_name>
```

Example output

NAME	PLATFORM	REGION	CLUSTERTYPE	INSTALLED	INFRAID
VERSION	POWERSTATE	AGE			
Sno0026	agent-baremetal		false		Initialized

2d14h

If the status in the **INSTALLED** column is **false**, the installation was unsuccessful.

3. If the installation failed, enter the following command to review the status of the **AgentClusterInstall** resource:

```
$ oc describe agentclusterinstall -n <cluster_name> <cluster_name>
```

4. Resolve the errors and reset the cluster:

- a. Remove the cluster's managed cluster resource:

```
$ oc delete managedcluster <cluster_name>
```

- b. Remove the cluster's namespace:

```
$ oc delete namespace <cluster_name>
```

This deletes all of the namespace-scoped custom resources created for this cluster. You must wait for the **ManagedCluster** CR deletion to complete before proceeding.

- c. Recreate the custom resources for the managed cluster.

5.7. RHACM GENERATED CLUSTER INSTALLATION CRS REFERENCE

Red Hat Advanced Cluster Management (RHACM) supports deploying OpenShift Container Platform on single-node clusters, three-node clusters, and standard clusters with a specific set of installation custom resources (CRs) that you generate using **SiteConfig** CRs for each site.



NOTE

Every managed cluster has its own namespace, and all of the installation CRs except for **ManagedCluster** and **ClusterImageSet** are under that namespace. **ManagedCluster** and **ClusterImageSet** are cluster-scoped, not namespace-scoped. The namespace and the CR names match the cluster name.

The following table lists the installation CRs that are automatically applied by the RHACM assisted service when it installs clusters using the **SiteConfig** CRs that you configure.

Table 5.1. Cluster installation CRs generated by RHACM

CR	Description	Usage
BareMetalHost	Contains the connection information for the Baseboard Management Controller (BMC) of the target bare-metal host.	Provides access to the BMC to load and start the discovery image on the target server by using the Redfish protocol.
InfraEnv	Contains information for installing OpenShift Container Platform on the target bare-metal host.	Used with ClusterDeployment to generate the discovery ISO for the managed cluster.

CR	Description	Usage
AgentClusterInstall	Specifies details of the managed cluster configuration such as networking and the number of control plane nodes. Displays the cluster kubeconfig and credentials when the installation is complete.	Specifies the managed cluster configuration information and provides status during the installation of the cluster.
ClusterDeployment	References the AgentClusterInstall CR to use.	Used with InfraEnv to generate the discovery ISO for the managed cluster.
NMStateConfig	Provides network configuration information such as MAC address to IP mapping, DNS server, default route, and other network settings.	Sets up a static IP address for the managed cluster's Kube API server.
Agent	Contains hardware information about the target bare-metal host.	Created automatically on the hub when the target machine's discovery image boots.
Managed Cluster	When a cluster is managed by the hub, it must be imported and known. This Kubernetes object provides that interface.	The hub uses this resource to manage and show the status of managed clusters.
Klusterlet AddonConfig	Contains the list of services provided by the hub to be deployed to the ManagedCluster resource.	Tells the hub which addon services to deploy to the ManagedCluster resource.
NameSpace	Logical space for ManagedCluster resources existing on the hub. Unique per site.	Propagates resources to the ManagedCluster .
Secret	Two CRs are created: BMC Secret and Image Pull Secret .	<ul style="list-style-type: none"> ● BMC Secret authenticates into the target bare-metal host using its username and password. ● Image Pull Secret contains authentication information for the OpenShift Container Platform image installed on the target bare-metal host.
ClusterImageSet	Contains OpenShift Container Platform image information such as the repository and image name.	Passed into resources to provide OpenShift Container Platform images.

CHAPTER 6. RECOMMENDED SINGLE-NODE OPENSIFT CLUSTER CONFIGURATION FOR VDU APPLICATION WORKLOADS

Use the following reference information to understand the single-node OpenShift configurations required to deploy virtual distributed unit (vDU) applications in the cluster. Configurations include cluster optimizations for high performance workloads, enabling workload partitioning, and minimizing the number of reboots required postinstallation.

Additional resources

- To deploy a single cluster by hand, see [Manually installing a single-node OpenShift cluster with GitOps ZTP](#).
- To deploy a fleet of clusters using GitOps Zero Touch Provisioning (ZTP), see [Deploying far edge sites with GitOps ZTP](#).

6.1. RUNNING LOW LATENCY APPLICATIONS ON OPENSIFT CONTAINER PLATFORM

OpenShift Container Platform enables low latency processing for applications running on commercial off-the-shelf (COTS) hardware by using several technologies and specialized hardware devices:

Real-time kernel for RHCOS

Ensures workloads are handled with a high degree of process determinism.

CPU isolation

Avoids CPU scheduling delays and ensures CPU capacity is available consistently.

NUMA-aware topology management

Aligns memory and huge pages with CPU and PCI devices to pin guaranteed container memory and huge pages to the non-uniform memory access (NUMA) node. Pod resources for all Quality of Service (QoS) classes stay on the same NUMA node. This decreases latency and improves performance of the node.

Huge pages memory management

Using huge page sizes improves system performance by reducing the amount of system resources required to access page tables.

Precision timing synchronization using PTP

Allows synchronization between nodes in the network with sub-microsecond accuracy.

6.2. RECOMMENDED CLUSTER HOST REQUIREMENTS FOR VDU APPLICATION WORKLOADS

Running vDU application workloads requires a bare-metal host with sufficient resources to run OpenShift Container Platform services and production workloads.

Table 6.1. Minimum resource requirements

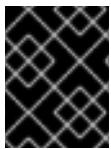
Profile	vCPU	Memory	Storage
Minimum	4 to 8 vCPU	32GB of RAM	120GB



NOTE

One vCPU equals one physical core. However, if you enable simultaneous multithreading (SMT), or Hyper-Threading, use the following formula to calculate the number of vCPUs that represent one physical core:

- $(\text{threads per core} \times \text{cores}) \times \text{sockets} = \text{vCPUs}$



IMPORTANT

The server must have a Baseboard Management Controller (BMC) when booting with virtual media.

6.3. CONFIGURING HOST FIRMWARE FOR LOW LATENCY AND HIGH PERFORMANCE

Bare-metal hosts require the firmware to be configured before the host can be provisioned. The firmware configuration is dependent on the specific hardware and the particular requirements of your installation.

Procedure

1. Set the **UEFI/BIOS Boot Mode** to **UEFI**.
2. In the host boot sequence order, set **Hard drive first**
3. Apply the specific firmware configuration for your hardware. The following table describes a representative firmware configuration for an Intel Xeon Skylake server and later hardware generations, based on the Intel FlexRAN 4G and 5G baseband PHY reference design.



IMPORTANT

The exact firmware configuration depends on your specific hardware and network requirements. The following sample configuration is for illustrative purposes only.

Table 6.2. Sample firmware configuration

Firmware setting	Configuration
CPU Power and Performance Policy	Performance
Uncore Frequency Scaling	Disabled
Performance P-limit	Disabled

Firmware setting	Configuration
Enhanced Intel SpeedStep® Tech	Enabled
Intel Configurable TDP	Enabled
Configurable TDP Level	Level 2
Intel® Turbo Boost Technology	Enabled
Energy Efficient Turbo	Disabled
Hardware P-States	Disabled
Package C-State	C0/C1 state
C1E	Disabled
Processor C6	Disabled



NOTE

Enable global SR-IOV and VT-d settings in the firmware for the host. These settings are relevant to bare-metal environments.

6.4. CONNECTIVITY PREREQUISITES FOR MANAGED CLUSTER NETWORKS

Before you can install and provision a managed cluster with the GitOps Zero Touch Provisioning (ZTP) pipeline, the managed cluster host must meet the following networking prerequisites:

- There must be bi-directional connectivity between the GitOps ZTP container in the hub cluster and the Baseboard Management Controller (BMC) of the target bare-metal host.
- The managed cluster must be able to resolve and reach the API hostname of the hub hostname and ***.apps** hostname. Here is an example of the API hostname of the hub and ***.apps** hostname:
 - **api.hub-cluster.internal.domain.com**
 - **console-openshift-console.apps.hub-cluster.internal.domain.com**
- The hub cluster must be able to resolve and reach the API and ***.apps** hostname of the managed cluster. Here is an example of the API hostname of the managed cluster and ***.apps** hostname:
 - **api.sno-managed-cluster-1.internal.domain.com**
 - **console-openshift-console.apps.sno-managed-cluster-1.internal.domain.com**

6.5. WORKLOAD PARTITIONING IN SINGLE-NODE OPENSHIFT WITH GITOPS ZTP

Workload partitioning configures OpenShift Container Platform services, cluster management workloads, and infrastructure pods to run on a reserved number of host CPUs.

To configure workload partitioning with GitOps Zero Touch Provisioning (ZTP), you configure a **cpuPartitioningMode** field in the **SiteConfig** custom resource (CR) that you use to install the cluster and you apply a **PerformanceProfile** CR that configures the **isolated** and **reserved** CPUs on the host.

Configuring the **SiteConfig** CR enables workload partitioning at cluster installation time and applying the **PerformanceProfile** CR configures the specific allocation of CPUs to reserved and isolated sets. Both of these steps happen at different points during cluster provisioning.



NOTE

Configuring workload partitioning by using the **cpuPartitioningMode** field in the **SiteConfig** CR is a Tech Preview feature in OpenShift Container Platform 4.13.

Alternatively, you can specify cluster management CPU resources with the **cpuset** field of the **SiteConfig** custom resource (CR) and the **reserved** field of the group **PolicyGenerator** or **PolicyGentemplate** CR. The GitOps ZTP pipeline uses these values to populate the required fields in the workload partitioning **MachineConfig** CR (**cpuset**) and the **PerformanceProfile** CR (**reserved**) that configure the single-node OpenShift cluster. This method is a General Availability feature in OpenShift Container Platform 4.14.

The workload partitioning configuration pins the OpenShift Container Platform infrastructure pods to the **reserved** CPU set. Platform services such as systemd, CRI-O, and kubelet run on the **reserved** CPU set. The **isolated** CPU sets are exclusively allocated to your container workloads. Isolating CPUs ensures that the workload has guaranteed access to the specified CPUs without contention from other applications running on the same node. All CPUs that are not isolated should be reserved.



IMPORTANT

Ensure that **reserved** and **isolated** CPU sets do not overlap with each other.

Additional resources

- For the recommended single-node OpenShift workload partitioning configuration, see [Workload partitioning](#).

6.6. ABOUT DISK ENCRYPTION WITH TPM AND PCR PROTECTION

You can use the **diskEncryption** field in the **SiteConfig** custom resource (CR) to configure disk encryption with Trusted Platform Module (TPM) and Platform Configuration Registers (PCRs) protection.

TPM is a hardware component that stores cryptographic keys and evaluates the security state of your system. PCRs within the TPM store hash values that represent the current hardware and software configuration of your system. You can use the following PCR registers to protect the encryption keys for disk encryption:

PCR 1

Represents the Unified Extensible Firmware Interface (UEFI) state.

PCR 7

Represents the secure boot state.

The TPM safeguards encryption keys by linking them to the system's current state, as recorded in PCR 1 and PCR 7. The **dmcrypt** utility uses these keys to encrypt the disk. The binding between the encryption keys and the expected PCR registers is automatically updated after upgrades, if needed.

During the system boot process, the **dmcrypt** utility uses the TPM PCR values to unlock the disk. If the current PCR values match with the previously linked values, the unlock succeeds. If the PCR values do not match, the encryption keys cannot be released, and the disk remains encrypted and inaccessible.



IMPORTANT

Configuring disk encryption by using the **diskEncryption** field in the **SiteConfig** CR 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](#).

Additional resources

- [TPM encryption](#)
- For information about enabling disk encryption, see [Enabling disk encryption with TPM and PCR protection](#).

6.7. RECOMMENDED CLUSTER INSTALL MANIFESTS

The ZTP pipeline applies the following custom resources (CRs) during cluster installation. These configuration CRs ensure that the cluster meets the feature and performance requirements necessary for running a vDU application.



NOTE

When using the GitOps ZTP plugin and **SiteConfig** CRs for cluster deployment, the following **MachineConfig** CRs are included by default.

Use the **SiteConfig extraManifests** filter to alter the CRs that are included by default. For more information, see [Advanced managed cluster configuration with SiteConfig CRs](#).

6.7.1. Workload partitioning

Single-node OpenShift clusters that run DU workloads require workload partitioning. This limits the cores allowed to run platform services, maximizing the CPU core for application payloads.



NOTE

Workload partitioning can be enabled during cluster installation only. You cannot disable workload partitioning postinstallation. You can however change the set of CPUs assigned to the isolated and reserved sets through the **PerformanceProfile** CR. Changes to CPU settings cause the node to reboot.



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When transitioning to using **cpuPartitioningMode** for enabling workload partitioning, remove the workload partitioning **MachineConfig** CRs from the **/extra-manifest** folder that you use to provision the cluster.

Recommended SiteConfig CR configuration for workload partitioning

```
apiVersion: ran.openshift.io/v1
kind: SiteConfig
metadata:
  name: "<site_name>"
  namespace: "<site_name>"
spec:
  baseDomain: "example.com"
  cpuPartitioningMode: AllNodes ①
```

- ① Set the **cpuPartitioningMode** field to **AllNodes** to configure workload partitioning for all nodes in the cluster.

Verification

Check that the applications and cluster system CPU pinning is correct. Run the following commands:

1. Open a remote shell prompt to the managed cluster:

```
$ oc debug node/example-sno-1
```

2. Check that the OpenShift infrastructure applications CPU pinning is correct:

```
sh-4.4# pgrep ovn | while read i; do taskset -cp $i; done
```

Example output

```
pid 8481's current affinity list: 0-1,52-53
pid 8726's current affinity list: 0-1,52-53
pid 9088's current affinity list: 0-1,52-53
pid 9945's current affinity list: 0-1,52-53
pid 10387's current affinity list: 0-1,52-53
pid 12123's current affinity list: 0-1,52-53
pid 13313's current affinity list: 0-1,52-53
```

3. Check that the system applications CPU pinning is correct:

```
sh-4.4# pgrep systemd | while read i; do taskset -cp $i; done
```

Example output

```
pid 1's current affinity list: 0-1,52-53
pid 938's current affinity list: 0-1,52-53
pid 962's current affinity list: 0-1,52-53
pid 1197's current affinity list: 0-1,52-53
```

6.7.2. Reduced platform management footprint

To reduce the overall management footprint of the platform, a **MachineConfig** custom resource (CR) is required that places all Kubernetes-specific mount points in a new namespace separate from the host operating system. The following base64-encoded example **MachineConfig** CR illustrates this configuration.

Recommended container mount namespace configuration (01-container-mount-ns-and-kubelet-conf-master.yaml)

```
# Automatically generated by extra-manifests-builder
# Do not make changes directly.
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: master
  name: container-mount-namespace-and-kubelet-conf-master
spec:
  config:
    ignition:
      version: 3.2.0
    storage:
      files:
        - contents:
            source: data:text/plain;charset=utf-8;base64,lyEvYmluL2Jhc2gKCmRIYnVnKCkgewogIGVjaG8gJEAgPiYyCn0KCnVzYWdlKCkgewogIGVjaG8gVXNhZ2U6ICQoYmFzZW5hbWUgJDApIFVOSVQgW2VudmZpbGUgW3Zhcm5hbWVdXQogIGVjaG8KICBIY2hvIEV4dHJhY3QgdGhlIGNvbnRlbnRzlG9mIHRoZSBmaXJzdCBFeGVjU3RhcnQgc3RhbnphIGZyb20gdGhlGdpdmVuIHN5c3RlbWQgdW5pdCBhbmqgcmV0dXJuIGl0IHRvIHN0ZG91dAogIGVjaG8KICBIY2hvICJJZiAnZW52ZmlsZScgaXMgcHJvdmlkZWQsIHB1dCBpdCBpbIB0aGVyZSBpbnN0ZWFKLCBhcyBhbiBlbnZpcm9ubWVudCB2YXJpYWJsZSBuYW1IZCAndmFybmFtZSciCiAgZWNobyAiRGVmYXVsdCAndmFybmFtZScgaXMgRVhFQ1NUQVJUIGlmlG5vdCBzcGVjaWZpZWQiCiAgZXhpdCAxCn0KCIVOSVQ9JDEKRU5WRkIMRT0kMgpWQVJOQU1FPSQzCmlmIFTbIC16ICRVTkIUIHx8ICRVTkIUD09ICItLWhlbHAIHx8ICRVTkIUID09ICItaClgXV07IHRoZW4KICB1c2FnZQpmaQpkZWJ1ZyAiRXh0cmFjdGluZyBFeGVjU3RhcnQgZnJvbSAKVU5JVCIKRkIMRT0kKHN5c3RlbWN0bCBjYXQgJFVOSVQgfCBoZWfkIC1uIDEpCkZJTEU9JHtGSUxF1wjIH0KaWYgW1sgISAtZIAkRkIMRSBdXTsgdGhlbgogIGRIYnVnICJGYWlsZWQgdG8gZmluZCByb290IGZpbGUgZm9yIHVuXQgJFVOSVQgKCRGSUxFKSIKICBleG10CmZpCmRIYnVnICJTZXJ2aWNIIGRIZmluaXRpb24gaXMgaW4gJEZJTEUiCkVYRUNTVEFSVD0kKHNIZCAtbiAtZSAnL15FeGVjU3RhcnQ9LipcXCQvLC9bXIcXSQvIHsgcy9eRXhIY1N0YXJ0PS8vOyBwIH0nIC1IICcvXkV4ZWNTdGFydD0uKltexFxdJC8geyBzL15FeGVjU3RhcnQ9Ly87IHAgfScgJEZJTEUpCgppZiBbWyAkRU5WRkIMRSBdXTsgdGhlbgogIFZBUk5BTUU9JHtWQVJOQU1FOi1FWEVDU1RBUIR9CiAgZWNobyAiJHtWQVJOQU1FfT0ke0VYRUNTVEFSVH0iID4gJEVOVkJTEUKZWxzZQogIGVjaG8gJEVYRUNTVEFSVApmQo=
      mode: 493
      path: /usr/local/bin/extractExecStart
    - contents:
        source: data:text/plain;charset=utf-
```

```

8;base64,lyEvYmluL2Jhc2gKbnNlbnRlcAtLW1vdW50PS9ydW4vY29udGFpbmVyLW1vdW50LW5hbW\zcGFjZS9tbnQgliRAIgo=
mode: 493
path: /usr/local/bin/nsenterCmns
systemd:
units:
- contents: |
  [Unit]
  Description=Manages a mount namespace that both kubelet and crio can use to share their
container-specific mounts

  [Service]
  Type=oneshot
  RemainAfterExit=yes
  RuntimeDirectory=container-mount-namespace
  Environment=RUNTIME_DIRECTORY=%t/container-mount-namespace
  Environment=BIND_POINT=%t/container-mount-namespace/mnt
  ExecStartPre=bash -c "findmnt ${RUNTIME_DIRECTORY} || mount --make-unbindable --
bind ${RUNTIME_DIRECTORY} ${RUNTIME_DIRECTORY}"
  ExecStartPre=touch ${BIND_POINT}
  ExecStart=unshare --mount=${BIND_POINT} --propagation slave mount --make-rshared /
  ExecStop=umount -R ${RUNTIME_DIRECTORY}
  name: container-mount-namespace.service
- dropins:
- contents: |
  [Unit]
  Wants=container-mount-namespace.service
  After=container-mount-namespace.service

  [Service]
  ExecStartPre=/usr/local/bin/extractExecStart %n /%t/%N-execstart.env
ORIG_EXECSTART
  EnvironmentFile=-/%t/%N-execstart.env
  ExecStart=
  ExecStart=bash -c "nsenter --mount=%t/container-mount-namespace/mnt \
  ${ORIG_EXECSTART}"
  name: 90-container-mount-namespace.conf
  name: crio.service
- dropins:
- contents: |
  [Unit]
  Wants=container-mount-namespace.service
  After=container-mount-namespace.service

  [Service]
  ExecStartPre=/usr/local/bin/extractExecStart %n /%t/%N-execstart.env
ORIG_EXECSTART
  EnvironmentFile=-/%t/%N-execstart.env
  ExecStart=
  ExecStart=bash -c "nsenter --mount=%t/container-mount-namespace/mnt \
  ${ORIG_EXECSTART} --housekeeping-interval=30s"
  name: 90-container-mount-namespace.conf
- contents: |
  [Service]
  Environment="OPENSHIFT_MAX_HOUSEKEEPING_INTERVAL_DURATION=60s"

```

```
Environment="OPENSHIFT_EViction_MONITORING_PERIOD_DURATION=30s"
name: 30-kubelet-interval-tuning.conf
name: kubelet.service
```

6.7.3. SCTP

Stream Control Transmission Protocol (SCTP) is a key protocol used in RAN applications. This **MachineConfig** object adds the SCTP kernel module to the node to enable this protocol.

Recommended control plane node SCTP configuration (**03-sctp-machine-config-master.yaml**)

```
# Automatically generated by extra-manifests-builder
# Do not make changes directly.
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: master
  name: load-sctp-module-master
spec:
  config:
    ignition:
      version: 2.2.0
    storage:
      files:
        - contents:
            source: data:;
            verification: {}
          filesystem: root
          mode: 420
          path: /etc/modprobe.d/sctp-blacklist.conf
        - contents:
            source: data:text/plain;charset=utf-8,sctp
          filesystem: root
          mode: 420
          path: /etc/modules-load.d/sctp-load.conf
```

Recommended worker node SCTP configuration (**03-sctp-machine-config-worker.yaml**)

```
# Automatically generated by extra-manifests-builder
# Do not make changes directly.
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: load-sctp-module-worker
spec:
  config:
    ignition:
      version: 2.2.0
    storage:
      files:
```



```

udD0kMiB0aHJlc2hvbgQ9JDMKICBsb2NhbCBkZWx0YT0wIHBjaGFuZ2UKICBkZWx0YT0kKCggY3V
cmVudCATIGxhc3QgKSkJICBpZiBbWyAkY3VycmVudCATZXEGJGxhc3QgXV07IHRoZW4KICAgIHBJaG
FuZ2U9MAogIGVsaWYgW1sgJGxhc3QgLWVxDAGXV07IHRoZW4KICAgIHBJaGFuZ2U9MTAwMDA
wMAogIGVsc2UKICAgIHBJaGFuZ2U9JCgoICggiRkZWx0YSIgKiAxMDApIC8gbGFzdCApKQogIGZpCi
AgZWNobyAtbiAibGFzdDokbGFzdCBjdXJyZW50OIRjdXJyZW50IGRlbHRhOIRkZWx0YSBwY2hhbmdl
OIR7cGNoYW5nZX0IOiAiCiAgbG9jYWwgYWJzb2x1dGUgbGltaXQKICBjYXNIICR0aHJlc2hvbgQqaW4
KICAgICoIKQogICAgICBhYnNvbHV0ZT0ke3BjaGFuZ2Ujly19ICMgYWJzb2x1dGUgdmFsdWUKICAgI
CAgbGltaXQ9JHt0aHJlc2hvbgQIJSV9CiAgICAqIDs7CiAgICAqKQogICAgICBhYnNvbHV0ZT0ke2RlbH
RhlyMtfSAjIGFic29sdXRlHZhbHVICiAgICAqGxpbdI0PSR0aHJlc2hvbgQKICAgICAqOzsKICBlc2FjCiA
gaWYgW1sgJGFic29sdXRlIC1sZSAkbGltaXQgXV07IHRoZW4KICAgIGVjaG8gIndpdGhpbiAoKy8tKSR
0aHJlc2hvbgQqCiAgICByZXR1cm4gMAogIGVsc2UKICAgIGVjaG8gIm91dHNpZGUgKCsvLSkkdGhyZ
XNob2xlgogICAgcmV0dXJuIDEKICBmaQp9CgpzdGVhZHlzdGF0ZSgplHsKICBsb2NhbCBsYXN0PS
QxIGN1cnJlbnQ9JDIKICBpZiBbWyAkbGFzdCATbHQgJFNURUFewv9TVEFURV9NSU5JTVVNIF1dO
yB0aGVuCiAgICBIY2hvICJsYXN0OIRsYXN0IGN1cnJlbnQ6JGN1cnJlbnQgV2FpdGluZyB0byByZWFja
CAkU1RFQURZX1NUQVRFX01JTkINVU0gYmVm3JIIGNoZWNraW5nIGZvciBzdGVhZHktc3RhdGUI
CiAgICByZXR1cm4gMQogIGZpCiAgd2l0aGluIClkBFzdC1gliRjdXJyZW50liAiJFNURUFewv9TVEFU
RV9USFJFU0hPTEQiCn0KCndhaXRGb3JSZWFKeSgpIHsKICBsb2dnZXIgIIJY292ZXJ5OIBXYWI0aW
5nICR7TUFYSU1VTV9XQUIUX1RJTUV9cyBmb3IgdGhlIGluXRpYWxpmF0aW9ulHRvIGNvbXBsZX
RllgogIGxvY2FsIHQ9MCBzPTEwCiAgbG9jYWwgbdGFzdENjb3VudD0wIGNjb3VudD0wIHN0ZWfkeVN
0YXRIVGltZT0wCiAgd2hpGUgW1sgJHqgLWx0ICRNQVhJTVVN1dBSVRfVEINRSBdXTsgZG8KIC
AgIHNsZWVwICRzCiAgICAoKHQgKz0gcykpCiAgICAjIERldGVjdCBzdGVhZHktc3RhdGUgcG9kIGNvd
W50CiAgICBjY291bnQ9JChcmljdGwgchMj4vZGV2L251bGwgfCB3YyAtbCkKICAgIGlmIFtbICRjY2
91bnQgLWd0IDAjXV0gJiYgc3RIYWR5c3RhdGUgliRsYXN0Q2NvdW50liAiJGNjb3VudCI7IHRoZW4KI
CAgICAkCHzdGVhZHITdGF0ZVRpbWUgKz0gcykpCiAgICAqIGVjaG8gIIN0ZWfkeS1zdGF0ZSBmb3
IgJHtzdGVhZHITdGF0ZVRpbWV9cy8ke1NURUFewv9TVEFURV9XSU5ET1d9cyIKICAgICAqAwygW
1sgJHN0ZWfkeVN0YXRIVGltZSAzT2UgJFNURUFewv9TVEFURV9XSU5ET1cgXV07IHRoZW4KICA
gICAqICBsb2dnZXIgIIJY292ZXJ5OIBtDGVhZHktc3RhdGUgKCsvLSAkU1RFQURZX1NUQVRFX1RI
UkVTSE9MRCkgZm9yICR7U1RFQURZX1NUQVRFX1dJTkRPV31zOibeB25llgogICAgICAqIHJldHVy
biAwCiAgICAqIGZpCiAgICB1bHNICiAgICAqIGlmIFtbICRzdGVhZHITdGF0ZVRpbWUgLWd0IDAjXV07
IHRoZW4KICAgICAqICBIY2hvICJSZNldHRpbmcgc3RIYWR5LN0YXRlHRpbWVlgogICAgICAqIH
0ZWfkeVN0YXRIVGltZT0wCiAgICAqIGZpCiAgICBmaQogICAqGFBzdENjb3VudD0kY2NvdW50CiAgZ
G9uZQogIGxvZ2dlciAiUmVjb3Zlcnk6IFJY292ZXJ5IENvbXBsZXRlFRpbWVvdXQiCh0KCnNldFJjdU5vc
m1hbCgpIHsKICBIY2hvICJTZR0aW5nIHJjdV9ub3JtYWwgG8gMSIKICBIY2hvIDEgPiAvc3lzL2tlcm5lk
C9yY3Vfbm9ybWFsCn0KCm1haW4oKSB7CiAgd2FpdEZvclJYWR5CiAgZWNobyAiV2FpdGluZyBmb3I
gc3RIYWR5IHNOYXRlHRvb2s6ICQoYXdrICd7cHJpbnQgaW50KCQxLzM2MDApImgiLCBpbnQoKCQ
xJTM2MDApLzYwKSJtliwgaW50KCQxJTYwKSJzIn0nIC9wcm9jL3VwdGltZskiCiAgc2V0UmN1Tm9yb
WFsCn0KCm1mIFtbIClke0JBU0hfU09VUkNFWzBdfSlgPSAiJHswfSlgXV07IHRoZW4KICBtYWIuIClke0
B9IgogIGV4aXQgJD8KZmkK

```

mode: 493

path: /usr/local/bin/set-rcu-normal.sh

systemd:

units:

- contents: |

[Unit]

Description=Disable rcu_expedited after node has finished booting by setting rcu_normal to 1

[Service]

Type=simple

ExecStart=/usr/local/bin/set-rcu-normal.sh

Maximum wait time is 600s = 10m:

Environment=MAXIMUM_WAIT_TIME=600

Steady-state threshold = 2%

Allowed values:

4 - absolute pod count (+/-)

```

# 4% - percent change (+/-)
# -1 - disable the steady-state check
# Note: '%' must be escaped as '%%' in systemd unit files
Environment=STEADY_STATE_THRESHOLD=2%%

# Steady-state window = 120s
# If the running pod count stays within the given threshold for this time
# period, return CPU utilization to normal before the maximum wait time has
# expires
Environment=STEADY_STATE_WINDOW=120

# Steady-state minimum = 40
# Increasing this will skip any steady-state checks until the count rises above
# this number to avoid false positives if there are some periods where the
# count doesn't increase but we know we can't be at steady-state yet.
Environment=STEADY_STATE_MINIMUM=40

[Install]
WantedBy=multi-user.target
enabled: true
name: set-rcu-normal.service

```

6.7.5. Automatic kernel crash dumps with kdump

kdump is a Linux kernel feature that creates a kernel crash dump when the kernel crashes. **kdump** is enabled with the following **MachineConfig** CRs.

Recommended control plane node kdump configuration (06-kdump-master.yaml)

```

# Automatically generated by extra-manifests-builder
# Do not make changes directly.
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: master
  name: 06-kdump-enable-master
spec:
  config:
    ignition:
      version: 3.2.0
    systemd:
      units:
        - enabled: true
          name: kdump.service
    kernelArguments:
      - crashkernel=512M

```

Recommended kdump worker node configuration (06-kdump-worker.yaml)

```

# Automatically generated by extra-manifests-builder
# Do not make changes directly.
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig

```

```

metadata:
labels:
  machineconfiguration.openshift.io/role: worker
  name: 06-kdump-enable-worker
spec:
config:
  ignition:
    version: 3.2.0
  systemd:
    units:
      - enabled: true
        name: kdump.service
  kernelArguments:
    - crashkernel=512M

```

6.7.6. Disable automatic CRI-O cache wipe

After an uncontrolled host shutdown or cluster reboot, CRI-O automatically deletes the entire CRI-O cache, causing all images to be pulled from the registry when the node reboots. This can result in unacceptably slow recovery times or recovery failures. To prevent this from happening in single-node OpenShift clusters that you install with GitOps ZTP, disable the CRI-O delete cache feature during cluster installation.

Recommended MachineConfig CR to disable CRI-O cache wipe on control plane nodes (99-crio-disable-wipe-master.yaml)

```

# Automatically generated by extra-manifests-builder
# Do not make changes directly.
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
labels:
  machineconfiguration.openshift.io/role: master
  name: 99-crio-disable-wipe-master
spec:
config:
  ignition:
    version: 3.2.0
  storage:
    files:
      - contents:
          source: data:text/plain;charset=utf-
8;base64,W2NyaW9dCmNsZWFFuX3NodXRkb3duX2ZpbGUgPSAilgo=
          mode: 420
          path: /etc/crio/crio.conf.d/99-crio-disable-wipe.toml

```

Recommended MachineConfig CR to disable CRI-O cache wipe on worker nodes (99-crio-disable-wipe-worker.yaml)

```

# Automatically generated by extra-manifests-builder
# Do not make changes directly.
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:

```

```

labels:
  machineconfiguration.openshift.io/role: worker
name: 99-crio-disable-wipe-worker
spec:
  config:
    ignition:
      version: 3.2.0
    storage:
      files:
        - contents:
            source: data:text/plain;charset=utf-
8;base64,W2NyaW9dCmNsZWFFuX3NodXRkb3duX2ZpbGUgPSAilgo=
          mode: 420
        path: /etc/crio/crio.conf.d/99-crio-disable-wipe.toml

```

6.7.7. Configuring crun as the default container runtime

The following **ContainerRuntimeConfig** custom resources (CRs) configure crun as the default OCI container runtime for control plane and worker nodes. The crun container runtime is fast and lightweight and has a low memory footprint.



IMPORTANT

For optimal performance, enable crun for control plane and worker nodes in single-node OpenShift, three-node OpenShift, and standard clusters. To avoid the cluster rebooting when the CR is applied, apply the change as a GitOps ZTP additional Day 0 install-time manifest.

Recommended ContainerRuntimeConfig CR for control plane nodes (`enable-crun-master.yaml`)

```

apiVersion: machineconfiguration.openshift.io/v1
kind: ContainerRuntimeConfig
metadata:
  name: enable-crun-master
spec:
  machineConfigPoolSelector:
    matchLabels:
      pools.operator.machineconfiguration.openshift.io/master: ""
  containerRuntimeConfig:
    defaultRuntime: crun

```

Recommended ContainerRuntimeConfig CR for worker nodes (`enable-crun-worker.yaml`)

```

apiVersion: machineconfiguration.openshift.io/v1
kind: ContainerRuntimeConfig
metadata:
  name: enable-crun-worker
spec:
  machineConfigPoolSelector:
    matchLabels:

```

```

pools.operator.machineconfiguration.openshift.io/worker: ""
containerRuntimeConfig:
  defaultRuntime: crun

```

6.7.8. Enabling disk encryption with TPM and PCR protection

You can use the **diskEncryption** field in the **SiteConfig** custom resource (CR) to configure disk encryption with Trusted Platform Module (TPM) and Platform Configuration Registers (PCRs) protection.

Configuring the **SiteConfig** CR enables disk encryption at the time of cluster installation.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in as a user with **cluster-admin** privileges.
- You read the "About disk encryption with TPM and PCR protection" section.

Procedure

- Configure the **spec.clusters.diskEncryption** field in the **SiteConfig** CR:

Recommended SiteConfig CR configuration to enable disk encryption with PCR protection

```

apiVersion: ran.openshift.io/v1
kind: SiteConfig
metadata:
  name: "encryption-tpm2"
  namespace: "encryption-tpm2"
spec:
  clusters:
    - clusterName: "encryption-tpm2"
      clusterImageSetNameRef: "openshift-v4.13.0"
      diskEncryption:
        type: "tpm2" ①
        tpm2:
          pcrList: "1,7" ②
      nodes:
        - hostName: "node1"
          role: master

```

- ① Set the disk encryption type to **tpm2**.
- ② Configure the list of PCRs to be used for disk encryption. You must use PCR registers 1 and 7.

Verification

- Check that the disk encryption with TPM and PCR protection is enabled by running the following command:

\$ clevis luks list -d <disk_path> ①

- ① Replace <disk_path> with the path to the disk. For example, /dev/sda4.

Example output

```
1: tpm2 {"hash":"sha256","key":"ecc","pcr_bank":"sha256","pcr_ids":"1,7"}
```

Additional resources

- [About disk encryption with TPM and PCR protection](#)

6.8. RECOMMENDED POSTINSTALLATION CLUSTER CONFIGURATIONS

When the cluster installation is complete, the ZTP pipeline applies the following custom resources (CRs) that are required to run DU workloads.



NOTE

In GitOps ZTP v4.10 and earlier, you configure UEFI secure boot with a **MachineConfig** CR. This is no longer required in GitOps ZTP v4.11 and later. In v4.11, you configure UEFI secure boot for single-node OpenShift clusters by updating the **spec.clusters.nodes.bootMode** field in the **SiteConfig** CR that you use to install the cluster. For more information, see [Deploying a managed cluster with SiteConfig and GitOps ZTP](#).

6.8.1. Operators

Single-node OpenShift clusters that run DU workloads require the following Operators to be installed:

- Local Storage Operator
- Logging Operator
- PTP Operator
- SR-IOV Network Operator

You also need to configure a custom **CatalogSource** CR, disable the default **OperatorHub** configuration, and configure an **ImageContentSourcePolicy** mirror registry that is accessible from the clusters that you install.

Recommended Storage Operator namespace and Operator group configuration (`StorageNS.yaml`, `StorageOperGroup.yaml`)

```
---
apiVersion: v1
kind: Namespace
metadata:
  name: openshift-local-storage
  annotations:
```

```

workload.openshift.io/allowed: management
---
apiVersion: operators.coreos.com/v1
kind: OperatorGroup
metadata:
  name: openshift-local-storage
  namespace: openshift-local-storage
  annotations: {}
spec:
  targetNamespaces:
    - openshift-local-storage

```

**Recommended Cluster Logging Operator namespace and Operator group configuration
(ClusterLogNS.yaml, ClusterLogOperGroup.yaml)**

```

---
apiVersion: v1
kind: Namespace
metadata:
  name: openshift-logging
  annotations:
    workload.openshift.io/allowed: management
---
apiVersion: operators.coreos.com/v1
kind: OperatorGroup
metadata:
  name: cluster-logging
  namespace: openshift-logging
  annotations: {}
spec:
  targetNamespaces:
    - openshift-logging

```

**Recommended PTP Operator namespace and Operator group configuration
(PtpSubscriptionNS.yaml, PtpSubscriptionOperGroup.yaml)**

```

---
apiVersion: v1
kind: Namespace
metadata:
  name: openshift-ptp
  annotations:
    workload.openshift.io/allowed: management
  labels:
    openshift.io/cluster-monitoring: "true"
---
apiVersion: operators.coreos.com/v1
kind: OperatorGroup
metadata:
  name: ptp-operators
  namespace: openshift-ptp
  annotations: {}
spec:
  targetNamespaces:
    - openshift-ptp

```

**Recommended SR-IOV Operator namespace and Operator group configuration
(SriovSubscriptionNS.yaml, SriovSubscriptionOperGroup.yaml)**

```
---
apiVersion: v1
kind: Namespace
metadata:
  name: openshift-sriov-network-operator
  annotations:
    workload.openshift.io/allowed: management
---
apiVersion: operators.coreos.com/v1
kind: OperatorGroup
metadata:
  name: sriov-network-operators
  namespace: openshift-sriov-network-operator
  annotations: {}
spec:
  targetNamespaces:
    - openshift-sriov-network-operator
```

Recommended CatalogSource configuration (DefaultCatsrc.yaml)

```
apiVersion: operators.coreos.com/v1alpha1
kind: CatalogSource
metadata:
  name: default-cat-source
  namespace: openshift-marketplace
  annotations:
    target.workload.openshift.io/management: '{"effect": "PreferredDuringScheduling"}'
spec:
  displayName: default-cat-source
  image: $imageUrl
  publisher: Red Hat
  sourceType: grpc
  updateStrategy:
    registryPoll:
      interval: 1h
status:
  connectionState:
    lastObservedState: READY
```

Recommended ImageContentSourcePolicy configuration (DisconnectedICSP.yaml)

```
apiVersion: operator.openshift.io/v1alpha1
kind: ImageContentSourcePolicy
metadata:
  name: disconnected-internal-icsp
  annotations: {}
spec:
#  repositoryDigestMirrors:
#    - $mirrors
```

Recommended OperatorHub configuration (OperatorHub.yaml)

```
apiVersion: config.openshift.io/v1
kind: OperatorHub
metadata:
  name: cluster
  annotations: {}
spec:
  disableAllDefaultSources: true
```

6.8.2. Operator subscriptions

Single-node OpenShift clusters that run DU workloads require the following **Subscription** CRs. The subscription provides the location to download the following Operators:

- Local Storage Operator
- Logging Operator
- PTP Operator
- SR-IOV Network Operator
- SRIOV-FEC Operator

For each Operator subscription, specify the channel to get the Operator from. The recommended channel is **stable**.

You can specify **Manual** or **Automatic** updates. In **Automatic** mode, the Operator automatically updates to the latest versions in the channel as they become available in the registry. In **Manual** mode, new Operator versions are installed only when they are explicitly approved.

TIP

Use **Manual** mode for subscriptions. This allows you to control the timing of Operator updates to fit within scheduled maintenance windows.

Recommended Local Storage Operator subscription (StorageSubscription.yaml)

```
apiVersion: operators.coreos.com/v1alpha1
kind: Subscription
metadata:
  name: local-storage-operator
  namespace: openshift-local-storage
  annotations: {}
spec:
  channel: "stable"
  name: local-storage-operator
  source: redhat-operators-disconnected
  sourceNamespace: openshift-marketplace
  installPlanApproval: Manual
status:
  state: AtLatestKnown
```

Recommended SR-IOV Operator subscription (`SriovSubscription.yaml`)

```
apiVersion: operators.coreos.com/v1alpha1
kind: Subscription
metadata:
  name: sriov-network-operator-subscription
  namespace: openshift-sriov-network-operator
  annotations: {}
spec:
  channel: "stable"
  name: sriov-network-operator
  source: redhat-operators-disconnected
  sourceNamespace: openshift-marketplace
  installPlanApproval: Manual
status:
  state: AtLatestKnown
```

Recommended PTP Operator subscription (`PtpSubscription.yaml`)

```
---
apiVersion: operators.coreos.com/v1alpha1
kind: Subscription
metadata:
  name: ptp-operator-subscription
  namespace: openshift-ptp
  annotations: {}
spec:
  channel: "stable"
  name: ptp-operator
  source: redhat-operators-disconnected
  sourceNamespace: openshift-marketplace
  installPlanApproval: Manual
status:
  state: AtLatestKnown
```

Recommended Cluster Logging Operator subscription (`ClusterLogSubscription.yaml`)

```
apiVersion: operators.coreos.com/v1alpha1
kind: Subscription
metadata:
  name: cluster-logging
  namespace: openshift-logging
  annotations: {}
spec:
  channel: "stable-6.0"
  name: cluster-logging
  source: redhat-operators-disconnected
  sourceNamespace: openshift-marketplace
  installPlanApproval: Manual
status:
  state: AtLatestKnown
```

6.8.3. Cluster logging and log forwarding

Single-node OpenShift clusters that run DU workloads require logging and log forwarding for debugging. The following custom resources (CRs) are required.

Recommended ClusterLogForwarder.yaml

```

apiVersion: "observability.openshift.io/v1"
kind: ClusterLogForwarder
metadata:
  name: instance
  namespace: openshift-logging
  annotations: {}
spec:
  # outputs: $outputs
  # pipelines: $pipelines
  serviceAccount:
    name: logcollector
#apiVersion: "observability.openshift.io/v1"
#kind: ClusterLogForwarder
#metadata:
#  name: instance
#  namespace: openshift-logging
#  spec:
#    outputs:
#      - type: "kafka"
#        name: kafka-open
#        # below url is an example
#        kafka:
#          url: tcp://10.46.55.190:9092/test
#    filters:
#      - name: test-labels
#        type: openshiftLabels
#        openshiftLabels:
#          label1: test1
#          label2: test2
#          label3: test3
#          label4: test4
#    pipelines:
#      - name: all-to-default
#        inputRefs:
#          - audit
#          - infrastructure
#        filterRefs:
#          - test-labels
#        outputRefs:
#          - kafka-open
#        serviceAccount:
#          name: logcollector

```



NOTE

Set the **spec.outputs.kafka.url** field to the URL of the Kafka server where the logs are forwarded to.

Recommended ClusterLogNS.yaml

```
---  
apiVersion: v1  
kind: Namespace  
metadata:  
  name: openshift-logging  
  annotations:  
    workload.openshift.io/allowed: management
```

Recommended ClusterLogOperatorGroup.yaml

```
---  
apiVersion: operators.coreos.com/v1  
kind: OperatorGroup  
metadata:  
  name: cluster-logging  
  namespace: openshift-logging  
  annotations: {}  
spec:  
  targetNamespaces:  
    - openshift-logging
```

Recommended ClusterLogServiceAccount.yaml

```
---  
apiVersion: v1  
kind: ServiceAccount  
metadata:  
  name: logcollector  
  namespace: openshift-logging  
  annotations: {}
```

Recommended ClusterLogServiceAccountAuditBinding.yaml

```
---  
apiVersion: rbac.authorization.k8s.io/v1  
kind: ClusterRoleBinding  
metadata:  
  name: logcollector-audit-logs-binding  
  annotations: {}  
roleRef:  
  apiGroup: rbac.authorization.k8s.io  
  kind: ClusterRole  
  name: collect-audit-logs  
subjects:  
  - kind: ServiceAccount  
    name: logcollector  
    namespace: openshift-logging
```

Recommended ClusterLogServiceAccountInfrastructureBinding.yaml

```
---  
apiVersion: rbac.authorization.k8s.io/v1  
kind: ClusterRoleBinding
```

```

metadata:
  name: logcollector-infrastructure-logs-binding
  annotations: {}
roleRef:
  apiGroup: rbac.authorization.k8s.io
  kind: ClusterRole
  name: collect-infrastructure-logs
subjects:
  - kind: ServiceAccount
    name: logcollector
    namespace: openshift-logging

```

Recommended ClusterLogSubscription.yaml

```

apiVersion: operators.coreos.com/v1alpha1
kind: Subscription
metadata:
  name: cluster-logging
  namespace: openshift-logging
  annotations: {}
spec:
  channel: "stable-6.0"
  name: cluster-logging
  source: redhat-operators-disconnected
  sourceNamespace: openshift-marketplace
  installPlanApproval: Manual
status:
  state: AtLatestKnown

```

6.8.4. Performance profile

Single-node OpenShift clusters that run DU workloads require a Node Tuning Operator performance profile to use real-time host capabilities and services.



NOTE

In earlier versions of OpenShift Container Platform, the Performance Addon Operator was used to implement automatic tuning to achieve low latency performance for OpenShift applications. In OpenShift Container Platform 4.11 and later, this functionality is part of the Node Tuning Operator.

The following example **PerformanceProfile** CR illustrates the required single-node OpenShift cluster configuration.

Recommended performance profile configuration (**PerformanceProfile.yaml**)

```

apiVersion: performance.openshift.io/v2
kind: PerformanceProfile
metadata:
  # if you change this name make sure the 'include' line in TunedPerformancePatch.yaml
  # matches this name: include=openshift-node-performance-${PerformanceProfile.metadata.name}
  # Also in file 'validatorCRs/informDuValidator.yaml':
  # name: 50-performance-${PerformanceProfile.metadata.name}
  name: openshift-node-performance-profile

```

```

annotations:
  ran.openshift.io/reference-configuration: "ran-du.redhat.com"
spec:
  additionalKernelArgs:
    - "rcupdate.rcu_normal_after_boot=0"
    - "efi=runtime"
    - "vfio_pci.enable_sriov=1"
    - "vfio_pci.disable_idle_d3=1"
    - "module_blacklist=irdma"
  cpu:
    isolated: $isolated
    reserved: $reserved
  hugepages:
    defaultHugepagesSize: $defaultHugepagesSize
    pages:
      - size: $size
        count: $count
        node: $node
  machineConfigPoolSelector:
    pools.operator.machineconfiguration.openshift.io/$mcp: ""
  nodeSelector:
    node-role.kubernetes.io/$mcp: ""
  numa:
    topologyPolicy: "restricted"
  # To use the standard (non-realtime) kernel, set enabled to false
  realTimeKernel:
    enabled: true
  workloadHints:
    # WorkloadHints defines the set of upper level flags for different type of workloads.
    # See https://github.com/openshift/cluster-node-tuning-
    operator/blob/master/docs/performanceprofile/performance_profile.md#workloadhints
    # for detailed descriptions of each item.
    # The configuration below is set for a low latency, performance mode.
    realTime: true
    highPowerConsumption: false
    perPodPowerManagement: false

```

Table 6.3. PerformanceProfile CR options for single-node OpenShift clusters

PerformanceProfile CR field	Description
metadata.name	<p>Ensure that name matches the following fields set in related GitOps ZTP custom resources (CRs):</p> <ul style="list-style-type: none"> • include=openshift-node-performance-\${PerformanceProfile.metadata.name} in TunedPerformancePatch.yaml • name: 50-performance-\${PerformanceProfile.metadata.name} in validatorCRs/informDuValidator.yaml

PerformanceProfile CR field	Description
spec.additionalKernelArgs	" efi=runtime " Configures UEFI secure boot for the cluster host.
spec.cpu.isolated	Set the isolated CPUs. Ensure all of the Hyper-Threading pairs match.  IMPORTANT The reserved and isolated CPU pools must not overlap and together must span all available cores. CPU cores that are not accounted for cause an undefined behaviour in the system.
spec.cpu.reserved	Set the reserved CPUs. When workload partitioning is enabled, system processes, kernel threads, and system container threads are restricted to these CPUs. All CPUs that are not isolated should be reserved.
spec.hugepages.pages	<ul style="list-style-type: none"> Set the number of huge pages (count) Set the huge pages size (size). Set node to the NUMA node where the hugepages are allocated (node)
spec.realTimeKernel	Set enabled to true to use the realtime kernel.
spec.workloadHints	Use workloadHints to define the set of top level flags for different type of workloads. The example configuration configures the cluster for low latency and high performance.

6.8.5. Configuring cluster time synchronization

Run a one-time system time synchronization job for control plane or worker nodes.

Recommended one time time-sync for control plane nodes (99-sync-time-once-master.yaml)

```
# Automatically generated by extra-manifests-builder
# Do not make changes directly.
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: master
```

```

name: 99-sync-time-once-master
spec:
  config:
    ignition:
      version: 3.2.0
    systemd:
      units:
        - contents: |
          [Unit]
          Description=Sync time once
          After=network-online.target
          Wants=network-online.target
          [Service]
          Type=oneshot
          TimeoutStartSec=300
          ExecCondition=/bin/bash -c 'systemctl is-enabled chronyd.service --quiet && exit 1 || exit 0'
          ExecStart=/usr/sbin/chronyd -n -f /etc/chrony.conf -q
          RemainAfterExit=yes
          [Install]
          WantedBy=multi-user.target
  enabled: true
  name: sync-time-once.service

```

Recommended one time time-sync for worker nodes (99-sync-time-once-worker.yaml)

```

# Automatically generated by extra-manifests-builder
# Do not make changes directly.
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 99-sync-time-once-worker
spec:
  config:
    ignition:
      version: 3.2.0
    systemd:
      units:
        - contents: |
          [Unit]
          Description=Sync time once
          After=network-online.target
          Wants=network-online.target
          [Service]
          Type=oneshot
          TimeoutStartSec=300
          ExecCondition=/bin/bash -c 'systemctl is-enabled chronyd.service --quiet && exit 1 || exit 0'
          ExecStart=/usr/sbin/chronyd -n -f /etc/chrony.conf -q
          RemainAfterExit=yes
          [Install]
          WantedBy=multi-user.target
  enabled: true
  name: sync-time-once.service

```

6.8.6. PTP

Single-node OpenShift clusters use Precision Time Protocol (PTP) for network time synchronization. The following example **PtpConfig** CRs illustrate the required PTP configurations for ordinary clocks, boundary clocks, and grandmaster clocks. The exact configuration you apply will depend on the node hardware and specific use case.

Recommended PTP ordinary clock configuration (**PtpConfigSlave.yaml**)

```
apiVersion: ptp.openshift.io/v1
kind: PtpConfig
metadata:
  name: ordinary
  namespace: openshift-ptp
  annotations: {}
spec:
  profile:
    - name: "ordinary"
      # The interface name is hardware-specific
      interface: $interface
      ptp4IOpts: "-2 -s"
      phc2sysOpts: "-a -r -n 24"
      ptpSchedulingPolicy: SCHED_FIFO
      ptpSchedulingPriority: 10
      ptpSettings:
        logReduce: "true"
        ptp4IConf: |
          [global]
          #
          # Default Data Set
          #
          twoStepFlag 1
          slaveOnly 1
          priority1 128
          priority2 128
          domainNumber 24
          #utc_offset 37
          clockClass 255
          clockAccuracy 0xFE
          offsetScaledLogVariance 0xFFFF
          free_running 0
          freq_est_interval 1
          dscp_event 0
          dscp_general 0
          dataset_comparison G.8275.x
          G.8275.defaultDS.localPriority 128
          #
          # Port Data Set
          #
          logAnnounceInterval -3
          logSyncInterval -4
          logMinDelayReqInterval -4
          logMinPdelayReqInterval -4
          announceReceiptTimeout 3
          syncReceiptTimeout 0
          delayAsymmetry 0
```

```
fault_reset_interval -4
neighborPropDelayThresh 20000000
masterOnly 0
G.8275.portDS.localPriority 128
#
# Run time options
#
assume_two_step 0
logging_level 6
path_trace_enabled 0
follow_up_info 0
hybrid_e2e 0
inhibit_multicast_service 0
net_sync_monitor 0
tc_spanning_tree 0
tx_timestamp_timeout 50
unicast_listen 0
unicast_master_table 0
unicast_req_duration 3600
use_syslog 1
verbose 0
summary_interval 0
kernel_leap 1
check_fup_sync 0
clock_class_threshold 7
#
# Servo Options
#
pi_proportional_const 0.0
pi_integral_const 0.0
pi_proportional_scale 0.0
pi_proportional_exponent -0.3
pi_proportional_norm_max 0.7
pi_integral_scale 0.0
pi_integral_exponent 0.4
pi_integral_norm_max 0.3
step_threshold 2.0
first_step_threshold 0.00002
max_frequency 900000000
clock_servo pi
sanity_freq_limit 200000000
ntpshm_segment 0
#
# Transport options
#
transportSpecific 0x0
ptp_dst_mac 01:1B:19:00:00:00
p2p_dst_mac 01:80:C2:00:00:0E
udp_ttl 1
udp6_scope 0x0E
uds_address /var/run/ptp4l
#
# Default interface options
#
clock_type OC
network_transport L2
```

```

delay_mechanism E2E
time_stamping hardware
tsproc_mode filter
delay_filter moving_median
delay_filter_length 10
egressLatency 0
ingressLatency 0
boundary_clock_jbod 0
#
# Clock description
#
productDescription ;;
revisionData ;;
manufacturerIdentity 00:00:00
userDescription ;
timeSource 0xA0
recommend:
- profile: "ordinary"
  priority: 4
  match:
    - nodeLabel: "node-role.kubernetes.io/$mcp"

```

Recommended boundary clock configuration (PtpConfigBoundary.yaml)

```

apiVersion: ptp.openshift.io/v1
kind: PtpConfig
metadata:
  name: boundary
  namespace: openshift-ptp
  annotations: {}
spec:
  profile:
    - name: "boundary"
      ptpt4IOpts: "-2"
      phc2sysOpts: "-a -r -n 24"
      ptptSchedulingPolicy: SCHED_FIFO
      ptptSchedulingPriority: 10
      ptptSettings:
        logReduce: "true"
      ptpt4IConf: |
        # The interface name is hardware-specific
        [$iface_slave]
        masterOnly 0
        [$iface_master_1]
        masterOnly 1
        [$iface_master_2]
        masterOnly 1
        [$iface_master_3]
        masterOnly 1
        [global]
        #
        # Default Data Set
        #
        twoStepFlag 1
        slaveOnly 0

```

```
priority1 128
priority2 128
domainNumber 24
#utc_offset 37
clockClass 248
clockAccuracy 0xFE
offsetScaledLogVariance 0xFFFF
free_running 0
freq_est_interval 1
dscp_event 0
dscp_general 0
dataset_comparison G.8275.x
G.8275.defaultDS.localPriority 128
#
# Port Data Set
#
logAnnounceInterval -3
logSyncInterval -4
logMinDelayReqInterval -4
logMinPdelayReqInterval -4
announceReceiptTimeout 3
syncReceiptTimeout 0
delayAsymmetry 0
fault_reset_interval -4
neighborPropDelayThresh 20000000
masterOnly 0
G.8275.portDS.localPriority 128
#
# Run time options
#
assume_two_step 0
logging_level 6
path_trace_enabled 0
follow_up_info 0
hybrid_e2e 0
inhibit_multicast_service 0
net_sync_monitor 0
tc_spanning_tree 0
tx_timestamp_timeout 50
unicast_listen 0
unicast_master_table 0
unicast_req_duration 3600
use_syslog 1
verbose 0
summary_interval 0
kernel_leap 1
check_fup_sync 0
clock_class_threshold 135
#
# Servo Options
#
pi_proportional_const 0.0
pi_integral_const 0.0
pi_proportional_scale 0.0
pi_proportional_exponent -0.3
pi_proportional_norm_max 0.7
```

```

pi_integral_scale 0.0
pi_integral_exponent 0.4
pi_integral_norm_max 0.3
step_threshold 2.0
first_step_threshold 0.00002
max_frequency 900000000
clock_servo pi
sanity_freq_limit 200000000
ntpshm_segment 0
#
# Transport options
#
transportSpecific 0x0
ptp_dst_mac 01:1B:19:00:00:00
p2p_dst_mac 01:80:C2:00:00:0E
udp_ttl 1
udp6_scope 0x0E
uds_address /var/run/ptp4l
#
# Default interface options
#
clock_type BC
network_transport L2
delay_mechanism E2E
time_stamping hardware
tsproc_mode filter
delay_filter moving_median
delay_filter_length 10
egressLatency 0
ingressLatency 0
boundary_clock_jbod 0
#
# Clock description
#
productDescription ;;
revisionData ;;
manufacturerIdentity 00:00:00
userDescription ;
timeSource 0xA0
recommend:
- profile: "boundary"
priority: 4
match:
- nodeLabel: "node-role.kubernetes.io/$mcp"

```

Recommended PTP Westport Channel e810 grandmaster clock configuration (PtpConfigGmWpc.yaml)

```

# The grandmaster profile is provided for testing only
# It is not installed on production clusters
apiVersion: ptp.openshift.io/v1
kind: PtpConfig
metadata:
  name: grandmaster
  namespace: openshift-ptp

```

```

annotations: {}
spec:
profile:
- name: "grandmaster"
  ptp4lOpts: "-2 --summary_interval -4"
  phc2sysOpts: -r -u 0 -m -w -N 8 -R 16 -s $iface_master -n 24
  ptpSchedulingPolicy: SCHED_FIFO
  ptpSchedulingPriority: 10
  ptpSettings:
    logReduce: "true"
  plugins:
    e810:
      enableDefaultConfig: false
      settings:
        LocalMaxHoldoverOffSet: 1500
        LocalHoldoverTimeout: 14400
        MaxInSpecOffset: 1500
      pins: $e810_pins
      # "$iface_master":
      #   "U.FL2": "0 2"
      #   "U.FL1": "0 1"
      #   "SMA2": "0 2"
      #   "SMA1": "0 1"
      ublxCmds:
        - args: #ubxtool -P 29.20 -z CFG-HW-ANT_CFG_VOLTCTRL,1
          - "-P"
          - "29.20"
          - "-z"
          - "CFG-HW-ANT_CFG_VOLTCTRL,1"
        reportOutput: false
        - args: #ubxtool -P 29.20 -e GPS
          - "-P"
          - "29.20"
          - "-e"
          - "GPS"
        reportOutput: false
        - args: #ubxtool -P 29.20 -d Galileo
          - "-P"
          - "29.20"
          - "-d"
          - "Galileo"
        reportOutput: false
        - args: #ubxtool -P 29.20 -d GLONASS
          - "-P"
          - "29.20"
          - "-d"
          - "GLONASS"
        reportOutput: false
        - args: #ubxtool -P 29.20 -d BeiDou
          - "-P"
          - "29.20"
          - "-d"
          - "BeiDou"
        reportOutput: false
        - args: #ubxtool -P 29.20 -d SBAS
          - "-P"

```

```

    - "29.20"
    - "-d"
    - "SBAS"
    reportOutput: false
- args: #ubxtool -P 29.20 -t -w 5 -v 1 -e SURVEYIN,600,50000
    - "-P"
    - "29.20"
    - "-t"
    - "-w"
    - "5"
    - "-v"
    - "1"
    - "-e"
    - "SURVEYIN,600,50000"
    reportOutput: true
- args: #ubxtool -P 29.20 -p MON-HW
    - "-P"
    - "29.20"
    - "-p"
    - "MON-HW"
    reportOutput: true
- args: #ubxtool -P 29.20 -p CFG-MSG,1,38,248
    - "-P"
    - "29.20"
    - "-p"
    - "CFG-MSG,1,38,248"
    reportOutput: true
ts2phcOpts: " "
ts2phcConf: |
[nmea]
ts2phc.master 1
[global]
use_syslog 0
verbose 1
logging_level 7
ts2phc.pulsewidth 100000000
#cat /dev/GNSS to find available serial port
#example value of gnss_serialport is /dev/ttyGNSS_1700_0
ts2phc.nmea_serialport $gnss_serialport
leapfile /usr/share/zoneinfo/leap-seconds.list
[$iface_master]
ts2phc.extts_polarity rising
ts2phc.extts_correction 0
ptp4lConf: |
[$iface_master]
masterOnly 1
[$iface_master_1]
masterOnly 1
[$iface_master_2]
masterOnly 1
[$iface_master_3]
masterOnly 1
[global]
#
# Default Data Set
#

```

```
twoStepFlag 1
priority1 128
priority2 128
domainNumber 24
#utc_offset 37
clockClass 6
clockAccuracy 0x27
offsetScaledLogVariance 0xFFFF
free_running 0
freq_est_interval 1
dscp_event 0
dscp_general 0
dataset_comparison G.8275.x
G.8275.defaultDS.localPriority 128
#
# Port Data Set
#
logAnnounceInterval -3
logSyncInterval -4
logMinDelayReqInterval -4
logMinPdelayReqInterval 0
announceReceiptTimeout 3
syncReceiptTimeout 0
delayAsymmetry 0
fault_reset_interval -4
neighborPropDelayThresh 20000000
masterOnly 0
G.8275.portDS.localPriority 128
#
# Run time options
#
assume_two_step 0
logging_level 6
path_trace_enabled 0
follow_up_info 0
hybrid_e2e 0
inhibit_multicast_service 0
net_sync_monitor 0
tc_spanning_tree 0
tx_timestamp_timeout 50
unicast_listen 0
unicast_master_table 0
unicast_req_duration 3600
use_syslog 1
verbose 0
summary_interval -4
kernel_leap 1
check_fup_sync 0
clock_class_threshold 7
#
# Servo Options
#
pi_proportional_const 0.0
pi_integral_const 0.0
pi_proportional_scale 0.0
pi_proportional_exponent -0.3
```

```

pi_proportional_norm_max 0.7
pi_integral_scale 0.0
pi_integral_exponent 0.4
pi_integral_norm_max 0.3
step_threshold 2.0
first_step_threshold 0.00002
clock_servo pi
sanity_freq_limit 200000000
ntpshm_segment 0
#
# Transport options
#
transportSpecific 0x0
ptp_dst_mac 01:1B:19:00:00:00
p2p_dst_mac 01:80:C2:00:00:0E
udp_ttl 1
udp6_scope 0x0E
uds_address /var/run/ptp4l
#
# Default interface options
#
clock_type BC
network_transport L2
delay_mechanism E2E
time_stamping hardware
tsproc_mode filter
delay_filter moving_median
delay_filter_length 10
egressLatency 0
ingressLatency 0
boundary_clock_jbod 0
#
# Clock description
#
productDescription ;;
revisionData ;;
manufacturerIdentity 00:00:00
userDescription ;
timeSource 0x20
recommend:
- profile: "grandmaster"
priority: 4
match:
- nodeLabel: "node-role.kubernetes.io/$mcp"

```

The following optional **PtpOperatorConfig** CR configures PTP events reporting for the node.

Recommended PTP events configuration (**PtpOperatorConfigForEvent.yaml**)

```

apiVersion: ptp.openshift.io/v1
kind: PtpOperatorConfig
metadata:
  name: default
  namespace: openshift-ptp
  annotations: {}
spec:

```

```

daemonNodeSelector:
  node-role.kubernetes.io/$mcp: ""
ptpEventConfig:
  apiVersion: $event_api_version
  enableEventPublisher: true
  transportHost: "http://ptp-event-publisher-service-NODE_NAME.openshift-
ptp.svc.cluster.local:9043"

```

6.8.7. Extended Tuned profile

Single-node OpenShift clusters that run DU workloads require additional performance tuning configurations necessary for high-performance workloads. The following example **Tuned** CR extends the **Tuned** profile:

Recommended extended Tuned profile configuration (`TunedPerformancePatch.yaml`)

```

apiVersion: tuned.openshift.io/v1
kind: Tuned
metadata:
  name: performance-patch
  namespace: openshift-cluster-node-tuning-operator
  annotations: {}
spec:
  profile:
    - name: performance-patch
      # Please note:
      # - The 'include' line must match the associated PerformanceProfile name, following below
      pattern
        # include=openshift-node-performance-${PerformanceProfile.metadata.name}
        # - When using the standard (non-realtime) kernel, remove the kernel.timer_migration override
      from
        # the [sysctl] section and remove the entire section if it is empty.
      data: |
        [main]
        summary=Configuration changes profile inherited from performance created tuned
        include=openshift-node-performance-openshift-node-performance-profile
        [scheduler]
        group.ice-ptp=0:f:10:*:ice-ptp.*
        group.ice-gnss=0:f:10:*:ice-gnss.*
        group.ice-dplls=0:f:10:*:ice-dplls.*
        [service]
        service.stalld=start,enable
        service.chronyd=stop,disable
  recommend:
    - machineConfigLabels:
        machineconfiguration.openshift.io/role: "$mcp"
      priority: 19
      profile: performance-patch

```

Table 6.4. Tuned CR options for single-node OpenShift clusters

Tuned CR field	Description
----------------	-------------

Tuned CR field	Description
spec.profile.data	<ul style="list-style-type: none"> The include line that you set in spec.profile.data must match the associated PerformanceProfile CR name. For example, include=openshift-node-performance-\${PerformanceProfile.metadata.name}.

6.8.8. SR-IOV

Single root I/O virtualization (SR-IOV) is commonly used to enable fronthaul and midhaul networks. The following YAML example configures SR-IOV for a single-node OpenShift cluster.



NOTE

The configuration of the **SriovNetwork** CR will vary depending on your specific network and infrastructure requirements.

Recommended **SriovOperatorConfig** CR configuration (**SriovOperatorConfig.yaml**)

```

apiVersion: sriovnetwork.openshift.io/v1
kind: SriovOperatorConfig
metadata:
  name: default
  namespace: openshift-sriov-network-operator
  annotations: {}
spec:
  configDaemonNodeSelector:
    "node-role.kubernetes.io/$mcp": ""
  # Injector and OperatorWebhook pods can be disabled (set to "false") below
  # to reduce the number of management pods. It is recommended to start with the
  # webhook and injector pods enabled, and only disable them after verifying the
  # correctness of user manifests.
  # If the injector is disabled, containers using sr-iov resources must explicitly assign
  # them in the "requests"/"limits" section of the container spec, for example:
  # containers:
  #   - name: my-sriov-workload-container
  #     resources:
  #       limits:
  #         openshift.io/<resource_name>: "1"
  #       requests:
  #         openshift.io/<resource_name>: "1"
  enableInjector: false
  enableOperatorWebhook: false
  logLevel: 0

```

Table 6.5. **SriovOperatorConfig** CR options for single-node OpenShift clusters

SriovOperatorConfig CR field	Description
spec.enableInjector	<p>Disable Injector pods to reduce the number of management pods. Start with the Injector pods enabled, and only disable them after verifying the user manifests. If the injector is disabled, containers that use SR-IOV resources must explicitly assign them in the requests and limits section of the container spec.</p> <p>For example:</p> <pre>containers: - name: my-sriov-workload-container resources: limits: openshift.io/<resource_name>: "1" requests: openshift.io/<resource_name>: "1"</pre>
spec.enableOperatorWebhook	<p>Disable OperatorWebhook pods to reduce the number of management pods. Start with the OperatorWebhook pods enabled, and only disable them after verifying the user manifests.</p>

Recommended SriovNetwork configuration (`SriovNetwork.yaml`)

```
apiVersion: sriovnetwork.openshift.io/v1
kind: SriovNetwork
metadata:
  name: ""
  namespace: openshift-sriov-network-operator
  annotations: {}
spec:
  # resourceName: ""
  networkNamespace: openshift-sriov-network-operator
  # vlan: ""
  # spoofChk: ""
  # ipam: ""
  # linkState: ""
  # maxTxRate: ""
  # minTxRate: ""
  # vlanQoS: ""
  # trust: ""
  # capabilities: ""
```

Table 6.6. **SriovNetwork** CR options for single-node OpenShift clusters

SriovNetwork CR field	Description
spec.vlan	Configure vlan with the VLAN for the midhaul network.

SriovNetwork CR field	Description
-----------------------	-------------

Recommended SriovNetworkNodePolicy CR configuration (`SriovNetworkNodePolicy.yaml`)

```

apiVersion: sriovnetwork.openshift.io/v1
kind: SriovNetworkNodePolicy
metadata:
  name: $name
  namespace: openshift-sriov-network-operator
  annotations: {}
spec:
  # The attributes for Mellanox/Intel based NICs as below.
  #   deviceType: netdevice/vfio-pci
  #   isRdma: true/false
  deviceType: $deviceType
  isRdma: $isRdma
  nicSelector:
    # The exact physical function name must match the hardware used
    pfNames: [$pfNames]
  nodeSelector:
    node-role.kubernetes.io/$mcp: ""
  numVfs: $numVfs
  priority: $priority
  resourceName: $resourceName

```

Table 6.7. SriovNetworkPolicy CR options for single-node OpenShift clusters

SriovNetworkNodePolicy CR field	Description
spec.deviceType	Configure deviceType as vfio-pci or netdevice . For Mellanox NICs, set deviceType: netdevice , and isRdma: true . For Intel based NICs, set deviceType: vfio-pci and isRdma: false .
spec.nicSelector.pfNames	Specifies the interface connected to the fronthaul network.
spec.numVfs	Specifies the number of VFs for the fronthaul network.
spec.nicSelector.pfNames	The exact name of physical function must match the hardware.

Recommended SR-IOV kernel configurations (`07-sriov-related-kernel-args-master.yaml`)

```

# Automatically generated by extra-manifests-builder
# Do not make changes directly.

```

```

apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: master
  name: 07-sriov-related-kernel-args-master
spec:
  config:
    ignition:
      version: 3.2.0
  kernelArguments:
    - intel_iommu=on
    - iommu=pt

```

6.8.9. Console Operator

Use the cluster capabilities feature to prevent the Console Operator from being installed. When the node is centrally managed it is not needed. Removing the Operator provides additional space and capacity for application workloads.

To disable the Console Operator during the installation of the managed cluster, set the following in the **spec.clusters.0.installConfigOverrides** field of the **SiteConfig** custom resource (CR):

```
installConfigOverrides: "{\"capabilities\":{\"baselineCapabilitySet\": \"None\" }}"
```

6.8.10. Alertmanager

Single-node OpenShift clusters that run DU workloads require reduced CPU resources consumed by the OpenShift Container Platform monitoring components. The following **ConfigMap** custom resource (CR) disables Alertmanager.

Recommended cluster monitoring configuration ([ReduceMonitoringFootprint.yaml](#))

```

apiVersion: v1
kind: ConfigMap
metadata:
  name: cluster-monitoring-config
  namespace: openshift-monitoring
  annotations: {}
data:
  config.yaml: |
    alertmanagerMain:
      enabled: false
    telemeterClient:
      enabled: false
    prometheusK8s:
      retention: 24h

```

6.8.11. Operator Lifecycle Manager

Single-node OpenShift clusters that run distributed unit workloads require consistent access to CPU resources. Operator Lifecycle Manager (OLM) collects performance data from Operators at regular intervals, resulting in an increase in CPU utilisation. The following **ConfigMap** custom resource (CR)

disables the collection of Operator performance data by OLM.

Recommended cluster OLM configuration (`ReduceOLMFootprint.yaml`)

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: collect-profiles-config
  namespace: openshift-operator-lifecycle-manager
data:
  pprof-config.yaml: |
    disabled: True
```

6.8.12. LVM Storage

You can dynamically provision local storage on single-node OpenShift clusters with Logical Volume Manager (LVM) Storage.



NOTE

The recommended storage solution for single-node OpenShift is the Local Storage Operator. Alternatively, you can use LVM Storage but it requires additional CPU resources to be allocated.

The following YAML example configures the storage of the node to be available to OpenShift Container Platform applications.

Recommended LVMCluster configuration (`StorageLVMCluster.yaml`)

```
apiVersion: lvm.topolvm.io/v1alpha1
kind: LVMCluster
metadata:
  name: lvmcluster
  namespace: openshift-storage
  annotations: {}
spec: {}
#example: creating a vg1 volume group leveraging all available disks on the node
#      except the installation disk.
# storage:
#   deviceClasses:
#     - name: vg1
#       thinPoolConfig:
#         name: thin-pool-1
#         sizePercent: 90
#         overprovisionRatio: 10
```

Table 6.8. **LVMCluster** CR options for single-node OpenShift clusters

LVMCluster CR field	Description
---------------------	-------------

LVMCluster CR field	Description
deviceSelector.paths	Configure the disks used for LVM storage. If no disks are specified, the LVM Storage uses all the unused disks in the specified thin pool.

6.8.13. Network diagnostics

Single-node OpenShift clusters that run DU workloads require less inter-pod network connectivity checks to reduce the additional load created by these pods. The following custom resource (CR) disables these checks.

Recommended network diagnostics configuration ([DisableSnoNetworkDiag.yaml](#))

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
  annotations: {}
spec:
  disableNetworkDiagnostics: true
```

Additional resources

- [Deploying far edge sites using ZTP](#)

CHAPTER 7. VALIDATING SINGLE-NODE OPENSIFT CLUSTER TUNING FOR VDU APPLICATION WORKLOADS

Before you can deploy virtual distributed unit (vDU) applications, you need to tune and configure the cluster host firmware and various other cluster configuration settings. Use the following information to validate the cluster configuration to support vDU workloads.

Additional resources

- [Workload partitioning in single-node OpenShift with GitOps ZTP](#)
- [Reference configuration for deploying vDUs on single-node OpenShift](#)

7.1. RECOMMENDED FIRMWARE CONFIGURATION FOR VDU CLUSTER HOSTS

Use the following table as the basis to configure the cluster host firmware for vDU applications running on OpenShift Container Platform 4.18.



NOTE

The following table is a general recommendation for vDU cluster host firmware configuration. Exact firmware settings will depend on your requirements and specific hardware platform. Automatic setting of firmware is not handled by the zero touch provisioning pipeline.

Table 7.1. Recommended cluster host firmware settings

Firmware setting	Configuration	Description
HyperTransport (HT)	Enabled	HyperTransport (HT) bus is a bus technology developed by AMD. HT provides a high-speed link between the components in the host memory and other system peripherals.
UEFI	Enabled	Enable booting from UEFI for the vDU host.
CPU Power and Performance Policy	Performance	Set CPU Power and Performance Policy to optimize the system for performance over energy efficiency.
Uncore Frequency Scaling	Disabled	Disable Uncore Frequency Scaling to prevent the voltage and frequency of non-core parts of the CPU from being set independently.
Uncore Frequency	Maximum	Sets the non-core parts of the CPU such as cache and memory controller to their maximum possible frequency of operation.
Performance P-limit	Disabled	Disable Performance P-limit to prevent the Uncore frequency coordination of processors.

Firmware setting	Configuration	Description
Enhanced Intel® SpeedStep Tech	Enabled	Enable Enhanced Intel SpeedStep to allow the system to dynamically adjust processor voltage and core frequency that decreases power consumption and heat production in the host.
Intel® Turbo Boost Technology	Enabled	Enable Turbo Boost Technology for Intel-based CPUs to automatically allow processor cores to run faster than the rated operating frequency if they are operating below power, current, and temperature specification limits.
Intel Configurable TDP	Enabled	Enables Thermal Design Power (TDP) for the CPU.
Configurable TDP Level	Level 2	TDP level sets the CPU power consumption required for a particular performance rating. TDP level 2 sets the CPU to the most stable performance level at the cost of power consumption.
Energy Efficient Turbo	Disabled	Disable Energy Efficient Turbo to prevent the processor from using an energy-efficiency based policy.
Hardware P-States	Enabled or Disabled	Enable OS-controlled P-States to allow power saving configurations. Disable P-states (performance states) to optimize the operating system and CPU for performance over power consumption.
Package C-State	C0/C1 state	Use C0 or C1 states to set the processor to a fully active state (C0) or to stop CPU internal clocks running in software (C1).
C1E	Disabled	CPU Enhanced Halt (C1E) is a power saving feature in Intel chips. Disabling C1E prevents the operating system from sending a halt command to the CPU when inactive.
Processor C6	Disabled	C6 power-saving is a CPU feature that automatically disables idle CPU cores and cache. Disabling C6 improves system performance.
Sub-NUMA Clustering	Disabled	Sub-NUMA clustering divides the processor cores, cache, and memory into multiple NUMA domains. Disabling this option can increase performance for latency-sensitive workloads.



NOTE

Enable global SR-IOV and VT-d settings in the firmware for the host. These settings are relevant to bare-metal environments.

**NOTE**

Enable both **C-states** and OS-controlled **P-States** to allow per pod power management.

7.2. RECOMMENDED CLUSTER CONFIGURATIONS TO RUN VDU APPLICATIONS

Clusters running virtualized distributed unit (vDU) applications require a highly tuned and optimized configuration. The following information describes the various elements that you require to support vDU workloads in OpenShift Container Platform 4.18 clusters.

7.2.1. Recommended cluster MachineConfig CRs for single-node OpenShift clusters

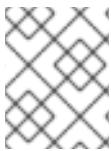
Check that the **MachineConfig** custom resources (CRs) that you extract from the **ztp-site-generate** container are applied in the cluster. The CRs can be found in the extracted **out/source-crs/extra-manifest/** folder.

The following **MachineConfig** CRs from the **ztp-site-generate** container configure the cluster host:

Table 7.2. Recommended GitOps ZTP MachineConfig CRs

MachineConfig CR	Description
01-container-mount-ns-and-kubelet-conf-master.yaml	Configures the container mount namespace and kubelet configuration.
01-container-mount-ns-and-kubelet-conf-worker.yaml	
03-sctp-machine-config-master.yaml 03-sctp-machine-config-worker.yaml	Loads the SCTP kernel module. These MachineConfig CRs are optional and can be omitted if you do not require this kernel module.
06-kdump-master.yaml 06-kdump-worker.yaml	Configures kdump crash reporting for the cluster.
07-sriov-related-kernel-args-master.yaml	Configures SR-IOV kernel arguments in the cluster.
08-set rcu-normal-master.yaml 08-set rcu-normal-worker.yaml	Disables rcu_expedited mode after the cluster has rebooted.
99-crio-disable-wipe-master.yaml 99-crio-disable-wipe-worker.yaml	Disables the automatic CRI-O cache wipe following cluster reboot.
99-sync-time-once-master.yaml 99-sync-time-once-worker.yaml	Configures the one-time check and adjustment of the system clock by the Chrony service.

MachineConfig CR	Description
enable-crun-master.yaml	Enables the crun OCI container runtime.
enable-crun-worker.yaml	
extra-manifest/enable-cgroups-v1.yaml source-crs/extra-manifest/enable-cgroups-v1.yaml	Enables cgroups v1 during cluster installation and when generating RHACM cluster policies.

**NOTE**

In OpenShift Container Platform 4.14 and later, you configure workload partitioning with the **cpuPartitioningMode** field in the **SiteConfig** CR.

Additional resources

- [Workload partitioning in single-node OpenShift with GitOps ZTP](#)
- [Extracting source CRs from the ztp-site-generate container](#)

7.2.2. Recommended cluster Operators

The following Operators are required for clusters running virtualized distributed unit (vDU) applications and are a part of the baseline reference configuration:

- Node Tuning Operator (NTO). NTO packages functionality that was previously delivered with the Performance Addon Operator, which is now a part of NTO.
- PTP Operator
- SR-IOV Network Operator
- Red Hat OpenShift Logging Operator
- Local Storage Operator

7.2.3. Recommended cluster kernel configuration

Always use the latest supported real-time kernel version in your cluster. Ensure that you apply the following configurations in the cluster:

1. Ensure that the following **additionalKernelArgs** are set in the cluster performance profile:

```

apiVersion: performance.openshift.io/v2
kind: PerformanceProfile
# ...
spec:
  additionalKernelArgs:
    - "rcupdate.rcu_normal_after_boot=0"
    - "efi=runtime"
  
```

```

- "vfio_pci.enable_sriov=1"
- "vfio_pci.disable_idle_d3=1"
- "module_blacklist=irdma"

#

```

2. Optional: Set the CPU frequency under the **hardwareTuning** field:

You can use hardware tuning to tune CPU frequencies for reserved and isolated core CPUs. For FlexRAN like applications, hardware vendors recommend that you run CPU frequencies below the default provided frequencies. It is highly recommended that, before setting any frequencies, you refer to the hardware vendor's guidelines for maximum frequency settings for your processor generation. This example sets the frequencies for reserved and isolated CPUs to 2500 MHz:

```

apiVersion: performance.openshift.io/v2
kind: PerformanceProfile
metadata:
  name: openshift-node-performance-profile
spec:
  cpu:
    isolated: "2-19,22-39"
    reserved: "0-1,20-21"
  hugepages:
    defaultHugepagesSize: 1G
  pages:
    - size: 1G
      count: 32
  realTimeKernel:
    enabled: true
  hardwareTuning:
    isolatedCpuFreq: 2500000
    reservedCpuFreq: 2500000

```

3. Ensure that the **performance-patch** profile in the **Tuned** CR configures the correct CPU isolation set that matches the **isolated** CPU set in the related **PerformanceProfile** CR, for example:

```

apiVersion: tuned.openshift.io/v1
kind: Tuned
metadata:
  name: performance-patch
  namespace: openshift-cluster-node-tuning-operator
  annotations:
    ran.openshift.io/ztp-deploy-wave: "10"
spec:
  profile:
    - name: performance-patch
      # The 'include' line must match the associated PerformanceProfile name, for example:
      # include=openshift-node-performance-${PerformanceProfile.metadata.name}
      # When using the standard (non-realtime) kernel, remove the kernel.timer_migration
      # override from the [sysctl] section
      data: |
        [main]
        summary=Configuration changes profile inherited from performance created tuned
        include=openshift-node-performance-openshift-node-performance-profile

```

```
[scheduler]
group.ice-ptp=0:f:10*:ice-ptp.*
group.ice-gnss=0:f:10*:ice-gnss.*
group.ice-dplls=0:f:10*:ice-dplls.*
[service]
service.stalld=start,enable
service.chronyd=stop,disable
# ...
```

7.2.4. Checking the realtime kernel version

Always use the latest version of the realtime kernel in your OpenShift Container Platform clusters. If you are unsure about the kernel version that is in use in the cluster, you can compare the current realtime kernel version to the release version with the following procedure.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You are logged in as a user with **cluster-admin** privileges.
- You have installed **podman**.

Procedure

1. Run the following command to get the cluster version:

```
$ OCP_VERSION=$(oc get clusterversion version -o jsonpath='{.status.desired.version} {"\n"}')
```

2. Get the release image SHA number:

```
$ DTK_IMAGE=$(oc adm release info --image-for=driver-toolkit quay.io/openshift-release-dev/ocp-release:$OCP_VERSION-x86_64)
```

3. Run the release image container and extract the kernel version that is packaged with cluster's current release:

```
$ podman run --rm $DTK_IMAGE rpm -qa | grep 'kernel-rt-core-' | sed 's#kernel-rt-core-##'
```

Example output

```
4.18.0-305.49.1.rt7.121.el8_4.x86_64
```

This is the default realtime kernel version that ships with the release.



NOTE

The realtime kernel is denoted by the string **.rt** in the kernel version.

Verification

Check that the kernel version listed for the cluster's current release matches actual realtime kernel that is running in the cluster. Run the following commands to check the running realtime kernel version:

1. Open a remote shell connection to the cluster node:

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

2. Check the realtime kernel version:

```
sh-4.4# uname -r
```

Example output

```
4.18.0-305.49.1.rt7.121.el8_4.x86_64
```

7.3. CHECKING THAT THE RECOMMENDED CLUSTER CONFIGURATIONS ARE APPLIED

You can check that clusters are running the correct configuration. The following procedure describes how to check the various configurations that you require to deploy a DU application in OpenShift Container Platform 4.18 clusters.

Prerequisites

- You have deployed a cluster and tuned it for vDU workloads.
- You have installed the OpenShift CLI (**oc**).
- You have logged in as a user with **cluster-admin** privileges.

Procedure

1. Check that the default OperatorHub sources are disabled. Run the following command:

```
$ oc get operatorhub cluster -o yaml
```

Example output

```
spec:  
  disableAllDefaultSources: true
```

2. Check that all required **CatalogSource** resources are annotated for workload partitioning (**PreferredDuringScheduling**) by running the following command:

```
$ oc get catalogsource -A -o jsonpath='{range .items[*]}.metadata.name{" -- "}'  
.metadata.annotations.target\\.workload\\.openshift\\.io/management>{"\n"}{end}'
```

Example output

```
certified-operators -- {"effect": "PreferredDuringScheduling"}  
community-operators -- {"effect": "PreferredDuringScheduling"}  
ran-operators ①
```

```
redhat-marketplace -- {"effect": "PreferredDuringScheduling"}
redhat-operators -- {"effect": "PreferredDuringScheduling"}
```

- 1 **CatalogSource** resources that are not annotated are also returned. In this example, the **ran-operators CatalogSource** resource is not annotated and does not have the **PreferredDuringScheduling** annotation.

**NOTE**

In a properly configured vDU cluster, only a single annotated catalog source is listed.

3. Check that all applicable OpenShift Container Platform Operator namespaces are annotated for workload partitioning. This includes all Operators installed with core OpenShift Container Platform and the set of additional Operators included in the reference DU tuning configuration. Run the following command:

```
$ oc get namespaces -A -o jsonpath='{range .items[*]}\{.metadata.name\}" -- "
{.metadata.annotations.workload.openshift.io/allowed}\{"\n"\}{end}'
```

Example output

```
default --
openshift-apiserver -- management
openshift-apiserver-operator -- management
openshift-authentication -- management
openshift-authentication-operator -- management
```

**IMPORTANT**

Additional Operators must not be annotated for workload partitioning. In the output from the previous command, additional Operators should be listed without any value on the right side of the **--** separator.

4. Check that the **ClusterLogging** configuration is correct. Run the following commands:

- a. Validate that the appropriate input and output logs are configured:

```
$ oc get -n openshift-logging ClusterLogForwarder instance -o yaml
```

Example output

```
apiVersion: logging.openshift.io/v1
kind: ClusterLogForwarder
metadata:
  creationTimestamp: "2022-07-19T21:51:41Z"
  generation: 1
  name: instance
  namespace: openshift-logging
  resourceVersion: "1030342"
  uid: 8c1a842d-80c5-447a-9150-40350bdf40f0
spec:
```

```

inputs:
- infrastructure: {}
  name: infra-logs
outputs:
- name: kafka-open
  type: kafka
  url: tcp://10.46.55.190:9092/test
pipelines:
- inputRefs:
  - audit
  name: audit-logs
  outputRefs:
  - kafka-open
- inputRefs:
  - infrastructure
  name: infrastructure-logs
  outputRefs:
  - kafka-open
...

```

- b. Check that the curation schedule is appropriate for your application:

```
$ oc get -n openshift-logging clusterloggings.logging.openshift.io instance -o yaml
```

Example output

```

apiVersion: logging.openshift.io/v1
kind: ClusterLogging
metadata:
  creationTimestamp: "2022-07-07T18:22:56Z"
  generation: 1
  name: instance
  namespace: openshift-logging
  resourceVersion: "235796"
  uid: ef67b9b8-0e65-4a10-88ff-ec06922ea796
spec:
  collection:
    logs:
      fluentd: {}
      type: fluentd
  curation:
    curator:
      schedule: 30 3 * * *
      type: curator
    managementState: Managed
...

```

5. Check that the web console is disabled (**managementState: Removed**) by running the following command:

```
$ oc get consoles.operator.openshift.io cluster -o jsonpath="{ .spec.managementState }"
```

Example output

Removed

- Check that **chrony** is disabled on the cluster node by running the following commands:

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

Check the status of **chrony** on the node:

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

```
sh-4.4# systemctl status chronyd
```

Example output

```
● chronyd.service - NTP client/server
  Loaded: loaded (/usr/lib/systemd/system/chronyd.service; disabled; vendor preset: enabled)
  Active: inactive (dead)
    Docs: man:chronyd(8)
          man:chrony.conf(5)
```

- Check that the PTP interface is successfully synchronized to the primary clock using a remote shell connection to the **linuxptp-daemon** container and the PTP Management Client (**pmc**) tool:

- Set the **\$PTP_POD_NAME** variable with the name of the **linuxptp-daemon** pod by running the following command:

```
$ PTP_POD_NAME=$(oc get pods -n openshift-ptp -l app=linuxptp-daemon -o name)
```

- Run the following command to check the sync status of the PTP device:

```
$ oc -n openshift-ptp rsh -c linuxptp-daemon-container ${PTP_POD_NAME} pmc -u -f /var/run/ptp4l.0.config -b 0 'GET PORT_DATA_SET'
```

Example output

```
sending: GET PORT_DATA_SET
3cecef.ffe.7a7020-1 seq 0 RESPONSE MANAGEMENT PORT_DATA_SET
portIdentity      3cecef.ffe.7a7020-1
portState        SLAVE
logMinDelayReqInterval -4
peerMeanPathDelay 0
logAnnounceInterval 1
announceReceiptTimeout 3
logSyncInterval   0
delayMechanism    1
logMinPdelayReqInterval 0
versionNumber     2
3cecef.ffe.7a7020-2 seq 0 RESPONSE MANAGEMENT PORT_DATA_SET
portIdentity      3cecef.ffe.7a7020-2
portState        LISTENING
logMinDelayReqInterval 0
```

```

peerMeanPathDelay      0
logAnnounceInterval   1
announceReceiptTimeout 3
logSyncInterval        0
delayMechanism         1
logMinPdelayReqInterval 0
versionNumber          2

```

- c. Run the following **pmc** command to check the PTP clock status:

```
$ oc -n openshift-ptp rsh -c linuxptp-daemon-container ${PTP_POD_NAME} pmc -u -f /var/run/ptp4l.0.config -b 0 'GET TIME_STATUS_NP'
```

Example output

```

sending: GET TIME_STATUS_NP
3cecef.ffe.7a7020-0 seq 0 RESPONSE MANAGEMENT TIME_STATUS_NP
master_offset      10 ①
ingress_time       1657275432697400530
cumulativeScaledRateOffset +0.000000000
scaledLastGmPhaseChange 0
gmTimeBaseIndicator 0
lastGmPhaseChange   0x0000'0000000000000000.0000
gmPresent          true ②
gmlIdentity        3c2c30.ffff.670e00

```

- ① **master_offset** should be between -100 and 100 ns.
- ② Indicates that the PTP clock is synchronized to a master, and the local clock is not the grandmaster clock.

- d. Check that the expected **master offset** value corresponding to the value in **/var/run/ptp4l.0.config** is found in the **linuxptp-daemon-container** log:

```
$ oc logs ${PTP_POD_NAME} -n openshift-ptp -c linuxptp-daemon-container
```

Example output

```

phc2sys[56020.341]: [ptp4l.1.config] CLOCK_REALTIME phc offset -1731092 s2 freq -
1546242 delay 497
ptp4l[56020.390]: [ptp4l.1.config] master offset      -2 s2 freq -5863 path delay    541
ptp4l[56020.390]: [ptp4l.0.config] master offset      -8 s2 freq -10699 path delay    533

```

8. Check that the SR-IOV configuration is correct by running the following commands:

- a. Check that the **disableDrain** value in the **SriovOperatorConfig** resource is set to **true**:

```
$ oc get sriovoperatorconfig -n openshift-sriov-network-operator default -o jsonpath=".spec.disableDrain}{\n"}"
```

Example output

true

- b. Check that the **SriovNetworkNodeState** sync status is **Succeeded** by running the following command:

```
$ oc get SriovNetworkNodeStates -n openshift-sriov-network-operator -o jsonpath=".items[*].status.syncStatus}{\n}"
```

Example output

Succeeded

- c. Verify that the expected number and configuration of virtual functions (**Vfs**) under each interface configured for SR-IOV is present and correct in the **.status.interfaces** field. For example:

```
$ oc get SriovNetworkNodeStates -n openshift-sriov-network-operator -o yaml
```

Example output

```
apiVersion: v1
items:
- apiVersion: sriovnetwork.openshift.io/v1
  kind: SriovNetworkNodeState
...
status:
  interfaces:
  ...
  - Vfs:
    - deviceID: 154c
      driver: vfio-pci
      pciAddress: 0000:3b:0a.0
      vendor: "8086"
      vfID: 0
    - deviceID: 154c
      driver: vfio-pci
      pciAddress: 0000:3b:0a.1
      vendor: "8086"
      vfID: 1
    - deviceID: 154c
      driver: vfio-pci
      pciAddress: 0000:3b:0a.2
      vendor: "8086"
      vfID: 2
    - deviceID: 154c
      driver: vfio-pci
      pciAddress: 0000:3b:0a.3
      vendor: "8086"
      vfID: 3
    - deviceID: 154c
      driver: vfio-pci
      pciAddress: 0000:3b:0a.4
      vendor: "8086"
      vfID: 4
```

```

- deviceID: 154c
  driver: vfio-pci
  pciAddress: 0000:3b:0a.5
  vendor: "8086"
  vfID: 5
- deviceID: 154c
  driver: vfio-pci
  pciAddress: 0000:3b:0a.6
  vendor: "8086"
  vfID: 6
- deviceID: 154c
  driver: vfio-pci
  pciAddress: 0000:3b:0a.7
  vendor: "8086"
  vfID: 7

```

- Check that the cluster performance profile is correct. The **cpu** and **hugepages** sections will vary depending on your hardware configuration. Run the following command:

```
$ oc get PerformanceProfile openshift-node-performance-profile -o yaml
```

Example output

```

apiVersion: performance.openshift.io/v2
kind: PerformanceProfile
metadata:
  creationTimestamp: "2022-07-19T21:51:31Z"
  finalizers:
  - foreground-deletion
  generation: 1
  name: openshift-node-performance-profile
  resourceVersion: "33558"
  uid: 217958c0-9122-4c62-9d4d-fdc27c31118c
spec:
  additionalKernelArgs:
  - idle=poll
  - rcupdate.rcu_normal_after_boot=0
  - efi=runtime
  cpu:
    isolated: 2-51,54-103
    reserved: 0-1,52-53
  hugepages:
    defaultHugepagesSize: 1G
    pages:
    - count: 32
      size: 1G
  machineConfigPoolSelector:
    pools.operator.machineconfiguration.openshift.io/master: ""
  net:
    userLevelNetworking: true
  nodeSelector:
    node-role.kubernetes.io/master: ""
  numa:
    topologyPolicy: restricted
  realTimeKernel:

```

```

    enabled: true
  status:
    conditions:
      - lastHeartbeatTime: "2022-07-19T21:51:31Z"
        lastTransitionTime: "2022-07-19T21:51:31Z"
        status: "True"
        type: Available
      - lastHeartbeatTime: "2022-07-19T21:51:31Z"
        lastTransitionTime: "2022-07-19T21:51:31Z"
        status: "True"
        type: Upgradeable
      - lastHeartbeatTime: "2022-07-19T21:51:31Z"
        lastTransitionTime: "2022-07-19T21:51:31Z"
        status: "False"
        type: Progressing
      - lastHeartbeatTime: "2022-07-19T21:51:31Z"
        lastTransitionTime: "2022-07-19T21:51:31Z"
        status: "False"
        type: Degraded
    runtimeClass: performance-openshift-node-performance-profile
    tuned: openshift-cluster-node-tuning-operator/openshift-node-performance-openshift-node-
          performance-profile

```



NOTE

CPU settings are dependent on the number of cores available on the server and should align with workload partitioning settings. **hugepages** configuration is server and application dependent.

- Check that the **PerformanceProfile** was successfully applied to the cluster by running the following command:

```
$ oc get performanceprofile openshift-node-performance-profile -o jsonpath='{range
  .status.conditions[*]}{ "@.type }{' -- '}{@.status}{\'n\'}{end}'
```

Example output

```

Available -- True
Upgradeable -- True
Progressing -- False
Degraded -- False

```

- Check the **Tuned** performance patch settings by running the following command:

```
$ oc get tuneds.tuned.openshift.io -n openshift-cluster-node-tuning-operator performance-
patch -o yaml
```

Example output

```

apiVersion: tuned.openshift.io/v1
kind: Tuned
metadata:
  creationTimestamp: "2022-07-18T10:33:52Z"

```

```

generation: 1
name: performance-patch
namespace: openshift-cluster-node-tuning-operator
resourceVersion: "34024"
uid: f9799811-f744-4179-bf00-32d4436c08fd
spec:
  profile:
    - data:
        [main]
          summary=Configuration changes profile inherited from performance created tuned
          include=openshift-node-performance-openshift-node-performance-profile
        [bootloader]
          cmdline_crash=nohz_full=2-23,26-47 ①
        [sysctl]
          kernel.timer_migration=1
        [scheduler]
          group.ice-ptp=0:f:10:*:ice-ptp. *
        [service]
          service.stalld=start,enable
          service.chronyd=stop,disable
      name: performance-patch
  recommend:
    - machineConfigLabels:
        machineconfiguration.openshift.io/role: master
      priority: 19
    profile: performance-patch

```

① The cpu list in **cmdline=nohz_full=** will vary based on your hardware configuration.

- Check that cluster networking diagnostics are disabled by running the following command:

```
$ oc get networks.operator.openshift.io cluster -o
jsonpath='{.spec.disableNetworkDiagnostics}'
```

Example output

```
true
```

- Check that the **Kubelet** housekeeping interval is tuned to slower rate. This is set in the **containerMountNS** machine config. Run the following command:

```
$ oc describe machineconfig container-mount-namespace-and-kubelet-conf-master | grep
OPENSOURCE_MAX_HOUSEKEEPING_INTERVAL_DURATION
```

Example output

```
Environment="OPENSOURCE_MAX_HOUSEKEEPING_INTERVAL_DURATION=60s"
```

- Check that Grafana and **alertManagerMain** are disabled and that the Prometheus retention period is set to 24h by running the following command:

```
$ oc get configmap cluster-monitoring-config -n openshift-monitoring -o jsonpath="{
.data.config\yaml }"
```

Example output

```
grafana:  
  enabled: false  
alertmanagerMain:  
  enabled: false  
prometheusK8s:  
  retention: 24h
```

- a. Use the following commands to verify that Grafana and **alertManagerMain** routes are not found in the cluster:

```
$ oc get route -n openshift-monitoring alertmanager-main
```

```
$ oc get route -n openshift-monitoring grafana
```

Both queries should return **Error from server (NotFound)** messages.

15. Check that there is a minimum of 4 CPUs allocated as **reserved** for each of the **PerformanceProfile**, **Tuned** performance-patch, workload partitioning, and kernel command-line arguments by running the following command:

```
$ oc get performanceprofile -o jsonpath="{ .items[0].spec.cpu.reserved }"
```

Example output

```
0-3
```



NOTE

Depending on your workload requirements, you might require additional reserved CPUs to be allocated.

CHAPTER 8. ADVANCED MANAGED CLUSTER CONFIGURATION WITH SITECONFIG RESOURCES

You can use **SiteConfig** custom resources (CRs) to deploy custom functionality and configurations in your managed clusters at installation time.



IMPORTANT

SiteConfig v1 is deprecated starting with OpenShift Container Platform version 4.18. Equivalent and improved functionality is now available through the SiteConfig Operator using the **ClusterInstance** custom resource. For more information, see [Procedure to transition from SiteConfig CRs to the ClusterInstance API](#).

For more information about the SiteConfig Operator, see [SiteConfig](#).

8.1. CUSTOMIZING EXTRA INSTALLATION MANIFESTS IN THE GITOFS ZTP PIPELINE

You can define a set of extra manifests for inclusion in the installation phase of the GitOps Zero Touch Provisioning (ZTP) pipeline. These manifests are linked to the **SiteConfig** custom resources (CRs) and are applied to the cluster during installation. Including **MachineConfig** CRs at install time makes the installation process more efficient.

Prerequisites

- Create a Git repository where you manage your custom site configuration data. The repository must be accessible from the hub cluster and be defined as a source repository for the Argo CD application.

Procedure

1. Create a set of extra manifest CRs that the GitOps ZTP pipeline uses to customize the cluster installs.
2. In your custom **/siteconfig** directory, create a subdirectory **/custom-manifest** for your extra manifests. The following example illustrates a sample **/siteconfig** with **/custom-manifest** folder:

```

siteconfig
└── site1-sno-du.yaml
└── site2-standard-du.yaml
└── extra-manifest/
    └── custom-manifest
        └── 01-example-machine-config.yaml

```



NOTE

The subdirectory names **/custom-manifest** and **/extra-manifest** used throughout are example names only. There is no requirement to use these names and no restriction on how you name these subdirectories. In this example **/extra-manifest** refers to the Git subdirectory that stores the contents of **/extra-manifest** from the **ztp-site-generate** container.

3. Add your custom extra manifest CRs to the **siteconfig/custom-manifest** directory.
4. In your **SiteConfig** CR, enter the directory name in the **extraManifests.searchPaths** field, for example:

```
clusters:
- clusterName: "example-sno"
  networkType: "OVNKubernetes"
  extraManifests:
    searchPaths:
      - extra-manifest/ ①
      - custom-manifest/ ②
```

- ① Folder for manifests copied from the **ztp-site-generate** container.
- ② Folder for custom manifests.

5. Save the **SiteConfig**, **/extra-manifest**, and **/custom-manifest** CRs, and push them to the site configuration repo.

During cluster provisioning, the GitOps ZTP pipeline appends the CRs in the **/custom-manifest** directory to the default set of extra manifests stored in **extra-manifest/**.



NOTE

As of version 4.14 **extraManifestPath** is subject to a deprecation warning.

While **extraManifestPath** is still supported, we recommend that you use **extraManifests.searchPaths**. If you define **extraManifests.searchPaths** in the **SiteConfig** file, the GitOps ZTP pipeline does not fetch manifests from the **ztp-site-generate** container during site installation.

If you define both **extraManifestPath** and **extraManifests.searchPaths** in the **Siteconfig** CR, the setting defined for **extraManifests.searchPaths** takes precedence.

It is strongly recommended that you extract the contents of **/extra-manifest** from the **ztp-site-generate** container and push it to the GIT repository.

8.2. FILTERING CUSTOM RESOURCES USING SITECONFIG FILTERS

By using filters, you can easily customize **SiteConfig** custom resources (CRs) to include or exclude other CRs for use in the installation phase of the GitOps Zero Touch Provisioning (ZTP) pipeline.

You can specify an **inclusionDefault** value of **include** or **exclude** for the **SiteConfig** CR, along with a list of the specific **extraManifest** RAN CRs that you want to include or exclude. Setting **inclusionDefault** to **include** makes the GitOps ZTP pipeline apply all the files in **/source-crs/extra-manifest** during installation. Setting **inclusionDefault** to **exclude** does the opposite.

You can exclude individual CRs from the **/source-crs/extra-manifest** folder that are otherwise included by default. The following example configures a custom single-node OpenShift **SiteConfig** CR to exclude the **/source-crs/extra-manifest/03-sctp-machine-config-worker.yaml** CR at installation time.

Some additional optional filtering scenarios are also described.

Prerequisites

- You configured the hub cluster for generating the required installation and policy CRs.
- You created a Git repository where you manage your custom site configuration data. The repository must be accessible from the hub cluster and be defined as a source repository for the Argo CD application.

Procedure

1. To prevent the GitOps ZTP pipeline from applying the **03-sctp-machine-config-worker.yaml** CR file, apply the following YAML in the **SiteConfig** CR:

```
apiVersion: ran.openshift.io/v1
kind: SiteConfig
metadata:
  name: "site1-sno-du"
  namespace: "site1-sno-du"
spec:
  baseDomain: "example.com"
  pullSecretRef:
    name: "assisted-deployment-pull-secret"
    clusterImageSetNameRef: "openshift-4.18"
    sshPublicKey: "<ssh_public_key>"
  clusters:
    - clusterName: "site1-sno-du"
      extraManifests:
        filter:
          exclude:
            - 03-sctp-machine-config-worker.yaml
```

The GitOps ZTP pipeline skips the **03-sctp-machine-config-worker.yaml** CR during installation. All other CRs in **/source-crs/extra-manifest** are applied.

2. Save the **SiteConfig** CR and push the changes to the site configuration repository. The GitOps ZTP pipeline monitors and adjusts what CRs it applies based on the **SiteConfig** filter instructions.
3. Optional: To prevent the GitOps ZTP pipeline from applying all the **/source-crs/extra-manifest** CRs during cluster installation, apply the following YAML in the **SiteConfig** CR:

```
- clusterName: "site1-sno-du"
  extraManifests:
    filter:
      inclusionDefault: exclude
```

4. Optional: To exclude all the **/source-crs/extra-manifest** RAN CRs and instead include a custom CR file during installation, edit the custom **SiteConfig** CR to set the custom manifests folder and the **include** file, for example:

```
clusters:
- clusterName: "site1-sno-du"
  extraManifestPath: "<custom_manifest_folder>" ①
  extraManifests:
    filter:
```

```

inclusionDefault: exclude ②
include:
- custom-sctp-machine-config-worker.yaml

```

- 1** Replace **<custom_manifest_folder>** with the name of the folder that contains the custom installation CRs, for example, **user-custom-manifest/**.
- 2** Set **inclusionDefault** to **exclude** to prevent the GitOps ZTP pipeline from applying the files in **/source-crs/extra-manifest** during installation.

The following example illustrates the custom folder structure:

```

siteconfig
└── site1-sno-du.yaml
    └── user-custom-manifest
        └── custom-sctp-machine-config-worker.yaml

```

8.3. DELETING A NODE BY USING THE SITECONFIG CR

By using a **SiteConfig** custom resource (CR), you can delete and reprovision a node. This method is more efficient than manually deleting the node.

Prerequisites

- You have configured the hub cluster to generate the required installation and policy CRs.
- You have created a Git repository in which you can manage your custom site configuration data. The repository must be accessible from the hub cluster and be defined as the source repository for the Argo CD application.

Procedure

1. Update the **SiteConfig** CR to include the **bmac.agent-install.openshift.io/remove-agent-and-node-on-delete=true** annotation and push the changes to the Git repository:

```

apiVersion: ran.openshift.io/v1
kind: SiteConfig
metadata:
  name: "cnfdf20"
  namespace: "cnfdf20"
spec:
  clusters:
    nodes:
      - hostname: node6
        role: "worker"
      crAnnotations:
        add:
          BareMetalHost:
            bmac.agent-install.openshift.io/remove-agent-and-node-on-delete: true
# ...

```

2. Verify that the **BareMetalHost** object is annotated by running the following command:

```
oc get bmh -n <managed-cluster-namespace> <bmh-object> -ojsonpath='{.metadata}' | jq -r '.annotations["bmac.agent-install.openshift.io/remove-agent-and-node-on-delete"]'
```

Example output

```
true
```

3. Suppress the generation of the **BareMetalHost** CR by updating the **SiteConfig** CR to include the **crSuppression.BareMetalHost** annotation:

```
apiVersion: ran.openshift.io/v1
kind: SiteConfig
metadata:
  name: "cnfdf20"
  namespace: "cnfdf20"
spec:
  clusters:
    - nodes:
      - hostName: node6
        role: "worker"
        crSuppression:
          - BareMetalHost
# ...
```

4. Push the changes to the Git repository and wait for deprovisioning to start. The status of the **BareMetalHost** CR should change to **deprovisioning**. Wait for the **BareMetalHost** to finish deprovisioning, and be fully deleted.

Verification

1. Verify that the **BareMetalHost** and **Agent** CRs for the worker node have been deleted from the hub cluster by running the following commands:

```
$ oc get bmh -n <cluster-ns>
```

```
$ oc get agent -n <cluster-ns>
```

2. Verify that the node record has been deleted from the spoke cluster by running the following command:

```
$ oc get nodes
```



NOTE

If you are working with secrets, deleting a secret too early can cause an issue because ArgoCD needs the secret to complete resynchronization after deletion. Delete the secret only after the node cleanup, when the current ArgoCD synchronization is complete.

Next steps

To reprovision a node, delete the changes previously added to the **SiteConfig**, push the changes to the Git repository, and wait for the synchronization to complete. This regenerates the **BareMetalHost** CR of the worker node and triggers the re-install of the node.

CHAPTER 9. MANAGING CLUSTER POLICIES WITH POLICYGENERATOR RESOURCES

9.1. CONFIGURING MANAGED CLUSTER POLICIES BY USING POLICYGENERATOR RESOURCES

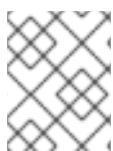
Applied **Policy** custom resources (CRs) configure the managed clusters that you provision. You can customize how Red Hat Advanced Cluster Management (RHACM) uses **PolicyGenerator** CRs to generate the applied **Policy** CRs.



IMPORTANT

Using PolicyGenerator resources with GitOps ZTP 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](#).



NOTE

For more information about **PolicyGenerator** resources, see the RHACM [Integrating Policy Generator](#) documentation.

9.1.1. Comparing RHACM PolicyGenerator and PolicyGenTemplate resource patching

PolicyGenerator custom resources (CRs) and **PolicyGenTemplate** CRs can be used in GitOps ZTP to generate RHACM policies for managed clusters.

There are advantages to using **PolicyGenerator** CRs over **PolicyGenTemplate** CRs when it comes to patching OpenShift Container Platform resources with GitOps ZTP. Using the RHACM **PolicyGenerator** API provides a generic way of patching resources which is not possible with **PolicyGenTemplate** resources.

The **PolicyGenerator** API is a part of the [Open Cluster Management](#) standard, while the **PolicyGenTemplate** API is not. A comparison of **PolicyGenerator** and **PolicyGenTemplate** resource patching and placement strategies are described in the following table.



IMPORTANT

Using **PolicyGenTemplate** CRs to manage and deploy policies to managed clusters will be deprecated in an upcoming OpenShift Container Platform release. Equivalent and improved functionality is available using Red Hat Advanced Cluster Management (RHACM) and **PolicyGenerator** CRs.

For more information about **PolicyGenerator** resources, see the RHACM [Integrating Policy Generator](#) documentation.

Table 9.1. Comparison of RHACM PolicyGenerator and PolicyGenTemplate patching

PolicyGenerator patching	PolicyGenTemplate patching
Uses Kustomize strategic merges for merging resources. For more information see Declarative Management of Kubernetes Objects Using Kustomize .	Works by replacing variables with their values as defined by the patch. This is less flexible than Kustomize merge strategies.
Supports ManagedClusterSet and Binding resources.	Does not support ManagedClusterSet and Binding resources.
Relies only on patching, no embedded variable substitution is required.	Overwrites variable values defined in the patch.
Does not support merging lists in merge patches. Replacing a list in a merge patch is supported.	Merging and replacing lists is supported in a limited fashion – you can only merge one object in the list.
Does not currently support the OpenAPI specification for resource patching. This means that additional directives are required in the patch to merge content that does not follow a schema, for example, PtpConfig resources.	Works by replacing fields and values with values as defined by the patch.
Requires additional directives, for example, \$patch: replace in the patch to merge content that does not follow a schema.	Substitutes fields and values defined in the source CR with values defined in the patch, for example \$name .
Can patch the Name and Namespace fields defined in the reference source CR, but only if the CR file has a single object.	Can patch the Name and Namespace fields defined in the reference source CR.

9.1.2. About the PolicyGenerator CRD

The **PolicyGenerator** custom resource definition (CRD) tells the **PolicyGen** policy generator what custom resources (CRs) to include in the cluster configuration, how to combine the CRs into the generated policies, and what items in those CRs need to be updated with overlay content.

The following example shows a **PolicyGenerator** CR (**acm-common-du-ranGen.yaml**) extracted from the **ztp-site-generate** reference container. The **acm-common-du-ranGen.yaml** file defines two Red Hat Advanced Cluster Management (RHACM) policies. The policies manage a collection of configuration CRs, one for each unique value of **policyName** in the CR. **acm-common-du-ranGen.yaml** creates a single placement binding and a placement rule to bind the policies to clusters based on the labels listed in the **policyDefaults.placement.labelSelector** section.

Example PolicyGenerator CR - acm-common-ranGen.yaml

```

apiVersion: policy.open-cluster-management.io/v1
kind: PolicyGenerator
metadata:
  name: common-latest
placementBindingDefaults:
  name: common-latest-placement-binding 1
policyDefaults:
  namespace: ztp-common
  placement:
    labelSelector:
      matchExpressions:
        - key: common
          operator: In
          values:
            - "true"
        - key: du-profile
          operator: In
          values:
            - latest
  remediationAction: inform
  severity: low
  namespaceSelector:
    exclude:
      - kube-*
    include:
      - *1
  evaluationInterval:
    compliant: 10m
    noncompliant: 10s
policies:
  - name: common-latest-config-policy
    policyAnnotations:
      ran.openshift.io/ztp-deploy-wave: "1"
    manifests:
      - path: source-crs/ReduceMonitoringFootprint.yaml
    patches:
      - metadata:
          name: redhat-operators-disconnected
        spec:
          displayName: disconnected-redhat-operators
          image: registry.example.com:5000/disconnected-redhat-operators/disconnected-redhat-operator-index:v4.9
      - path: source-crs/DisconnectedICSP.yaml
    patches:
      - spec:
          repositoryDigestMirrors:
            - mirrors:
                - registry.example.com:5000
              source: registry.redhat.io
  - name: common-latest-subscriptions-policy
    policyAnnotations:
      ran.openshift.io/ztp-deploy-wave: "2"

```

manifests: ③

- path: source-crs/SriovSubscriptionNS.yaml
- path: source-crs/SriovSubscriptionOperGroup.yaml
- path: source-crs/SriovSubscription.yaml
- path: source-crs/SriovOperatorStatus.yaml
- path: source-crs/PtpSubscriptionNS.yaml
- path: source-crs/PtpSubscriptionOperGroup.yaml
- path: source-crs/PtpSubscription.yaml
- path: source-crs/PtpOperatorStatus.yaml
- path: source-crs/ClusterLogNS.yaml
- path: source-crs/ClusterLogOperGroup.yaml
- path: source-crs/ClusterLogSubscription.yaml
- path: source-crs/ClusterLogOperatorStatus.yaml
- path: source-crs/StorageNS.yaml
- path: source-crs/StorageOperGroup.yaml
- path: source-crs/StorageSubscription.yaml
- path: source-crs/StorageOperatorStatus.yaml

- ① Applies the policies to all clusters with this label.
- ② The **DefaultCatsrc.yaml** file contains the catalog source for the disconnected registry and related registry configuration details.
- ③ Files listed under **policies.manifests** create the Operator policies for installed clusters.

A **PolicyGenerator** CR can be constructed with any number of included CRs. Apply the following example CR in the hub cluster to generate a policy containing a single CR:

```
apiVersion: policy.open-cluster-management.io/v1
kind: PolicyGenerator
metadata:
  name: group-du-sno
placementBindingDefaults:
  name: group-du-sno-placement-binding
policyDefaults:
  namespace: ztp-group
  placement:
    labelSelector:
      matchExpressions:
        - key: group-du-sno
          operator: Exists
  remediationAction: inform
  severity: low
  namespaceSelector:
    exclude:
      - kube-*
    include:
      - '*'
  evaluationInterval:
    compliant: 10m
    noncompliant: 10s
policies:
  - name: group-du-sno-config-policy
    policyAnnotations:
      ran.openshift.io/ztp-deploy-wave: '10'
```

```

manifests:
- path: source-crs/PtpConfigSlave-MCP-master.yaml
  patches:
    - metadata: null
      name: du-ptp-slave
      namespace: openshift-ptp
      annotations:
        ran.openshift.io/ztp-deploy-wave: '10'
  spec:
    profile:
      - name: slave
        interface: $interface
        ptpt4lOpts: '-2 -s'
        phc2sysOpts: '-a -r -n 24'
        ptptSchedulingPolicy: SCHED_FIFO
        ptptSchedulingPriority: 10
      ptptSettings:
        logReduce: 'true'
      ptpt4lConf: |
        [global]
        #
        # Default Data Set
        #
        twoStepFlag 1
        slaveOnly 1
        priority1 128
        priority2 128
        domainNumber 24
        #utc_offset 37
        clockClass 255
        clockAccuracy 0xFE
        offsetScaledLogVariance 0xFFFF
        free_running 0
        freq_est_interval 1
        dscp_event 0
        dscp_general 0
        dataset_comparison G.8275.x
        G.8275.defaultDS.localPriority 128
        #
        # Port Data Set
        #
        logAnnounceInterval -3
        logSyncInterval -4
        logMinDelayReqInterval -4
        logMinPdelayReqInterval -4
        announceReceiptTimeout 3
        syncReceiptTimeout 0
        delayAsymmetry 0
        fault_reset_interval -4
        neighborPropDelayThresh 20000000
        masterOnly 0
        G.8275.portDS.localPriority 128
        #
        # Run time options
        #
        assume_two_step 0

```

```
logging_level 6
path_trace_enabled 0
follow_up_info 0
hybrid_e2e 0
inhibit_multicast_service 0
net_sync_monitor 0
tc_spanning_tree 0
tx_timestamp_timeout 50
unicast_listen 0
unicast_master_table 0
unicast_req_duration 3600
use_syslog 1
verbose 0
summary_interval 0
kernel_leap 1
check_fup_sync 0
clock_class_threshold 7
#
# Servo Options
#
pi_proportional_const 0.0
pi_integral_const 0.0
pi_proportional_scale 0.0
pi_proportional_exponent -0.3
pi_proportional_norm_max 0.7
pi_integral_scale 0.0
pi_integral_exponent 0.4
pi_integral_norm_max 0.3
step_threshold 2.0
first_step_threshold 0.00002
max_frequency 900000000
clock_servo pi
sanity_freq_limit 200000000
ntpshm_segment 0
#
# Transport options
#
transportSpecific 0x0
ptp_dst_mac 01:1B:19:00:00:00
p2p_dst_mac 01:80:C2:00:00:0E
udp_ttl 1
udp6_scope 0x0E
uds_address /var/run/ptp4l
#
# Default interface options
#
clock_type OC
network_transport L2
delay_mechanism E2E
time_stamping hardware
tsproc_mode filter
delay_filter moving_median
delay_filter_length 10
egressLatency 0
ingressLatency 0
boundary_clock_jbod 0
```

```

#
# Clock description
#
productDescription ::;
revisionData ::;
manufacturerIdentity 00:00:00
userDescription ;
timeSource 0xA0
recommend:
- profile: slave
priority: 4
match:
- nodeLabel: node-role.kubernetes.io/master

```

Using the source file **PtpConfigSlave.yaml** as an example, the file defines a **PtpConfig** CR. The generated policy for the **PtpConfigSlave** example is named **group-du-sno-config-policy**. The **PtpConfig** CR defined in the generated **group-du-sno-config-policy** is named **du-ptp-slave**. The **spec** defined in **PtpConfigSlave.yaml** is placed under **du-ptp-slave** along with the other **spec** items defined under the source file.

The following example shows the **group-du-sno-config-policy** CR:

```

---
apiVersion: policy.open-cluster-management.io/v1
kind: PolicyGenerator
metadata:
  name: du-upgrade
placementBindingDefaults:
  name: du-upgrade-placement-binding
policyDefaults:
  namespace: ztp-group-du-sno
  placement:
    labelSelector:
      matchExpressions:
        - key: group-du-sno
          operator: Exists
  remediationAction: inform
  severity: low
  namespaceSelector:
    exclude:
      - kube-*
    include:
      - '*'
  evaluationInterval:
    compliant: 10m
    noncompliant: 10s
policies:
  - name: du-upgrade-operator-catsrc-policy
    policyAnnotations:
      ran.openshift.io/ztp-deploy-wave: "1"
    manifests:
      - path: source-crs/DefaultCatsrc.yaml
    patches:
      - metadata:
          name: redhat-operators
    spec:

```

```

displayName: Red Hat Operators Catalog
image: registry.example.com:5000/olm/redhat-operators:v4.14
updateStrategy:
  registryPoll:
    interval: 1h
status:
  connectionState:
    lastObservedState: READY

```

9.1.3. Recommendations when customizing PolicyGenerator CRs

Consider the following best practices when customizing site configuration **PolicyGenerator** custom resources (CRs):

- Use as few policies as are necessary. Using fewer policies requires less resources. Each additional policy creates increased CPU load for the hub cluster and the deployed managed cluster. CRs are combined into policies based on the **policyName** field in the **PolicyGenerator** CR. CRs in the same **PolicyGenerator** which have the same value for **policyName** are managed under a single policy.
- In disconnected environments, use a single catalog source for all Operators by configuring the registry as a single index containing all Operators. Each additional **CatalogSource** CR on the managed clusters increases CPU usage.
- **MachineConfig** CRs should be included as **extraManifests** in the **SiteConfig** CR so that they are applied during installation. This can reduce the overall time taken until the cluster is ready to deploy applications.
- **PolicyGenerator** CRs should override the channel field to explicitly identify the desired version. This ensures that changes in the source CR during upgrades does not update the generated subscription.

Additional resources

- For recommendations about scaling clusters with RHACM, see [Performance and scalability](#).



NOTE

When managing large numbers of spoke clusters on the hub cluster, minimize the number of policies to reduce resource consumption.

Grouping multiple configuration CRs into a single or limited number of policies is one way to reduce the overall number of policies on the hub cluster. When using the common, group, and site hierarchy of policies for managing site configuration, it is especially important to combine site-specific configuration into a single policy.

9.1.4. PolicyGenerator CRs for RAN deployments

Use **PolicyGenerator** custom resources (CRs) to customize the configuration applied to the cluster by using the GitOps Zero Touch Provisioning (ZTP) pipeline. The **PolicyGenerator** CR allows you to generate one or more policies to manage the set of configuration CRs on your fleet of clusters. The **PolicyGenerator** CR identifies the set of managed CRs, bundles them into policies, builds the policy wrapping around those CRs, and associates the policies with clusters by using label binding rules.

The reference configuration, obtained from the GitOps ZTP container, is designed to provide a set of

critical features and node tuning settings that ensure the cluster can support the stringent performance and resource utilization constraints typical of RAN (Radio Access Network) Distributed Unit (DU) applications. Changes or omissions from the baseline configuration can affect feature availability, performance, and resource utilization. Use the reference **PolicyGenerator** CRs as the basis to create a hierarchy of configuration files tailored to your specific site requirements.

The baseline **PolicyGenerator** CRs that are defined for RAN DU cluster configuration can be extracted from the GitOps ZTP **ztp-site-generate** container. See "Preparing the GitOps ZTP site configuration repository" for further details.

The **PolicyGenerator** CRs can be found in the `./out/argocd/example/acmpolicygenerator/` folder. The reference architecture has common, group, and site-specific configuration CRs. Each **PolicyGenerator** CR refers to other CRs that can be found in the `./out/source-crs` folder.

The **PolicyGenerator** CRs relevant to RAN cluster configuration are described below. Variants are provided for the group **PolicyGenerator** CRs to account for differences in single-node, three-node compact, and standard cluster configurations. Similarly, site-specific configuration variants are provided for single-node clusters and multi-node (compact or standard) clusters. Use the group and site-specific configuration variants that are relevant for your deployment.

Table 9.2. PolicyGenerator CRs for RAN deployments

PolicyGenerator CR	Description
acm-example-multinode-site.yaml	Contains a set of CRs that get applied to multi-node clusters. These CRs configure SR-IOV features typical for RAN installations.
acm-example-sno-site.yaml	Contains a set of CRs that get applied to single-node OpenShift clusters. These CRs configure SR-IOV features typical for RAN installations.
acm-common-mno-ranGen.yaml	Contains a set of common RAN policy configuration that get applied to multi-node clusters.
acm-common-ranGen.yaml	Contains a set of common RAN CRs that get applied to all clusters. These CRs subscribe to a set of operators providing cluster features typical for RAN as well as baseline cluster tuning.
acm-group-du-3node-ranGen.yaml	Contains the RAN policies for three-node clusters only.
acm-group-du-sno-ranGen.yaml	Contains the RAN policies for single-node clusters only.
acm-group-du-standard-ranGen.yaml	Contains the RAN policies for standard three control-plane clusters.
acm-group-du-3node-validator-ranGen.yaml	PolicyGenerator CR used to generate the various policies required for three-node clusters.

PolicyGenerator CR	Description
acm-group-du-standard-validator-ranGen.yaml	PolicyGenerator CR used to generate the various policies required for standard clusters.
acm-group-du-sno-validator-ranGen.yaml	PolicyGenerator CR used to generate the various policies required for single-node OpenShift clusters.

Additional resources

- [Preparing the GitOps ZTP site configuration repository](#)

9.1.5. Customizing a managed cluster with PolicyGenerator CRs

Use the following procedure to customize the policies that get applied to the managed cluster that you provision using the GitOps Zero Touch Provisioning (ZTP) pipeline.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.
- You configured the hub cluster for generating the required installation and policy CRs.
- You created a Git repository where you manage your custom site configuration data. The repository must be accessible from the hub cluster and be defined as a source repository for the Argo CD application.

Procedure

1. Create a **PolicyGenerator** CR for site-specific configuration CRs.
 - a. Choose the appropriate example for your CR from the `out/argocd/example/acmpolicygenerator/` folder, for example, `acm-example-sno-site.yaml` or `acm-example-multinode-site.yaml`.
 - b. Change the **policyDefaults.placement.labelSelector** field in the example file to match the site-specific label included in the **SiteConfig** CR. In the example **SiteConfig** file, the site-specific label is **sites: example-sno**.



NOTE

Ensure that the labels defined in your **PolicyGenerator** **policyDefaults.placement.labelSelector** field correspond to the labels that are defined in the related managed clusters **SiteConfig** CR.

2. Optional: Create a **PolicyGenerator** CR for any common configuration CRs that apply to the entire fleet of clusters.

- a. Select the appropriate example for your CR from the `out/argocd/example/acmpolicygenerator/` folder, for example, `acm-common-ranGen.yaml`.
- b. Change the content in the example file to match the required configuration.
3. Optional: Create a **PolicyGenerator** CR for any group configuration CRs that apply to the certain groups of clusters in the fleet.

Ensure that the content of the overlaid spec files matches your required end state. As a reference, the `out/source-crs` directory contains the full list of source-crs available to be included and overlaid by your PolicyGenerator templates.



NOTE

Depending on the specific requirements of your clusters, you might need more than a single group policy per cluster type, especially considering that the example group policies each have a single **PerformancePolicy.yaml** file that can only be shared across a set of clusters if those clusters consist of identical hardware configurations.

- a. Select the appropriate example for your CR from the `out/argocd/example/acmpolicygenerator/` folder, for example, `acm-group-du-sno-ranGen.yaml`.
- b. Change the content in the example file to match the required configuration.
4. Optional. Create a validator inform policy **PolicyGenerator** CR to signal when the GitOps ZTP installation and configuration of the deployed cluster is complete. For more information, see "Creating a validator inform policy".
5. Define all the policy namespaces in a YAML file similar to the example `out/argocd/example/acmpolicygenerator//ns.yaml` file.



IMPORTANT

Do not include the **Namespace** CR in the same file with the **PolicyGenerator** CR.

6. Add the **PolicyGenerator** CRs and **Namespace** CR to the **kustomization.yaml** file in the generators section, similar to the example shown in `out/argocd/example/acmpolicygenerator/kustomization.yaml`.
7. Commit the **PolicyGenerator** CRs, **Namespace** CR, and associated **kustomization.yaml** file in your Git repository and push the changes.

The ArgoCD pipeline detects the changes and begins the managed cluster deployment. You can push the changes to the **SiteConfig** CR and the **PolicyGenerator** CR simultaneously.

Additional resources

- [Signalling GitOps ZTP cluster deployment completion with validator inform policies](#)

9.1.6. Monitoring managed cluster policy deployment progress

The ArgoCD pipeline uses **PolicyGenerator** CRs in Git to generate the RHACM policies and then sync them to the hub cluster. You can monitor the progress of the managed cluster policy synchronization after the assisted service installs OpenShift Container Platform on the managed cluster.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.

Procedure

1. The Topology Aware Lifecycle Manager (TALM) applies the configuration policies that are bound to the cluster.

After the cluster installation is complete and the cluster becomes **Ready**, a **ClusterGroupUpgrade** CR corresponding to this cluster, with a list of ordered policies defined by the **ran.openshift.io/ztp-deploy-wave annotations**, is automatically created by the TALM. The cluster's policies are applied in the order listed in **ClusterGroupUpgrade** CR.

You can monitor the high-level progress of configuration policy reconciliation by using the following commands:

```
$ export CLUSTER=<clusterName>
$ oc get clustergroupupgrades -n ztp-install $CLUSTER -o jsonpath='{.status.conditions[-1:]}' | jq
```

Example output

```
{
  "lastTransitionTime": "2022-11-09T07:28:09Z",
  "message": "Remediating non-compliant policies",
  "reason": "InProgress",
  "status": "True",
  "type": "Progressing"
}
```

2. You can monitor the detailed cluster policy compliance status by using the RHACM dashboard or the command line.
 - a. To check policy compliance by using **oc**, run the following command:

```
$ oc get policies -n $CLUSTER
```

Example output

NAME	REMEDIATION ACTION	COMPLIANCE STATE
AGE		
ztp-common.common-config-policy	inform	Compliant
3h42m		
ztp-common.common-subscriptions-policy	inform	NonCompliant
3h42m		
ztp-group.group-du-sno-config-policy	inform	NonCompliant
3h42m		

ztp-group.group-du-sno-validator-du-policy 3h42m	inform	NonCompliant
ztp-install.example1-common-config-policy-pjz9s 167m	enforce	Compliant
ztp-install.example1-common-subscriptions-policy-zzd9k 164m	enforce	NonCompliant
ztp-site.example1-config-policy	inform	NonCompliant
ztp-site.example1-perf-policy	inform	NonCompliant

- b. To check policy status from the RHACM web console, perform the following actions:

- i. Click **Governance** → **Find policies**.
- ii. Click on a cluster policy to check its status.

When all of the cluster policies become compliant, GitOps ZTP installation and configuration for the cluster is complete. The **ztp-done** label is added to the cluster.

In the reference configuration, the final policy that becomes compliant is the one defined in the ***-du-validator-policy** policy. This policy, when compliant on a cluster, ensures that all cluster configuration, Operator installation, and Operator configuration is complete.

9.1.7. Validating the generation of configuration policy CRs

Policy custom resources (CRs) are generated in the same namespace as the **PolicyGenerator** from which they are created. The same troubleshooting flow applies to all policy CRs generated from a **PolicyGenerator** regardless of whether they are **ztp-common**, **ztp-group**, or **ztp-site** based, as shown using the following commands:

```
$ export NS=<namespace>
```

```
$ oc get policy -n $NS
```

The expected set of policy-wrapped CRs should be displayed.

If the policies failed synchronization, use the following troubleshooting steps.

Procedure

- To display detailed information about the policies, run the following command:

```
$ oc describe -n openshift-gitops application policies
```

- Check for **Status: Conditions**: to show the error logs. For example, setting an invalid **sourceFile** entry to **fileName**: generates the error shown below:

```
Status:  
Conditions:  
Last Transition Time: 2021-11-26T17:21:39Z  
Message:      rpc error: code = Unknown desc = `kustomize build  
/tmp/https____git.com/ran-sites/policies/ --enable-alpha-plugins` failed exit status 1:  
2021/11/26 17:21:40 Error could not find test.yaml under source-crs/: no such file or directory
```

```
Error: failure in plugin configured via /tmp/kust-plugin-config-52463179; exit status 1: exit
status 1
Type: ComparisonError
```

- Check for **Status: Sync:**. If there are log errors at **Status: Conditions**, the **Status: Sync:** shows **Unknown** or **Error**:

```
Status:
Sync:
Compared To:
Destination:
  Namespace: policies-sub
  Server: https://kubernetes.default.svc
Source:
  Path:     policies
  Repo URL: https://git.com/ran-sites/policies/.git
  Target Revision: master
Status:      Error
```

- When Red Hat Advanced Cluster Management (RHACM) recognizes that policies apply to a **ManagedCluster** object, the policy CR objects are applied to the cluster namespace. Check to see if the policies were copied to the cluster namespace:

```
$ oc get policy -n $CLUSTER
```

Example output

NAME	REMEDIATION ACTION	COMPLIANCE STATE	AGE
ztp-common.common-config-policy	inform	Compliant	13d
ztp-common.common-subscriptions-policy	inform	Compliant	13d
ztp-group.group-du-sno-config-policy	inform	Compliant	13d
ztp-group.group-du-sno-validator-du-policy	inform	Compliant	13d
ztp-site.example-sno-config-policy	inform	Compliant	13d

RHACM copies all applicable policies into the cluster namespace. The copied policy names have the format: **<PolicyGenerator.Namespace>. <PolicyGenerator.Name>-<policyName>**.

- Check the placement rule for any policies not copied to the cluster namespace. The **matchSelector** in the **Placement** for those policies should match labels on the **ManagedCluster** object:

```
$ oc get Placement -n $NS
```

- Note the **Placement** name appropriate for the missing policy, common, group, or site, using the following command:

```
$ oc get Placement -n $NS <placement_rule_name> -o yaml
```

- The status-decisions should include your cluster name.
- The key-value pair of the **matchSelector** in the spec must match the labels on your managed cluster.

- Check the labels on the **ManagedCluster** object by using the following command:

```
$ oc get ManagedCluster $CLUSTER -o jsonpath='{.metadata.labels}' | jq
```

- Check to see what policies are compliant by using the following command:

```
$ oc get policy -n $CLUSTER
```

If the **Namespace**, **OperatorGroup**, and **Subscription** policies are compliant but the Operator configuration policies are not, it is likely that the Operators did not install on the managed cluster. This causes the Operator configuration policies to fail to apply because the CRD is not yet applied to the spoke.

9.1.8. Restarting policy reconciliation

You can restart policy reconciliation when unexpected compliance issues occur, for example, when the **ClusterGroupUpgrade** custom resource (CR) has timed out.

Procedure

- A **ClusterGroupUpgrade** CR is generated in the namespace **ztp-install** by the Topology Aware Lifecycle Manager after the managed cluster becomes **Ready**:

```
$ export CLUSTER=<clusterName>
```

```
$ oc get clustergroupupgrades -n ztp-install $CLUSTER
```

- If there are unexpected issues and the policies fail to become complaint within the configured timeout (the default is 4 hours), the status of the **ClusterGroupUpgrade** CR shows **UpgradeTimedOut**:

```
$ oc get clustergroupupgrades -n ztp-install $CLUSTER -o jsonpath='{.status.conditions[?(@.type=="Ready")]}'
```

- A **ClusterGroupUpgrade** CR in the **UpgradeTimedOut** state automatically restarts its policy reconciliation every hour. If you have changed your policies, you can start a retry immediately by deleting the existing **ClusterGroupUpgrade** CR. This triggers the automatic creation of a new **ClusterGroupUpgrade** CR that begins reconciling the policies immediately:

```
$ oc delete clustergroupupgrades -n ztp-install $CLUSTER
```

Note that when the **ClusterGroupUpgrade** CR completes with status **UpgradeCompleted** and the managed cluster has the label **ztp-done** applied, you can make additional configuration changes by using **PolicyGenerator**. Deleting the existing **ClusterGroupUpgrade** CR will not make the TALM generate a new CR.

At this point, GitOps ZTP has completed its interaction with the cluster and any further interactions should be treated as an update and a new **ClusterGroupUpgrade** CR created for remediation of the policies.

Additional resources

- For information about using Topology Aware Lifecycle Manager (TALM) to construct your own **ClusterGroupUpgrade** CR, see [About the ClusterGroupUpgrade CR](#).

9.1.9. Changing applied managed cluster CRs using policies

You can remove content from a custom resource (CR) that is deployed in a managed cluster through a policy.

By default, all **Policy** CRs created from a **PolicyGenerator** CR have the **complianceType** field set to **musthave**. A **musthave** policy without the removed content is still compliant because the CR on the managed cluster has all the specified content. With this configuration, when you remove content from a CR, TALM removes the content from the policy but the content is not removed from the CR on the managed cluster.

With the **complianceType** field to **mustonlyhave**, the policy ensures that the CR on the cluster is an exact match of what is specified in the policy.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.
- You have deployed a managed cluster from a hub cluster running RHACM.
- You have installed Topology Aware Lifecycle Manager on the hub cluster.

Procedure

1. Remove the content that you no longer need from the affected CRs. In this example, the **disableDrain: false** line was removed from the **SriovOperatorConfig** CR.

Example CR

```
apiVersion: sriovnetwork.openshift.io/v1
kind: SriovOperatorConfig
metadata:
  name: default
  namespace: openshift-sriov-network-operator
spec:
  configDaemonNodeSelector:
    "node-role.kubernetes.io/$mcp": ""
  disableDrain: true
  enableInjector: true
  enableOperatorWebhook: true
```

2. Change the **complianceType** of the affected policies to **mustonlyhave** in the **acm-group-dusno-ranGen.yaml** file.

Example YAML

```
# ...
policyDefaults:
  complianceType: "mustonlyhave"
# ...
policies:
  - name: config-policy
  policyAnnotations:
```

```

ran.openshift.io/ztp-deploy-wave: ""
manifests:
  - path: source-crs/SriovOperatorConfig.yaml

```

3. Create a **ClusterGroupUpdates** CR and specify the clusters that must receive the CR changes::

Example ClusterGroupUpdates CR

```

apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-remove
  namespace: default
spec:
  managedPolicies:
    - ztp-group.group-du-sno-config-policy
  enable: false
  clusters:
    - spoke1
    - spoke2
  remediationStrategy:
    maxConcurrency: 2
    timeout: 240
  batchTimeoutAction:

```

4. Create the **ClusterGroupUpgrade** CR by running the following command:

```
$ oc create -f cgu-remove.yaml
```

5. When you are ready to apply the changes, for example, during an appropriate maintenance window, change the value of the **spec.enable** field to **true** by running the following command:

```
$ oc --namespace=default patch clustergroupupgrade.ran.openshift.io/cgu-remove \
--patch '{"spec":{"enable":true}}' --type=merge
```

Verification

1. Check the status of the policies by running the following command:

```
$ oc get <kind> <changed_cr_name>
```

Example output

NAMESPACE	NAME	REMEDIATION ACTION	
COMPLIANCE STATE	AGE		
default	cgu-ztp-group.group-du-sno-config-policy	enforce	17m
default	ztp-group.group-du-sno-config-policy	inform	NonCompliant
	15h		

When the **COMPLIANCE STATE** of the policy is **Compliant**, it means that the CR is updated and the unwanted content is removed.

2. Check that the policies are removed from the targeted clusters by running the following command on the managed clusters:

```
$ oc get <kind> <changed_cr_name>
```

If there are no results, the CR is removed from the managed cluster.

9.1.10. Indication of done for GitOps ZTP installations

GitOps Zero Touch Provisioning (ZTP) simplifies the process of checking the GitOps ZTP installation status for a cluster. The GitOps ZTP status moves through three phases: cluster installation, cluster configuration, and GitOps ZTP done.

Cluster installation phase

The cluster installation phase is shown by the **ManagedClusterJoined** and **ManagedClusterAvailable** conditions in the **ManagedCluster** CR. If the **ManagedCluster** CR does not have these conditions, or the condition is set to **False**, the cluster is still in the installation phase. Additional details about installation are available from the **AgentClusterInstall** and **ClusterDeployment** CRs. For more information, see "Troubleshooting GitOps ZTP".

Cluster configuration phase

The cluster configuration phase is shown by a **ztp-running** label applied the **ManagedCluster** CR for the cluster.

GitOps ZTP done

Cluster installation and configuration is complete in the GitOps ZTP done phase. This is shown by the removal of the **ztp-running** label and addition of the **ztp-done** label to the **ManagedCluster** CR. The **ztp-done** label shows that the configuration has been applied and the baseline DU configuration has completed cluster tuning.

The change to the GitOps ZTP done state is conditional on the compliant state of a Red Hat Advanced Cluster Management (RHACM) validator inform policy. This policy captures the existing criteria for a completed installation and validates that it moves to a compliant state only when GitOps ZTP provisioning of the managed cluster is complete.

The validator inform policy ensures the configuration of the cluster is fully applied and Operators have completed their initialization. The policy validates the following:

- The target **MachineConfigPool** contains the expected entries and has finished updating. All nodes are available and not degraded.
- The SR-IOV Operator has completed initialization as indicated by at least one **SriovNetworkNodeState** with **syncStatus: Succeeded**.
- The PTP Operator daemon set exists.

9.2. ADVANCED MANAGED CLUSTER CONFIGURATION WITH POLICYGENERATOR RESOURCES

You can use **PolicyGenerator** CRs to deploy custom functionality in your managed clusters.



IMPORTANT

Using PolicyGenerator resources with GitOps ZTP 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](#).



NOTE

For more information about **PolicyGenerator** resources, see the RHACM [Policy Generator](#) documentation.

9.2.1. Deploying additional changes to clusters

If you require cluster configuration changes outside of the base GitOps Zero Touch Provisioning (ZTP) pipeline configuration, there are three options:

Apply the additional configuration after the GitOps ZTP pipeline is complete

When the GitOps ZTP pipeline deployment is complete, the deployed cluster is ready for application workloads. At this point, you can install additional Operators and apply configurations specific to your requirements. Ensure that additional configurations do not negatively affect the performance of the platform or allocated CPU budget.

Add content to the GitOps ZTP library

The base source custom resources (CRs) that you deploy with the GitOps ZTP pipeline can be augmented with custom content as required.

Create extra manifests for the cluster installation

Extra manifests are applied during installation and make the installation process more efficient.



IMPORTANT

Providing additional source CRs or modifying existing source CRs can significantly impact the performance or CPU profile of OpenShift Container Platform.

Additional resources

- [Customizing extra installation manifests in the GitOps ZTP pipeline](#)

9.2.2. Using PolicyGenerator CRs to override source CRs content

PolicyGenerator custom resources (CRs) allow you to overlay additional configuration details on top of the base source CRs provided with the GitOps plugin in the **ztp-site-generate** container. You can think of **PolicyGenerator** CRs as a logical merge or patch to the base CR. Use **PolicyGenerator** CRs to update a single field of the base CR, or overlay the entire contents of the base CR. You can update values and insert fields that are not in the base CR.

The following example procedure describes how to update fields in the generated **PerformanceProfile** CR for the reference configuration based on the **PolicyGenerator** CR in the **acm-group-du-sno-ranGen.yaml** file. Use the procedure as a basis for modifying other parts of the **PolicyGenerator** based

on your requirements.

Prerequisites

- Create a Git repository where you manage your custom site configuration data. The repository must be accessible from the hub cluster and be defined as a source repository for Argo CD.

Procedure

1. Review the baseline source CR for existing content. You can review the source CRs listed in the reference **PolicyGenerator** CRs by extracting them from the GitOps Zero Touch Provisioning (ZTP) container.

- a. Create an **/out** folder:

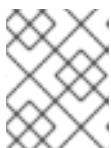
```
$ mkdir -p ./out
```

- b. Extract the source CRs:

```
$ podman run --log-driver=none --rm registry.redhat.io/openshift4/ztp-site-generate-rhel8:v4.18.1 extract /home/ztp --tar | tar x -C ./out
```

2. Review the baseline **PerformanceProfile** CR in **./out/source-crs/PerformanceProfile.yaml**:

```
apiVersion: performance.openshift.io/v2
kind: PerformanceProfile
metadata:
  name: $name
  annotations:
    ran.openshift.io/ztp-deploy-wave: "10"
spec:
  additionalKernelArgs:
    - "idle=poll"
    - "rcupdate.rcu_normal_after_boot=0"
  cpu:
    isolated: $isolated
    reserved: $reserved
  hugepages:
    defaultHugepagesSize: $defaultHugepagesSize
    pages:
      - size: $size
        count: $count
        node: $node
  machineConfigPoolSelector:
    pools.operator.machineconfiguration.openshift.io/$mcp: ""
  net:
    userLevelNetworking: true
  nodeSelector:
    node-role.kubernetes.io/$mcp: ""
  numa:
    topologyPolicy: "restricted"
  realTimeKernel:
    enabled: true
```

**NOTE**

Any fields in the source CR which contain `$...` are removed from the generated CR if they are not provided in the **PolicyGenerator** CR.

3. Update the **PolicyGenerator** entry for **PerformanceProfile** in the **acm-group-du-snoranGen.yaml** reference file. The following example **PolicyGenerator** CR stanza supplies appropriate CPU specifications, sets the **hugepages** configuration, and adds a new field that sets **globallyDisableIRQLoadBalancing** to false.

```
- path: source-crs/PerformanceProfile.yaml
patches:
- spec:
  # These must be tailored for the specific hardware platform
  cpu:
    isolated: "2-19,22-39"
    reserved: "0-1,20-21"
  hugepages:
    defaultHugepagesSize: 1G
    pages:
      - size: 1G
        count: 10
  globallyDisableIRQLoadBalancing: false
```

4. Commit the **PolicyGenerator** change in Git, and then push to the Git repository being monitored by the GitOps ZTP argo CD application.

Example output

The GitOps ZTP application generates an RHACM policy that contains the generated **PerformanceProfile** CR. The contents of that CR are derived by merging the **metadata** and **spec** contents from the **PerformanceProfile** entry in the **PolicyGenerator** onto the source CR. The resulting CR has the following content:

```
---
apiVersion: performance.openshift.io/v2
kind: PerformanceProfile
metadata:
  name: openshift-node-performance-profile
spec:
  additionalKernelArgs:
    - idle=poll
    - rcupdate.rcu_normal_after_boot=0
  cpu:
    isolated: 2-19,22-39
    reserved: 0-1,20-21
  globallyDisableIRQLoadBalancing: false
  hugepages:
    defaultHugepagesSize: 1G
    pages:
      - count: 10
        size: 1G
  machineConfigPoolSelector:
    pools.operator.machineconfiguration.openshift.io/master: ""
  net:
    userLevelNetworking: true
```

```

nodeSelector:
  node-role.kubernetes.io/master: ""
numa:
  topologyPolicy: restricted
realTimeKernel:
  enabled: true

```

NOTE

In the **/source-crs** folder that you extract from the **ztp-site-generate** container, the **\$** syntax is not used for template substitution as implied by the syntax. Rather, if the **policyGen** tool sees the **\$** prefix for a string and you do not specify a value for that field in the related **PolicyGenerator** CR, the field is omitted from the output CR entirely.

An exception to this is the **\$mcp** variable in **/source-crs** YAML files that is substituted with the specified value for **mcp** from the **PolicyGenerator** CR. For example, in **example/policygentemplates/acm-group-du-standard-ranGen.yaml**, the value for **mcp** is **worker**:

```

spec:
  bindingRules:
    group-du-standard: ""
  mcp: "worker"

```

The **policyGen** tool replace instances of **\$mcp** with **worker** in the output CRs.

9.2.3. Adding custom content to the GitOps ZTP pipeline

Perform the following procedure to add new content to the GitOps ZTP pipeline.

Procedure

- 1 Create a subdirectory named **source-crs** in the directory that contains the **kustomization.yaml** file for the **PolicyGenerator** custom resource (CR).
- 2 Add your user-provided CRs to the **source-crs** subdirectory, as shown in the following example:

```

example
└── acmpolicygenerator
    ├── dev.yaml
    ├── kustomization.yaml
    ├── mec-edge-sno1.yaml
    ├── sno.yaml
    └── source-crs ①
        ├── PaoCatalogSource.yaml
        ├── PaoSubscription.yaml
        ├── custom-crs
        │   ├── apiserver-config.yaml
        │   └── disable-nic-lldp.yaml
        └── elasticsearch
            ├── ElasticsearchNS.yaml
            └── ElasticsearchOperatorGroup.yaml

```

- 1 The **source-crs** subdirectory must be in the same directory as the **kustomization.yaml** file.
3. Update the required **PolicyGenerator** CRs to include references to the content you added in the **source-crs/custom-crs** and **source-crs/elasticsearch** directories. For example:

```
apiVersion: policy.open-cluster-management.io/v1
kind: PolicyGenerator
metadata:
  name: group-dev
placementBindingDefaults:
  name: group-dev-placement-binding
policyDefaults:
  namespace: ztp-clusters
  placement:
    labelSelector:
      matchExpressions:
        - key: dev
          operator: In
          values:
            - "true"
  remediationAction: inform
  severity: low
  namespaceSelector:
    exclude:
      - kube-*
    include:
      - '*'
  evaluationInterval:
    compliant: 10m
    noncompliant: 10s
policies:
  - name: group-dev-group-dev-cluster-log-ns
    policyAnnotations:
      ran.openshift.io/ztp-deploy-wave: "2"
    manifests:
      - path: source-crs/ClusterLogNS.yaml
  - name: group-dev-group-dev-cluster-log-operator-group
    policyAnnotations:
      ran.openshift.io/ztp-deploy-wave: "2"
    manifests:
      - path: source-crs/ClusterLogOperGroup.yaml
  - name: group-dev-group-dev-cluster-log-sub
    policyAnnotations:
      ran.openshift.io/ztp-deploy-wave: "2"
    manifests:
      - path: source-crs/ClusterLogSubscription.yaml
  - name: group-dev-group-dev-lso-ns
    policyAnnotations:
      ran.openshift.io/ztp-deploy-wave: "2"
    manifests:
      - path: source-crs/StorageNS.yaml
  - name: group-dev-group-dev-lso-operator-group
    policyAnnotations:
      ran.openshift.io/ztp-deploy-wave: "2"
```

```

manifests:
  - path: source-crs/StorageOpenGroup.yaml
- name: group-dev-group-dev-lso-sub
  policyAnnotations:
    ran.openshift.io/ztp-deploy-wave: "2"
  manifests:
    - path: source-crs/StorageSubscription.yaml
- name: group-dev-group-dev-pao-cat-source
  policyAnnotations:
    ran.openshift.io/ztp-deploy-wave: "1"
  manifests:
    - path: source-crs/PaoSubscriptionCatalogSource.yaml
  patches:
    - spec:
        image: <container_image_url>
- name: group-dev-group-dev-pao-ns
  policyAnnotations:
    ran.openshift.io/ztp-deploy-wave: "2"
  manifests:
    - path: source-crs/PaoSubscriptionNS.yaml
- name: group-dev-group-dev-pao-sub
  policyAnnotations:
    ran.openshift.io/ztp-deploy-wave: "2"
  manifests:
    - path: source-crs/PaoSubscription.yaml
- name: group-dev-group-dev-elasticsearch-ns
  policyAnnotations:
    ran.openshift.io/ztp-deploy-wave: "2"
  manifests:
    - path: elastic/ElasticsearchNS.yaml 1
- name: group-dev-group-dev-elasticsearch-operator-group
  policyAnnotations:
    ran.openshift.io/ztp-deploy-wave: "2"
  manifests:
    - path: elastic/ElasticsearchOperatorGroup.yaml
- name: group-dev-group-dev-apiserver-config
  policyAnnotations:
    ran.openshift.io/ztp-deploy-wave: "2"
  manifests:
    - path: custom-crs/apiserver-config.yaml 2
- name: group-dev-group-dev-disable-nic-lldp
  policyAnnotations:
    ran.openshift.io/ztp-deploy-wave: "2"
  manifests:
    - path: custom-crs/disable-nic-lldp.yaml

```

1 **2** Set **policies.manifests.path** to include the relative path to the file from the **/source-crs** parent directory.

4. Commit the **PolicyGenerator** change in Git, and then push to the Git repository that is monitored by the GitOps ZTP Argo CD policies application.
5. Update the **ClusterGroupUpgrade** CR to include the changed **PolicyGenerator** and save it as **cgu-test.yaml**. The following example shows a generated **cgu-test.yaml** file.

```

apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: custom-source-cr
  namespace: ztp-clusters
spec:
  managedPolicies:
    - group-dev-config-policy
  enable: true
  clusters:
    - cluster1
  remediationStrategy:
    maxConcurrency: 2
    timeout: 240

```

6. Apply the updated **ClusterGroupUpgrade** CR by running the following command:

```
$ oc apply -f cgu-test.yaml
```

Verification

- Check that the updates have succeeded by running the following command:

```
$ oc get cgu -A
```

Example output

NAMESPACE	NAME	AGE	STATE	DETAILS
ztp-clusters	custom-source-cr	6s	InProgress	Remediating non-compliant policies
ztp-install	cluster1	19h	Completed	All clusters are compliant with all the managed policies

9.2.4. Configuring policy compliance evaluation timeouts for PolicyGenerator CRs

Use Red Hat Advanced Cluster Management (RHACM) installed on a hub cluster to monitor and report on whether your managed clusters are compliant with applied policies. RHACM uses policy templates to apply predefined policy controllers and policies. Policy controllers are Kubernetes custom resource definition (CRD) instances.

You can override the default policy evaluation intervals with **PolicyGenerator** custom resources (CRs). You configure duration settings that define how long a **ConfigurationPolicy** CR can be in a state of policy compliance or non-compliance before RHACM re-evaluates the applied cluster policies.

The GitOps Zero Touch Provisioning (ZTP) policy generator generates **ConfigurationPolicy** CR policies with pre-defined policy evaluation intervals. The default value for the **noncompliant** state is 10 seconds. The default value for the **compliant** state is 10 minutes. To disable the evaluation interval, set the value to **never**.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.

- You have created a Git repository where you manage your custom site configuration data.

Procedure

1. To configure the evaluation interval for all policies in a **PolicyGenerator** CR, set appropriate **compliant** and **noncompliant** values for the **evaluationInterval** field. For example:

```
policyDefaults:
  evaluationInterval:
    compliant: 30m
    noncompliant: 45s
```



NOTE

You can also set **compliant** and **noncompliant** fields to **never** to stop evaluating the policy after it reaches particular compliance state.

2. To configure the evaluation interval for an individual policy object in a **PolicyGenerator** CR, add the **evaluationInterval** field and set appropriate values. For example:

```
policies:
  - name: "sriov-sub-policy"
    manifests:
      - path: "SriovSubscription.yaml"
        evaluationInterval:
          compliant: never
          noncompliant: 10s
```

3. Commit the **PolicyGenerator** CRs files in the Git repository and push your changes.

Verification

Check that the managed spoke cluster policies are monitored at the expected intervals.

1. Log in as a user with **cluster-admin** privileges on the managed cluster.
2. Get the pods that are running in the **open-cluster-management-agent-addon** namespace. Run the following command:

```
$ oc get pods -n open-cluster-management-agent-addon
```

Example output

NAME	READY	STATUS	RESTARTS	AGE
config-policy-controller-858b894c68-v4xdb	1/1	Running	22 (5d8h ago)	10d

3. Check the applied policies are being evaluated at the expected interval in the logs for the **config-policy-controller** pod:

```
$ oc logs -n open-cluster-management-agent-addon config-policy-controller-858b894c68-v4xdb
```

Example output

```
2022-05-10T15:10:25.280Z    info  configuration-policy-controller
controllers/configurationpolicy_controller.go:166    Skipping the policy evaluation due to the
policy not reaching the evaluation interval {"policy": "compute-1-config-policy-config"}
2022-05-10T15:10:25.280Z    info  configuration-policy-controller
controllers/configurationpolicy_controller.go:166    Skipping the policy evaluation due to the
policy not reaching the evaluation interval {"policy": "compute-1-common-compute-1-catalog-
policy-config"}
```

9.2.5. Signalling GitOps ZTP cluster deployment completion with validator inform policies

Create a validator inform policy that signals when the GitOps Zero Touch Provisioning (ZTP) installation and configuration of the deployed cluster is complete. This policy can be used for deployments of single-node OpenShift clusters, three-node clusters, and standard clusters.

Procedure

1. Create a standalone **PolicyGenerator** custom resource (CR) that contains the source file **validatorCRs/informDuValidator.yaml**. You only need one standalone **PolicyGenerator** CR for each cluster type. For example, this CR applies a validator inform policy for single-node OpenShift clusters:

Example single-node cluster validator inform policy CR (acm-group-du-sno-validator-ranGen.yaml)

```
apiVersion: policy.open-cluster-management.io/v1
kind: PolicyGenerator
metadata:
  name: group-du-sno-validator-latest
placementBindingDefaults:
  name: group-du-sno-validator-latest-placement-binding
policyDefaults:
  namespace: ztp-group
  placement:
    labelSelector:
      matchExpressions:
        - key: du-profile
          operator: In
          values:
            - latest
        - key: group-du-sno
          operator: Exists
        - key: ztp-done
          operator: DoesNotExist
  remediationAction: inform
  severity: low
  namespaceSelector:
    exclude:
      - kube-*
    include:
      - !*
evaluationInterval:
  compliant: 10m
  noncompliant: 10s
```

```

policies:
  - name: group-du-sno-validator-latest-du-policy
    policyAnnotations:
      ran.openshift.io/ztp-deploy-wave: "10000"
    evaluationInterval:
      compliant: 5s
    manifests:
      - path: source-crs/validatorCRs/informDuValidator-MCP-master.yaml

```

2. Commit the **PolicyGenerator** CR file in your Git repository and push the changes.

Additional resources

- [Upgrading GitOps ZTP](#)

9.2.6. Configuring power states using PolicyGenerator CRs

For low latency and high-performance edge deployments, it is necessary to disable or limit C-states and P-states. With this configuration, the CPU runs at a constant frequency, which is typically the maximum turbo frequency. This ensures that the CPU is always running at its maximum speed, which results in high performance and low latency. This leads to the best latency for workloads. However, this also leads to the highest power consumption, which might not be necessary for all workloads.

Workloads can be classified as critical or non-critical, with critical workloads requiring disabled C-state and P-state settings for high performance and low latency, while non-critical workloads use C-state and P-state settings for power savings at the expense of some latency and performance. You can configure the following three power states using GitOps Zero Touch Provisioning (ZTP):

- High-performance mode provides ultra low latency at the highest power consumption.
- Performance mode provides low latency at a relatively high power consumption.
- Power saving balances reduced power consumption with increased latency.

The default configuration is for a low latency, performance mode.

PolicyGenerator custom resources (CRs) allow you to overlay additional configuration details onto the base source CRs provided with the GitOps plugin in the **ztp-site-generate** container.

Configure the power states by updating the **workloadHints** fields in the generated **PerformanceProfile** CR for the reference configuration, based on the **PolicyGenerator** CR in the **acm-group-du-sno-ranGen.yaml**.

The following common prerequisites apply to configuring all three power states.

Prerequisites

- You have created a Git repository where you manage your custom site configuration data. The repository must be accessible from the hub cluster and be defined as a source repository for Argo CD.
- You have followed the procedure described in "Preparing the GitOps ZTP site configuration repository".

Additional resources

- Configuring node power consumption and realtime processing with workload hints

9.2.6.1. Configuring performance mode using PolicyGenerator CRs

Follow this example to set performance mode by updating the **workloadHints** fields in the generated **PerformanceProfile** CR for the reference configuration, based on the **PolicyGenerator** CR in the **acm-group-du-sno-ranGen.yaml**.

Performance mode provides low latency at a relatively high power consumption.

Prerequisites

- You have configured the BIOS with performance related settings by following the guidance in "Configuring host firmware for low latency and high performance".

Procedure

1. Update the **PolicyGenerator** entry for **PerformanceProfile** in the **acm-group-du-sno-ranGen.yaml** reference file in **out/argocd/example/acmpolicygenerator//** as follows to set performance mode.


```
- path: source-crs/PerformanceProfile.yaml
  patches:
    - spec:
        workloadHints:
          realTime: true
          highPowerConsumption: false
          perPodPowerManagement: false
```
2. Commit the **PolicyGenerator** change in Git, and then push to the Git repository being monitored by the GitOps ZTP Argo CD application.

9.2.6.2. Configuring high-performance mode using PolicyGenerator CRs

Follow this example to set high performance mode by updating the **workloadHints** fields in the generated **PerformanceProfile** CR for the reference configuration, based on the **PolicyGenerator** CR in the **acm-group-du-sno-ranGen.yaml**.

High performance mode provides ultra low latency at the highest power consumption.

Prerequisites

- You have configured the BIOS with performance related settings by following the guidance in "Configuring host firmware for low latency and high performance".

Procedure

1. Update the **PolicyGenerator** entry for **PerformanceProfile** in the **acm-group-du-sno-ranGen.yaml** reference file in **out/argocd/example/acmpolicygenerator/** as follows to set high-performance mode.


```
- path: source-crs/PerformanceProfile.yaml
  patches:
    - spec:
```

```

workloadHints:
  realTime: true
  highPowerConsumption: true
  perPodPowerManagement: false

```

- Commit the **PolicyGenerator** change in Git, and then push to the Git repository being monitored by the GitOps ZTP Argo CD application.

9.2.6.3. Configuring power saving mode using PolicyGenerator CRs

Follow this example to set power saving mode by updating the **workloadHints** fields in the generated **PerformanceProfile** CR for the reference configuration, based on the **PolicyGenerator** CR in the **acm-group-du-sno-ranGen.yaml**.

The power saving mode balances reduced power consumption with increased latency.

Prerequisites

- You enabled C-states and OS-controlled P-states in the BIOS.

Procedure

- Update the **PolicyGenerator** entry for **PerformanceProfile** in the **acm-group-du-sno-ranGen.yaml** reference file in **out/argocd/example/acmpolicygenerator/** as follows to configure power saving mode. It is recommended to configure the CPU governor for the power saving mode through the additional kernel arguments object.

```

- path: source-crs/PerformanceProfile.yaml
  patches:
    - spec:
        # ...
        workloadHints:
          realTime: true
          highPowerConsumption: false
          perPodPowerManagement: true
        # ...
        additionalKernelArgs:
          - "# ..."
          - "cpufreq.default_governor=schedutil" ①

```

- ① The **schedutil** governor is recommended, however, you can also use other governors, including **ondemand** and **powersave**.

- Commit the **PolicyGenerator** change in Git, and then push to the Git repository being monitored by the GitOps ZTP Argo CD application.

Verification

- Select a worker node in your deployed cluster from the list of nodes identified by using the following command:

```
$ oc get nodes
```

2. Log in to the node by using the following command:

```
$ oc debug node/<node-name>
```

Replace **<node-name>** with the name of the node you want to verify the power state on.

3. Set **/host** as the root directory within the debug shell. The debug pod mounts the host's root file system in **/host** within the pod. By changing the root directory to **/host**, you can run binaries contained in the host's executable paths as shown in the following example:

```
# chroot /host
```

4. Run the following command to verify the applied power state:

```
# cat /proc/cmdline
```

Expected output

- For power saving mode the **intel_pstate=passive**.

Additional resources

- [Configuring power saving for nodes that run colocated high and low priority workloads](#)
- [Configuring host firmware for low latency and high performance](#)
- [Preparing the GitOps ZTP site configuration repository](#)

9.2.6.4. Maximizing power savings

Limiting the maximum CPU frequency is recommended to achieve maximum power savings. Enabling C-states on the non-critical workload CPUs without restricting the maximum CPU frequency negates much of the power savings by boosting the frequency of the critical CPUs.

Maximize power savings by updating the **sysfs** plugin fields, setting an appropriate value for **max_perf_pct** in the **TunedPerformancePatch** CR for the reference configuration. This example based on the **acm-group-du-sno-ranGen.yaml** describes the procedure to follow to restrict the maximum CPU frequency.

Prerequisites

- You have configured power savings mode as described in "Using PolicyGenerator CRs to configure power savings mode".

Procedure

1. Update the **PolicyGenerator** entry for **TunedPerformancePatch** in the **acm-group-du-sno-ranGen.yaml** reference file in **out/argocd/example/acmpolicygenerator/**. To maximize power savings, add **max_perf_pct** as shown in the following example:

```
- path: source-crs/TunedPerformancePatch.yaml
  patches:
    - spec:
      profile:
```

```

- name: performance-patch
  data: |
    # ...
    [sysfs]
    /sys/devices/system/cpu/intel_pstate/max_perf_pct=<x> ①
  
```

- 1 The **max_perf_pct** controls the maximum frequency the **cpufreq** driver is allowed to set as a percentage of the maximum supported CPU frequency. This value applies to all CPUs. You can check the maximum supported frequency in **/sys/devices/system/cpu/cpu0/cpufreq/cpuinfo_max_freq**. As a starting point, you can use a percentage that caps all CPUs at the **All Cores Turbo** frequency. The **All Cores Turbo** frequency is the frequency that all cores run at when the cores are all fully occupied.



NOTE

To maximize power savings, set a lower value. Setting a lower value for **max_perf_pct** limits the maximum CPU frequency, thereby reducing power consumption, but also potentially impacting performance. Experiment with different values and monitor the system's performance and power consumption to find the optimal setting for your use-case.

- 2 Commit the **PolicyGenerator** change in Git, and then push to the Git repository being monitored by the GitOps ZTP Argo CD application.

9.2.7. Configuring LVM Storage using PolicyGenerator CRs

You can configure Logical Volume Manager (LVM) Storage for managed clusters that you deploy with GitOps Zero Touch Provisioning (ZTP).



NOTE

You use LVM Storage to persist event subscriptions when you use PTP events or bare-metal hardware events with HTTP transport.

Use the Local Storage Operator for persistent storage that uses local volumes in distributed units.

Prerequisites

- Install the OpenShift CLI (**oc**).
- Log in as a user with **cluster-admin** privileges.
- Create a Git repository where you manage your custom site configuration data.

Procedure

- 1 To configure LVM Storage for new managed clusters, add the following YAML to **policies.manifests** in the **acm-common-ranGen.yaml** file:

```

- name: subscription-policies
  policyAnnotations:
    ran.openshift.io/ztp-deploy-wave: "2"
  
```

manifests:

- path: source-crs/StorageLVMOSubscriptionNS.yaml
 - path: source-crs/StorageLVMOSubscriptionOperGroup.yaml
 - path: source-crs/StorageLVMOSubscription.yaml
- spec:
- name: lvms-operator
 - channel: stable-4.18

NOTE

The Storage LVMO subscription is deprecated. In future releases of OpenShift Container Platform, the storage LVMO subscription will not be available. Instead, you must use the Storage LVMS subscription.

In OpenShift Container Platform 4.18, you can use the Storage LVMS subscription instead of the LVMO subscription. The LVMS subscription does not require manual overrides in the **acm-common-ranGen.yaml** file. Add the following YAML to **policies.manifests** in the **acm-common-ranGen.yaml** file to use the Storage LVMS subscription:

- path: source-crs/StorageLVMSSubscriptionNS.yaml
- path: source-crs/StorageLVMSSubscriptionOperGroup.yaml
- path: source-crs/StorageLVMSSubscription.yaml

2. Add the **LVMCluster** CR to **policies.manifests** in your specific group or individual site configuration file. For example, in the **acm-group-du-sno-ranGen.yaml** file, add the following:

```

- fileName: StorageLVMCluster.yaml
  policyName: "lvms-config"
  metadata:
    name: "lvms-storage-cluster-config"
  spec:
    storage:
      deviceClasses:
        - name: vg1
          thinPoolConfig:
            name: thin-pool-1
            sizePercent: 90
            overprovisionRatio: 10

```

This example configuration creates a volume group (**vg1**) with all the available devices, except the disk where OpenShift Container Platform is installed. A thin-pool logical volume is also created.

3. Merge any other required changes and files with your custom site repository.
4. Commit the **PolicyGenerator** changes in Git, and then push the changes to your site configuration repository to deploy LVM Storage to new sites using GitOps ZTP.

9.2.8. Configuring PTP events with PolicyGenerator CRs

You can use the GitOps ZTP pipeline to configure PTP events that use HTTP transport.

9.2.8.1. Configuring PTP events that use HTTP transport

You can configure PTP events that use HTTP transport on managed clusters that you deploy with the GitOps Zero Touch Provisioning (ZTP) pipeline.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in as a user with **cluster-admin** privileges.
- You have created a Git repository where you manage your custom site configuration data.

Procedure

1. Apply the following **PolicyGenerator** changes to **acm-group-du-3node-ranGen.yaml**, **acm-group-du-sno-ranGen.yaml**, or **acm-group-du-standard-ranGen.yaml** files according to your requirements:

- a. In **policies.manifests**, add the **PtpOperatorConfig** CR file that configures the transport host:

```
- path: source-crs/PtpOperatorConfigForEvent.yaml
  patches:
  - metadata:
      name: default
      namespace: openshift-ptp
      annotations:
        ran.openshift.io/ztp-deploy-wave: "10"
    spec:
      daemonNodeSelector:
        node-role.kubernetes.io/$mcp: ""
      ptpEventConfig:
        enableEventPublisher: true
        transportHost: "http://ptp-event-publisher-service-NODE_NAME.openshift-
ptp.svc.cluster.local:9043"
```



NOTE

In OpenShift Container Platform 4.13 or later, you do not need to set the **transportHost** field in the **PtpOperatorConfig** resource when you use HTTP transport with PTP events.

- b. Configure the **linuxptp** and **phc2sys** for the PTP clock type and interface. For example, add the following YAML into **policies.manifests**:

```
- path: source-crs/PtpConfigSlave.yaml ①
  patches:
  - metadata:
      name: "du-ptp-slave"
    spec:
      recommend:
      - match:
          - nodeLabel: node-role.kubernetes.io/master
      priority: 4
```

```
profile: slave
profile:
- name: "slave"
# This interface must match the hardware in this group
interface: "ens5f0" 2
ptp4lOpts: "-2 -s --summary_interval -4" 3
phc2sysOpts: "-a -r -n 24" 4
ptpSchedulingPolicy: SCHED_FIFO
ptpSchedulingPriority: 10
ptpSettings:
logReduce: "true"
ptp4lConf: |
[global]
#
# Default Data Set
#
twoStepFlag 1
slaveOnly 1
priority1 128
priority2 128
domainNumber 24
#utc_offset 37
clockClass 255
clockAccuracy 0xFE
offsetScaledLogVariance 0xFFFF
free_running 0
freq_est_interval 1
dscp_event 0
dscp_general 0
dataset_comparison G.8275.x
G.8275.defaultDS.localPriority 128
#
# Port Data Set
#
logAnnounceInterval -3
logSyncInterval -4
logMinDelayReqInterval -4
logMinPdelayReqInterval -4
announceReceiptTimeout 3
syncReceiptTimeout 0
delayAsymmetry 0
fault_reset_interval -4
neighborPropDelayThresh 20000000
masterOnly 0
G.8275.portDS.localPriority 128
#
# Run time options
#
assume_two_step 0
logging_level 6
path_trace_enabled 0
follow_up_info 0
hybrid_e2e 0
inhibit_multicast_service 0
net_sync_monitor 0
tc_spanning_tree 0
```

```
tx_timestamp_timeout 50
unicast_listen 0
unicast_master_table 0
unicast_req_duration 3600
use_syslog 1
verbose 0
summary_interval 0
kernel_leap 1
check_fup_sync 0
clock_class_threshold 7
#
# Servo Options
#
pi_proportional_const 0.0
pi_integral_const 0.0
pi_proportional_scale 0.0
pi_proportional_exponent -0.3
pi_proportional_norm_max 0.7
pi_integral_scale 0.0
pi_integral_exponent 0.4
pi_integral_norm_max 0.3
step_threshold 2.0
first_step_threshold 0.00002
max_frequency 900000000
clock_servo pi
sanity_freq_limit 200000000
ntpshm_segment 0
#
# Transport options
#
transportSpecific 0x0
ptp_dst_mac 01:1B:19:00:00:00
p2p_dst_mac 01:80:C2:00:00:0E
udp_ttl 1
udp6_scope 0x0E
uds_address /var/run/ptp4l
#
# Default interface options
#
clock_type OC
network_transport L2
delay_mechanism E2E
time_stamping hardware
tsproc_mode filter
delay_filter moving_median
delay_filter_length 10
egressLatency 0
ingressLatency 0
boundary_clock_jbod 0
#
# Clock description
#
productDescription ;;
revisionData ;;
manufacturerIdentity 00:00:00
userDescription ;
```

```

timeSource 0xA0
ptpClockThreshold: ⑤
  holdOverTimeout: 30 # seconds
  maxOffsetThreshold: 100 # nano seconds
  minOffsetThreshold: -100

```

- ① Can be **PtpConfigMaster.yaml** or **PtpConfigSlave.yaml** depending on your requirements. For configurations based on **acm-group-du-sno-ranGen.yaml** or **acm-group-du-3node-ranGen.yaml**, use **PtpConfigSlave.yaml**.
- ② Device specific interface name.
- ③ You must append the **--summary_interval -4** value to **ptp4lOpts** in **.spec.sourceFiles.spec.profile** to enable PTP fast events.
- ④ Required **phc2sysOpts** values. **-m** prints messages to **stdout**. The **linuxptp-daemon DaemonSet** parses the logs and generates Prometheus metrics.
- ⑤ Optional. If the **ptpClockThreshold** stanza is not present, default values are used for the **ptpClockThreshold** fields. The stanza shows default **ptpClockThreshold** values. The **ptpClockThreshold** values configure how long after the PTP master clock is disconnected before PTP events are triggered. **holdOverTimeout** is the time value in seconds before the PTP clock event state changes to **FREERUN** when the PTP master clock is disconnected. The **maxOffsetThreshold** and **minOffsetThreshold** settings configure offset values in nanoseconds that compare against the values for **CLOCK_REALTIME (phc2sys)** or master offset (**ptp4l**). When the **ptp4l** or **phc2sys** offset value is outside this range, the PTP clock state is set to **FREERUN**. When the offset value is within this range, the PTP clock state is set to **LOCKED**.

2. Merge any other required changes and files with your custom site repository.
3. Push the changes to your site configuration repository to deploy PTP fast events to new sites using GitOps ZTP.

Additional resources

- [Using PolicyGenerator CRs to override source CRs content](#)

Additional resources

- [OpenShift image registry overview](#)

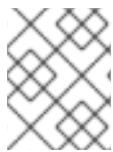
9.2.9. Configuring the Image Registry Operator for local caching of images

OpenShift Container Platform manages image caching using a local registry. In edge computing use cases, clusters are often subject to bandwidth restrictions when communicating with centralized image registries, which might result in long image download times.

Long download times are unavoidable during initial deployment. Over time, there is a risk that CRI-O will erase the **/var/lib/containers/storage** directory in the case of an unexpected shutdown. To address long image download times, you can create a local image registry on remote managed clusters using GitOps Zero Touch Provisioning (ZTP). This is useful in Edge computing scenarios where clusters are deployed at the far edge of the network.

Before you can set up the local image registry with GitOps ZTP, you need to configure disk partitioning

in the **SiteConfig** CR that you use to install the remote managed cluster. After installation, you configure the local image registry using a **PolicyGenerator** CR. Then, the GitOps ZTP pipeline creates Persistent Volume (PV) and Persistent Volume Claim (PVC) CRs and patches the **imagerregistry** configuration.



NOTE

The local image registry can only be used for user application images and cannot be used for the OpenShift Container Platform or Operator Lifecycle Manager operator images.

Additional resources

- [OpenShift Container Platform registry overview](#)

9.2.9.1. Configuring disk partitioning with SiteConfig

Configure disk partitioning for a managed cluster using a **SiteConfig** CR and GitOps Zero Touch Provisioning (ZTP). The disk partition details in the **SiteConfig** CR must match the underlying disk.



IMPORTANT

You must complete this procedure at installation time.

Prerequisites

- Install Butane.

Procedure

- 1 Create the **storage.bu** file.

```
variant: fcos
version: 1.3.0
storage:
  disks:
    - device: /dev/disk/by-path/pci-0000:01:00.0-scsi-0:2:0:0 ①
      wipe_table: false
    partitions:
      - label: var-lib-containers
        start_mib: <start_of_partition> ②
        size_mib: <partition_size> ③
  filesystems:
    - path: /var/lib/containers
      device: /dev/disk/by-partlabel/var-lib-containers
      format: xfs
      wipe_filesystem: true
      with_mount_unit: true
      mount_options:
        - defaults
        - prjquota
```

- 1 Specify the root disk.
- 2 Specify the start of the partition in MiB. If the value is too small, the installation fails.

- 3** Specify the size of the partition. If the value is too small, the deployments fails.

- Convert the **storage.bu** to an Ignition file by running the following command:

```
$ butane storage.bu
```

Example output

```
{"ignition":{"version":"3.2.0"},"storage":{"disks":[{"device":"/dev/disk/by-path/pci-0000:01:00.0-scsi-0:2:0:0","partitions":[{"label":"var-lib-containers","sizeMiB":0,"startMiB":250000}],"wipeTable":false}],"filesystems":[{"device":"/dev/disk/by-partlabel/var-lib-containers","format":"xfs","mountOptions":["defaults","prjquota"],"path":"/var/lib/containers","wipeFilesystem":true}]},"systemd":{"units":[{"contents": "# # Generated by Butane\n[Unit]\nRequires=systemd-fsck@dev-disk-by\\x2dpartlabel-var\\x2dlib\\x2dcontainers.service\nAfter=systemd-fsck@dev-disk-by\\x2dpartlabel-var\\x2dlib\\x2dcontainers.service\n\n[Mount]\nWhere=/var/lib/containers\nWhat=/dev/disk/by-partlabel/var-lib-containers\nType=xfs\nOptions=defaults,prjquota\n\n[Install]\nRequiredBy=local-fs.target","enabled":true,"name":"var-lib-containers.mount"}]}}
```

- Use a tool such as [JSON Pretty Print](#) to convert the output into JSON format.
- Copy the output into the **.spec.clusters.nodes.ignitionConfigOverride** field in the **SiteConfig** CR.

Example

```
[...]
spec:
clusters:
- nodes:
  - ignitionConfigOverride: |
    {
      "ignition": {
        "version": "3.2.0"
      },
      "storage": {
        "disks": [
          {
            "device": "/dev/disk/by-path/pci-0000:01:00.0-scsi-0:2:0:0",
            "partitions": [
              {
                "label": "var-lib-containers",
                "sizeMiB": 0,
                "startMiB": 250000
              }
            ],
            "wipeTable": false
          }
        ],
        "filesystems": [
          {
            "device": "/dev/disk/by-partlabel/var-lib-containers",
            "format": "xfs",
            "mountOptions": [
              "defaults",
              "prjquota"
            ],
            "path": "/var/lib/containers"
          }
        ]
      }
    }
```

```

    "format": "xfs",
    "mountOptions": [
        "defaults",
        "prjquota"
    ],
    "path": "/var/lib/containers",
    "wipeFilesystem": true
}
]
},
"systemd": {
    "units": [
        {
            "contents": "# # Generated by Butane\n[Unit]\nRequires=systemd-fsck@dev-disk-
by\\x2dpartlabel-var\\x2dlib\\x2dcontainers.service\nAfter=systemd-fsck@dev-disk-
by\\x2dpartlabel-
var\\x2dlib\\x2dcontainers.service\n\n[Mount]\nWhere=/var/lib/containers\nWhat=/dev/disk/by-
partlabel/var-lib-
containers\nType=xfs\nOptions=defaults,prjquota\n\n[Install]\nRequiredBy=local-fs.target",
            "enabled": true,
            "name": "var-lib-containers.mount"
        }
    ]
}
}
[...]

```



NOTE

If the **.spec.clusters.nodes.ignitionConfigOverride** field does not exist, create it.

Verification

- During or after installation, verify on the hub cluster that the **BareMetalHost** object shows the annotation by running the following command:

```
$ oc get bmh -n my-sno-ns my-sno -ojson | jq '.metadata.annotations["bmac.agent-
install.openshift.io/ignition-config-overrides"]'
```

Example output

```
"{\\"ignition\\":{\\"version\\":\"3.2.0\"},\"storage\\":{\\"disks\\": [{"device\\":\"/dev/disk/by-id/wwn-
0x6b07b250ebb9d0002a33509f24af1f62\", \"partitions\\": [{"label\\":\"var-lib-
containers\", \"sizeMiB\\":0, \"startMiB\\":250000}], \"wipeTable\\":false}], \"filesystems\\":
[{"device\\":\"/dev/disk/by-partlabel/var-lib-containers\", \"format\\":\"xfs\", \"mountOptions\\":
[\"defaults\", \"prjquota\"], \"path\\\":/var/lib/containers\", \"wipeFilesystem\\":true}]], \"systemd\\":
{\\"units\\": [{"contents\\": "# Generated by Butane\\n[Unit]\\nRequires=systemd-fsck@dev-disk-
by\\x2dpartlabel-var\\x2dlib\\x2dcontainers.service\\nAfter=systemd-fsck@dev-disk-
by\\x2dpartlabel-
var\\x2dlib\\x2dcontainers.service\\n\n[Mount]\\nWhere=/var/lib/containers\\nWhat=/dev/disk/
by-partlabel/var-lib-
containers\\nType=xfs\\nOptions=defaults,prjquota\\n\\n[Install]\\nRequiredBy=local-
fs.target\\\", \"enabled\\":true, \"name\\\":\"var-lib-containers.mount\"}]}}}
```

2. After installation, check the single-node OpenShift disk status.
 - a. Enter into a debug session on the single-node OpenShift node by running the following command. This step instantiates a debug pod called <node_name>-debug:


```
$ oc debug node/my-sno-node
```
 - b. Set /host as the root directory within the debug shell by running the following command. The debug pod mounts the host's root file system in /host within the pod. By changing the root directory to /host, you can run binaries contained in the host's executable paths:


```
# chroot /host
```
 - c. List information about all available block devices by running the following command:


```
# lsblk
```

Example output

```
NAME  MAJ:MIN RM  SIZE RO TYPE MOUNTPOINTS
sda   8:0    0 446.6G 0 disk
└─sda1 8:1    0   1M 0 part
└─sda2 8:2    0 127M 0 part
└─sda3 8:3    0 384M 0 part /boot
└─sda4 8:4    0 243.6G 0 part /var
              /sysroot/ostree/deploy/rhcos/var
              /usr
              /etc
              /
              /sysroot
└─sda5 8:5    0 202.5G 0 part /var/lib/containers
```

- d. Display information about the file system disk space usage by running the following command:

```
# df -h
```

Example output

Filesystem	Size	Used	Avail	Use%	Mounted on
devtmpfs	4.0M	0	4.0M	0%	/dev
tmpfs	126G	84K	126G	1%	/dev/shm
tmpfs	51G	93M	51G	1%	/run
/dev/sda4	244G	5.2G	239G	3%	/sysroot
tmpfs	126G	4.0K	126G	1%	/tmp
/dev/sda5	203G	119G	85G	59%	/var/lib/containers
/dev/sda3	350M	110M	218M	34%	/boot
tmpfs	26G	0	26G	0%	/run/user/1000

9.2.9.2. Configuring the image registry using PolicyGenerator CRs

Use **PolicyGenerator** (PGT) CRs to apply the CRs required to configure the image registry and patch the **imageregistry** configuration.

Prerequisites

- You have configured a disk partition in the managed cluster.
- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.
- You have created a Git repository where you manage your custom site configuration data for use with GitOps Zero Touch Provisioning (ZTP).

Procedure

1. Configure the storage class, persistent volume claim, persistent volume, and image registry configuration in the appropriate **PolicyGenerator** CR. For example, to configure an individual site, add the following YAML to the file **acm-example-sno-site.yaml**:

```

sourceFiles:
  # storage class
  - fileName: StorageClass.yaml
    policyName: "sc-for-image-registry"
    metadata:
      name: image-registry-sc
      annotations:
        ran.openshift.io/ztp-deploy-wave: "100" ①
  # persistent volume claim
  - fileName: StoragePVC.yaml
    policyName: "pvc-for-image-registry"
    metadata:
      name: image-registry-pvc
      namespace: openshift-image-registry
      annotations:
        ran.openshift.io/ztp-deploy-wave: "100"
  spec:
    accessModes:
      - ReadWriteMany
    resources:
      requests:
        storage: 100Gi
    storageClassName: image-registry-sc
    volumeMode: Filesystem
  # persistent volume
  - fileName: ImageRegistryPV.yaml ②
    policyName: "pv-for-image-registry"
    metadata:
      annotations:
        ran.openshift.io/ztp-deploy-wave: "100"
  - fileName: ImageRegistryConfig.yaml
    policyName: "config-for-image-registry"
    complianceType: musthave
    metadata:
      annotations:
        ran.openshift.io/ztp-deploy-wave: "100"
  spec:

```

```

storage:
pvc:
  claim: "image-registry-pvc"

```

- 1 Set the appropriate value for **ztp-deploy-wave** depending on whether you are configuring image registries at the site, common, or group level. **ztp-deploy-wave: "100"** is suitable for development or testing because it allows you to group the referenced source files together.
- 2 In **ImageRegistryPV.yaml**, ensure that the **spec.local.path** field is set to **/var/imageregistry** to match the value set for the **mount_point** field in the **SiteConfig** CR.



IMPORTANT

Do not set **complianceType: mustonlyhave** for the **-fileName: ImageRegistryConfig.yaml** configuration. This can cause the registry pod deployment to fail.

2. Commit the **PolicyGenerator** change in Git, and then push to the Git repository being monitored by the GitOps ZTP ArgoCD application.

Verification

Use the following steps to troubleshoot errors with the local image registry on the managed clusters:

- Verify successful login to the registry while logged in to the managed cluster. Run the following commands:
 - a. Export the managed cluster name:


```
$ cluster=<managed_cluster_name>
```
 - b. Get the managed cluster **kubeconfig** details:


```
$ oc get secret -n $cluster $cluster-admin-password -o jsonpath='{.data.password}' | base64 -d > kubeadmin-password-$cluster
```
 - c. Download and export the cluster **kubeconfig**:


```
$ oc get secret -n $cluster $cluster-admin-kubeconfig -o jsonpath='{.data.kubeconfig}' | base64 -d > kubeconfig-$cluster && export KUBECONFIG=./kubeconfig-$cluster
```
 - d. Verify access to the image registry from the managed cluster. See "Accessing the registry".
- Check that the **Config** CRD in the **imageregistry.operator.openshift.io** group instance is not reporting errors. Run the following command while logged in to the managed cluster:


```
$ oc get image.config.openshift.io cluster -o yaml
```

Example output

```

apiVersion: config.openshift.io/v1
kind: Image

```

```

metadata:
  annotations:
    include.release.openshift.io/ibm-cloud-managed: "true"
    include.release.openshift.io/self-managed-high-availability: "true"
    include.release.openshift.io/single-node-developer: "true"
    release.openshift.io/create-only: "true"
  creationTimestamp: "2021-10-08T19:02:39Z"
  generation: 5
  name: cluster
  resourceVersion: "688678648"
  uid: 0406521b-39c0-4cda-ba75-873697da75a4
spec:
  additionalTrustedCA:
    name: acm-ice

```

- Check that the **PersistentVolumeClaim** on the managed cluster is populated with data. Run the following command while logged in to the managed cluster:

```
$ oc get pv image-registry-sc
```

- Check that the **registry*** pod is running and is located under the **openshift-image-registry** namespace.

```
$ oc get pods -n openshift-image-registry | grep registry*
```

Example output

```

cluster-image-registry-operator-68f5c9c589-42cfg 1/1 Running 0 8d
image-registry-5f8987879-6nx6h 1/1 Running 0 8d

```

- Check that the disk partition on the managed cluster is correct:

- Open a debug shell to the managed cluster:

```
$ oc debug node/sno-1.example.com
```

- Run **lsblk** to check the host disk partitions:

```

sh-4.4# lsblk
NAME MAJ:MIN RM SIZE RO TYPE MOUNTPOINT
sda 8:0 0 446.6G 0 disk
|-sda1 8:1 0 1M 0 part
|-sda2 8:2 0 127M 0 part
|-sda3 8:3 0 384M 0 part /boot
|-sda4 8:4 0 336.3G 0 part /sysroot
`-sda5 8:5 0 100.1G 0 part /var/imageregistry ①
sdb 8:16 0 446.6G 0 disk
sr0 11:0 1 104M 0 rom

```

① **/var/imageregistry** indicates that the disk is correctly partitioned.

Additional resources

- [Accessing the registry](#)

9.3. UPDATING MANAGED CLUSTERS IN A DISCONNECTED ENVIRONMENT WITH POLICYGENERATOR RESOURCES AND TALM

You can use the Topology Aware Lifecycle Manager (TALM) to manage the software lifecycle of managed clusters that you have deployed using GitOps Zero Touch Provisioning (ZTP) and Topology Aware Lifecycle Manager (TALM). TALM uses Red Hat Advanced Cluster Management (RHACM) PolicyGenerator policies to manage and control changes applied to target clusters.



IMPORTANT

Using PolicyGenerator resources with GitOps ZTP 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](#).

Additional resources

- For more information about the Topology Aware Lifecycle Manager, see [About the Topology Aware Lifecycle Manager](#).

9.3.1. Setting up the disconnected environment

TALM can perform both platform and Operator updates.

You must mirror both the platform image and Operator images that you want to update to in your mirror registry before you can use TALM to update your disconnected clusters. Complete the following steps to mirror the images:

- For platform updates, you must perform the following steps:
 1. Mirror the desired OpenShift Container Platform image repository. Ensure that the desired platform image is mirrored by following the "Mirroring the OpenShift Container Platform image repository" procedure linked in the Additional resources. Save the contents of the **imageContentSources** section in the **imageContentSources.yaml** file:

Example output

```
imageContentSources:
- mirrors:
  - mirror-ocp-registry.ibmcloud.io.cpak:5000/openshift-release-dev/openshift4
    source: quay.io/openshift-release-dev/ocp-release
  - mirrors:
    - mirror-ocp-registry.ibmcloud.io.cpak:5000/openshift-release-dev/openshift4
      source: quay.io/openshift-release-dev/ocp-v4.0-art-dev
```

2. Save the image signature of the desired platform image that was mirrored. You must add the image signature to the **PolicyGenerator** CR for platform updates. To get the image signature, perform the following steps:

- Specify the desired OpenShift Container Platform tag by running the following command:

```
$ OCP_RELEASE_NUMBER=<release_version>
```

- Specify the architecture of the cluster by running the following command:

```
$ ARCHITECTURE=<cluster_architecture> ①
```

① Specify the architecture of the cluster, such as **x86_64**, **aarch64**, **s390x**, or **ppc64le**.

- Get the release image digest from Quay by running the following command

```
$ DIGEST=$(oc adm release info quay.io/openshift-release-dev/ocp-release:${OCP_RELEASE_NUMBER}-${ARCHITECTURE} | sed -n 's/Pull From: *@/p')"
```

- Set the digest algorithm by running the following command:

```
$ DIGEST_ALGO="${DIGEST%%:*}"
```

- Set the digest signature by running the following command:

```
$ DIGEST_ENCODED="${DIGEST#*:}"
```

- Get the image signature from the mirror.openshift.com website by running the following command:

```
$ SIGNATURE_BASE64=$(curl -s "https://mirror.openshift.com/pub/openshift-v4/signatures/openshift/release/${DIGEST_ALGO}=${DIGEST_ENCODED}/signature-1" | base64 -w0 && echo)
```

- Save the image signature to the **checksum-<OCP_RELEASE_NUMBER>.yaml** file by running the following commands:

```
$ cat >checksum-${OCP_RELEASE_NUMBER}.yaml <<EOF
${DIGEST_ALGO}-${DIGEST_ENCODED}: ${SIGNATURE_BASE64}
EOF
```

3. Prepare the update graph. You have two options to prepare the update graph:

- Use the OpenShift Update Service.

For more information about how to set up the graph on the hub cluster, see [Deploy the operator for OpenShift Update Service](#) and [Build the graph data init container](#).

- Make a local copy of the upstream graph. Host the update graph on an **http** or **https** server in the disconnected environment that has access to the managed cluster. To download the update graph, use the following command:

```
$ curl -s https://api.openshift.com/api/upgrades_info/v1/graph?channel=stable-4.18 -o ~/upgrade-graph_stable-4.18
```

- For Operator updates, you must perform the following task:
 - Mirror the Operator catalogs. Ensure that the desired operator images are mirrored by following the procedure in the "Mirroring Operator catalogs for use with disconnected clusters" section.

Additional resources

- For more information about how to update GitOps Zero Touch Provisioning (ZTP), see [Upgrading GitOps ZTP](#).
- For more information about how to mirror an OpenShift Container Platform image repository, see [Mirroring the OpenShift Container Platform image repository](#).
- For more information about how to mirror Operator catalogs for disconnected clusters, see [Mirroring Operator catalogs for use with disconnected clusters](#).
- For more information about how to prepare the disconnected environment and mirroring the desired image repository, see [Preparing the disconnected environment](#).
- For more information about update channels and releases, see [Understanding update channels and releases](#).

9.3.2. Performing a platform update with PolicyGenerator CRs

You can perform a platform update with the TALM.

Prerequisites

- Install the Topology Aware Lifecycle Manager (TALM).
- Update GitOps Zero Touch Provisioning (ZTP) to the latest version.
- Provision one or more managed clusters with GitOps ZTP.
- Mirror the desired image repository.
- Log in as a user with **cluster-admin** privileges.
- Create RHACM policies in the hub cluster.

Procedure

1. Create a **PolicyGenerator** CR for the platform update:
 - a. Save the following **PolicyGenerator** CR in the **du-upgrade.yaml** file:

Example of PolicyGenerator for platform update

```
apiVersion: policy.open-cluster-management.io/v1
kind: PolicyGenerator
metadata:
```

```

    name: du-upgrade
placementBindingDefaults:
    name: du-upgrade-placement-binding
policyDefaults:
    namespace: ztp-group-du-sno
    placement:
        labelSelector:
            matchExpressions:
                - key: group-du-sno
                  operator: Exists
    remediationAction: inform
    severity: low
    namespaceSelector:
        exclude:
            - kube-*
        include:
            - '*'
evaluationInterval:
    compliant: 10m
    noncompliant: 10s
policies:
    - name: du-upgrade-platform-upgrade
      policyAnnotations:
          ran.openshift.io/ztp-deploy-wave: "100"
      manifests:
          - path: source-crs/ClusterVersion.yaml 1
            patches:
                - metadata:
                    name: version
                spec:
                    channel: stable-4.18
                    desiredUpdate:
                        version: 4.18.4
                    upstream: http://upgrade.example.com/images/upgrade-graph_stable-4.18
      status:
          history:
              - state: Completed
                version: 4.18.4
    - name: du-upgrade-platform-upgrade-prep
      policyAnnotations:
          ran.openshift.io/ztp-deploy-wave: "1"
      manifests:
          - path: source-crs/ImageSignature.yaml 2
            - path: source-crs/DisconnectedICSP.yaml
              patches:
                  - metadata:
                      name: disconnected-internal-icsp-for-ocp
                  spec:
                      repositoryDigestMirrors: 3
                      - mirrors:
                          - quay-intern.example.com/ocp4/openshift-release-dev
                          source: quay.io/openshift-release-dev/ocp-release
                      - mirrors:
                          - quay-intern.example.com/ocp4/openshift-release-dev
                          source: quay.io/openshift-release-dev/ocp-v4.0-art-dev

```

- 1 Shows the **ClusterVersion** CR to trigger the update. The **channel**, **upstream**, and **desiredVersion** fields are all required for image pre-caching.
- 2 **ImageSignature.yaml** contains the image signature of the required release image. The image signature is used to verify the image before applying the platform update.
- 3 Shows the mirror repository that contains the required OpenShift Container Platform image. Get the mirrors from the **imageContentSources.yaml** file that you saved when following the procedures in the "Setting up the environment" section.

The **PolicyGenerator** CR generates two policies:

- The **du-upgrade-platform-upgrade-prep** policy does the preparation work for the platform update. It creates the **ConfigMap** CR for the desired release image signature, creates the image content source of the mirrored release image repository, and updates the cluster version with the desired update channel and the update graph reachable by the managed cluster in the disconnected environment.
 - The **du-upgrade-platform-upgrade** policy is used to perform platform upgrade.
- b. Add the **du-upgrade.yaml** file contents to the **kustomization.yaml** file located in the GitOps ZTP Git repository for the **PolicyGenerator** CRs and push the changes to the Git repository.
ArgoCD pulls the changes from the Git repository and generates the policies on the hub cluster.
- c. Check the created policies by running the following command:

```
$ oc get policies -A | grep platform-upgrade
```

2. Create the **ClusterGroupUpdate** CR for the platform update with the **spec.enable** field set to **false**.
- a. Save the content of the platform update **ClusterGroupUpdate** CR with the **du-upgrade-platform-upgrade-prep** and the **du-upgrade-platform-upgrade** policies and the target clusters to the **cgu-platform-upgrade.yaml** file, as shown in the following example:

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-platform-upgrade
  namespace: default
spec:
  managedPolicies:
    - du-upgrade-platform-upgrade-prep
    - du-upgrade-platform-upgrade
  preCaching: false
  clusters:
    - spoke1
  remediationStrategy:
    maxConcurrency: 1
  enable: false
```

- b. Apply the **ClusterGroupUpdate** CR to the hub cluster by running the following command:

```
$ oc apply -f cgu-platform-upgrade.yml
```

3. Optional: Pre-cache the images for the platform update.

- a. Enable pre-caching in the **ClusterGroupUpdate** CR by running the following command:

```
$ oc --namespace=default patch clustergroupupgrade.ran.openshift.io/cgu-platform-upgrade \  
--patch '{"spec":{"preCaching": true}}' --type=merge
```

- b. Monitor the update process and wait for the pre-caching to complete. Check the status of pre-caching by running the following command on the hub cluster:

```
$ oc get cgu cgu-platform-upgrade -o jsonpath='{.status.precaching.status}'
```

4. Start the platform update:

- a. Enable the **cgu-platform-upgrade** policy and disable pre-caching by running the following command:

```
$ oc --namespace=default patch clustergroupupgrade.ran.openshift.io/cgu-platform-upgrade \  
--patch '{"spec":{"enable":true, "preCaching": false}}' --type=merge
```

- b. Monitor the process. Upon completion, ensure that the policy is compliant by running the following command:

```
$ oc get policies --all-namespaces
```

Additional resources

- For more information about mirroring the images in a disconnected environment, see [Preparing the disconnected environment](#).

9.3.3. Performing an Operator update with PolicyGenerator CRs

You can perform an Operator update with the TALM.

Prerequisites

- Install the Topology Aware Lifecycle Manager (TALM).
- Update GitOps Zero Touch Provisioning (ZTP) to the latest version.
- Provision one or more managed clusters with GitOps ZTP.
- Mirror the desired index image, bundle images, and all Operator images referenced in the bundle images.
- Log in as a user with **cluster-admin** privileges.
- Create RHACM policies in the hub cluster.

Procedure

1. Update the **PolicyGenerator** CR for the Operator update.
- a. Update the **du-upgrade PolicyGenerator** CR with the following additional contents in the **du-upgrade.yaml** file:

```

apiVersion: policy.open-cluster-management.io/v1
kind: PolicyGenerator
metadata:
  name: du-upgrade
placementBindingDefaults:
  name: du-upgrade-placement-binding
policyDefaults:
  namespace: ztp-group-du-sno
  placement:
    labelSelector:
      matchExpressions:
        - key: group-du-sno
          operator: Exists
  remediationAction: inform
  severity: low
  namespaceSelector:
    exclude:
      - kube-*
    include:
      - '*'
  evaluationInterval:
    compliant: 10m
    noncompliant: 10s
policies:
  - name: du-upgrade-operator-catsrc-policy
    policyAnnotations:
      ran.openshift.io/ztp-deploy-wave: "1"
    manifests:
      - path: source-crs/DefaultCatsrc.yaml
    patches:
      - metadata:
          name: redhat-operators-disconnected
        spec:
          displayName: Red Hat Operators Catalog
          image: registry.example.com:5000/olm/redhat-operators-disconnected:v4.18
1
  updateStrategy: 2
  registryPoll:
    interval: 1h
  status:
    connectionState:
    lastObservedState: READY 3

```

- 1 Contains the required Operator images. If the index images are always pushed to the same image name and tag, this change is not needed.
- 2 Sets how frequently the Operator Lifecycle Manager (OLM) polls the index image for new Operator versions with the **registryPoll.interval** field. This change is not needed if a new index image tag is always pushed for y-stream and z-stream Operator

updates. The **registryPoll.interval** field can be set to a shorter interval to expedite the update, however shorter intervals increase computational load. To counteract this, you can restore **registryPoll.interval** to the default value once the update is complete.

- 3 Displays the observed state of the catalog connection. The **READY** value ensures that the **CatalogSource** policy is ready, indicating that the index pod is pulled and is running. This way, TALM upgrades the Operators based on up-to-date policy compliance states.
- b. This update generates one policy, **du-upgrade-operator-catsrc-policy**, to update the **redhat-operators-disconnected** catalog source with the new index images that contain the desired Operators images.



NOTE

If you want to use the image pre-caching for Operators and there are Operators from a different catalog source other than **redhat-operators-disconnected**, you must perform the following tasks:

- Prepare a separate catalog source policy with the new index image or registry poll interval update for the different catalog source.
- Prepare a separate subscription policy for the desired Operators that are from the different catalog source.

For example, the desired SRIOV-FEC Operator is available in the **certified-operators** catalog source. To update the catalog source and the Operator subscription, add the following contents to generate two policies, **du-upgrade-fec-catsrc-policy** and **du-upgrade-subscriptions-fec-policy**:

```
apiVersion: policy.open-cluster-management.io/v1
kind: PolicyGenerator
metadata:
  name: du-upgrade
placementBindingDefaults:
  name: du-upgrade-placement-binding
policyDefaults:
  namespace: ztp-group-du-sno
  placement:
    labelSelector:
      matchExpressions:
        - key: group-du-sno
          operator: Exists
  remediationAction: inform
  severity: low
  namespaceSelector:
    exclude:
      - kube-*
    include:
      - **
  evaluationInterval:
    compliant: 10m
    noncompliant: 10s
policies:
```

```

- name: du-upgrade-fec-catsrc-policy
  policyAnnotations:
    ran.openshift.io/ztp-deploy-wave: "1"
  manifests:
    - path: source-crs/DefaultCatsrc.yaml
      patches:
        - metadata:
            name: certified-operators
          spec:
            displayName: Intel SRIOV-FEC Operator
            image: registry.example.com:5000/olm/far-edge-sriov-fec:v4.10
            updateStrategy:
              registryPoll:
                interval: 10m
    - name: du-upgrade-subscriptions-fec-policy
      policyAnnotations:
        ran.openshift.io/ztp-deploy-wave: "2"
      manifests:
        - path: source-crs/AcceleratorsSubscription.yaml
          patches:
            - spec:
                channel: stable
                source: certified-operators

```

- c. Remove the specified subscriptions channels in the common **PolicyGenerator** CR, if they exist. The default subscriptions channels from the GitOps ZTP image are used for the update.



NOTE

The default channel for the Operators applied through GitOps ZTP 4.18 is **stable**, except for the **performance-addon-operator**. As of OpenShift Container Platform 4.11, the **performance-addon-operator** functionality was moved to the **node-tuning-operator**. For the 4.10 release, the default channel for PAO is **v4.10**. You can also specify the default channels in the common **PolicyGenerator** CR.

- d. Push the **PolicyGenerator** CRs updates to the GitOps ZTP Git repository.
ArgoCD pulls the changes from the Git repository and generates the policies on the hub cluster.
- e. Check the created policies by running the following command:

```
$ oc get policies -A | grep -E "catsrc-policy|subscription"
```

2. Apply the required catalog source updates before starting the Operator update.

- a. Save the content of the **ClusterGroupUpgrade** CR named **operator-upgrade-prep** with the catalog source policies and the target managed clusters to the **cgu-operator-upgrade-prep.yaml** file:

```

apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-operator-upgrade-prep

```

```

namespace: default
spec:
  clusters:
    - spoke1
  enable: true
  managedPolicies:
    - du-upgrade-operator-catsrc-policy
  remediationStrategy:
    maxConcurrency: 1

```

- b. Apply the policy to the hub cluster by running the following command:

```
$ oc apply -f cgu-operator-upgrade-prep.yml
```

- c. Monitor the update process. Upon completion, ensure that the policy is compliant by running the following command:

```
$ oc get policies -A | grep -E "catsrc-policy"
```

3. Create the **ClusterGroupUpgrade** CR for the Operator update with the **spec.enable** field set to **false**.
- a. Save the content of the Operator update **ClusterGroupUpgrade** CR with the **du-upgrade-operator-catsrc-policy** policy and the subscription policies created from the common **PolicyGenerator** and the target clusters to the **cgu-operator-upgrade.yml** file, as shown in the following example:

```

apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-operator-upgrade
  namespace: default
spec:
  managedPolicies:
    - du-upgrade-operator-catsrc-policy ①
    - common-subscriptions-policy ②
  preCaching: false
  clusters:
    - spoke1
  remediationStrategy:
    maxConcurrency: 1
  enable: false

```

- ① The policy is needed by the image pre-caching feature to retrieve the operator images from the catalog source.
- ② The policy contains Operator subscriptions. If you have followed the structure and content of the reference **PolicyGenTemplates**, all Operator subscriptions are grouped into the **common-subscriptions-policy** policy.



NOTE

One **ClusterGroupUpgrade** CR can only pre-cache the images of the desired Operators defined in the subscription policy from one catalog source included in the **ClusterGroupUpgrade** CR. If the desired Operators are from different catalog sources, such as in the example of the SRIOV-FEC Operator, another **ClusterGroupUpgrade** CR must be created with **du-upgrade-fec-catsrc-policy** and **du-upgrade-subscriptions-fec-policy** policies for the SRIOV-FEC Operator images pre-caching and update.

- b. Apply the **ClusterGroupUpgrade** CR to the hub cluster by running the following command:

```
$ oc apply -f cgu-operator-upgrade.yml
```

- 4. Optional: Pre-cache the images for the Operator update.

- a. Before starting image pre-caching, verify the subscription policy is **NonCompliant** at this point by running the following command:

```
$ oc get policy common-subscriptions-policy -n <policy_namespace>
```

Example output

NAME	REMEDIATION ACTION	COMPLIANCE STATE	AGE
common-subscriptions-policy	inform	NonCompliant	27d

- b. Enable pre-caching in the **ClusterGroupUpgrade** CR by running the following command:

```
$ oc --namespace=default patch clustergroupupgrade.ran.openshift.io/cgu-operator-upgrade \
--patch '{"spec":{"preCaching": true}}' --type=merge
```

- c. Monitor the process and wait for the pre-caching to complete. Check the status of pre-caching by running the following command on the managed cluster:

```
$ oc get cgu cgu-operator-upgrade -o jsonpath='{.status.precaching.status}'
```

- d. Check if the pre-caching is completed before starting the update by running the following command:

```
$ oc get cgu -n default cgu-operator-upgrade -ojsonpath='{.status.conditions}' | jq
```

Example output

```
[  
 {  
   "lastTransitionTime": "2022-03-08T20:49:08.000Z",  
   "message": "The ClusterGroupUpgrade CR is not enabled",  
   "reason": "UpgradeNotStarted",  
   "status": "False",  
   "type": "Ready"  
 },  
 {
```

```

    "lastTransitionTime": "2022-03-08T20:55:30.000Z",
    "message": "Precaching is completed",
    "reason": "PrecachingCompleted",
    "status": "True",
    "type": "PrecachingDone"
  }
]

```

5. Start the Operator update.

- Enable the **cgu-operator-upgrade ClusterGroupUpgrade** CR and disable pre-caching to start the Operator update by running the following command:

```
$ oc --namespace=default patch clustergroupupgrade.ran.openshift.io/cgu-operator-upgrade \
--patch '{"spec":{"enable":true, "preCaching": false}}' --type=merge
```

- Monitor the process. Upon completion, ensure that the policy is compliant by running the following command:

```
$ oc get policies --all-namespaces
```

Additional resources

- For more information about updating GitOps ZTP, see [Upgrading GitOps ZTP](#).

9.3.4. Troubleshooting missed Operator updates with PolicyGenerator CRs

In some scenarios, Topology Aware Lifecycle Manager (TALM) might miss Operator updates due to an out-of-date policy compliance state.

After a catalog source update, it takes time for the Operator Lifecycle Manager (OLM) to update the subscription status. The status of the subscription policy might continue to show as compliant while TALM decides whether remediation is needed. As a result, the Operator specified in the subscription policy does not get upgraded.

To avoid this scenario, add another catalog source configuration to the **PolicyGenerator** and specify this configuration in the subscription for any Operators that require an update.

Procedure

- Add a catalog source configuration in the **PolicyGenerator** resource:

```

manifests:
- path: source-crs/DefaultCatsrc.yaml
patches:
- metadata:
  name: redhat-operators-disconnected
spec:
  displayName: Red Hat Operators Catalog
  image: registry.example.com:5000/olm/redhat-operators-disconnected:v{product-version}
  updateStrategy:
    registryPoll:

```

```

interval: 1h
status:
  connectionState:
    lastObservedState: READY
- path: source-crs/DefaultCatsrc.yaml
patches:
- metadata:
  name: redhat-operators-disconnected-v2 ①
spec:
  displayName: Red Hat Operators Catalog v2 ②
  image: registry.example.com:5000/olm/redhat-operators-disconnected:<version> ③
  updateStrategy:
    registryPoll:
      interval: 1h
status:
  connectionState:
    lastObservedState: READY

```

- ① Update the name for the new configuration.
- ② Update the display name for the new configuration.
- ③ Update the index image URL. This **policies.manifests.patches.spec.image** field overrides any configuration in the **DefaultCatsrc.yaml** file.

2. Update the **Subscription** resource to point to the new configuration for Operators that require an update:

```

apiVersion: operators.coreos.com/v1alpha1
kind: Subscription
metadata:
  name: operator-subscription
  namespace: operator-namespace
# ...
spec:
  source: redhat-operators-disconnected-v2 ①
# ...

```

- ① Enter the name of the additional catalog source configuration that you defined in the **PolicyGenerator** resource.

9.3.5. Performing a platform and an Operator update together

You can perform a platform and an Operator update at the same time.

Prerequisites

- Install the Topology Aware Lifecycle Manager (TALM).
- Update GitOps Zero Touch Provisioning (ZTP) to the latest version.
- Provision one or more managed clusters with GitOps ZTP.

- Log in as a user with **cluster-admin** privileges.
- Create RHACM policies in the hub cluster.

Procedure

1. Create the **PolicyGenerator** CR for the updates by following the steps described in the "Performing a platform update" and "Performing an Operator update" sections.
2. Apply the prep work for the platform and the Operator update.
 - a. Save the content of the **ClusterGroupUpgrade** CR with the policies for platform update preparation work, catalog source updates, and target clusters to the **cgu-platform-operator-upgrade-prep.yml** file, for example:

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-platform-operator-upgrade-prep
  namespace: default
spec:
  managedPolicies:
    - du-upgrade-platform-upgrade-prep
    - du-upgrade-operator-catsrc-policy
  clusterSelector:
    - group-du-sno
  remediationStrategy:
    maxConcurrency: 10
  enable: true
```

- b. Apply the **cgu-platform-operator-upgrade-prep.yml** file to the hub cluster by running the following command:
3. Create the **ClusterGroupUpdate** CR for the platform and the Operator update with the **spec.enable** field set to **false**.
 - a. Save the contents of the platform and Operator update **ClusterGroupUpdate** CR with the policies and the target clusters to the **cgu-platform-operator-upgrade.yml** file, as shown in the following example:

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-du-upgrade
  namespace: default
spec:
  managedPolicies:
    - du-upgrade-platform-upgrade ①
```

```

- du-upgrade-operator-catsrc-policy 2
- common-subscriptions-policy 3
preCaching: true
clusterSelector:
- group-du-sno
remediationStrategy:
  maxConcurrency: 1
enable: false

```

- 1** This is the platform update policy.
- 2** This is the policy containing the catalog source information for the Operators to be updated. It is needed for the pre-caching feature to determine which Operator images to download to the managed cluster.
- 3** This is the policy to update the Operators.

- b. Apply the **cgu-platform-operator-upgrade.yml** file to the hub cluster by running the following command:

```
$ oc apply -f cgu-platform-operator-upgrade.yml
```

4. Optional: Pre-cache the images for the platform and the Operator update.

- a. Enable pre-caching in the **ClusterGroupUpgrade** CR by running the following command:

```
$ oc --namespace=default patch clustergroupupgrade.ran.openshift.io/cgu-du-upgrade \
--patch '{"spec":{"preCaching": true}}' --type=merge
```

- b. Monitor the update process and wait for the pre-caching to complete. Check the status of pre-caching by running the following command on the managed cluster:

```
$ oc get jobs,pods -n openshift-talm-pre-cache
```

- c. Check if the pre-caching is completed before starting the update by running the following command:

```
$ oc get cgu cgu-du-upgrade -ojsonpath='{.status.conditions}'
```

5. Start the platform and Operator update.

- a. Enable the **cgu-du-upgrade ClusterGroupUpgrade** CR to start the platform and the Operator update by running the following command:

```
$ oc --namespace=default patch clustergroupupgrade.ran.openshift.io/cgu-du-upgrade \
--patch '{"spec":{"enable":true, "preCaching": false}}' --type=merge
```

- b. Monitor the process. Upon completion, ensure that the policy is compliant by running the following command:

```
$ oc get policies --all-namespaces
```

**NOTE**

The CRs for the platform and Operator updates can be created from the beginning by configuring the setting to **spec.enable: true**. In this case, the update starts immediately after pre-caching completes and there is no need to manually enable the CR.

Both pre-caching and the update create extra resources, such as policies, placement bindings, placement rules, managed cluster actions, and managed cluster view, to help complete the procedures. Setting the **afterCompletion.deleteObjects** field to **true** deletes all these resources after the updates complete.

9.3.6. Removing Performance Addon Operator subscriptions from deployed clusters with PolicyGenerator CRs

In earlier versions of OpenShift Container Platform, the Performance Addon Operator provided automatic, low latency performance tuning for applications. In OpenShift Container Platform 4.11 or later, these functions are part of the Node Tuning Operator.

Do not install the Performance Addon Operator on clusters running OpenShift Container Platform 4.11 or later. If you upgrade to OpenShift Container Platform 4.11 or later, the Node Tuning Operator automatically removes the Performance Addon Operator.

**NOTE**

You need to remove any policies that create Performance Addon Operator subscriptions to prevent a re-installation of the Operator.

The reference DU profile includes the Performance Addon Operator in the **PolicyGenerator** CR **acm-common-ranGen.yaml**. To remove the subscription from deployed managed clusters, you must update **acm-common-ranGen.yaml**.

**NOTE**

If you install Performance Addon Operator 4.10.3-5 or later on OpenShift Container Platform 4.11 or later, the Performance Addon Operator detects the cluster version and automatically hibernates to avoid interfering with the Node Tuning Operator functions. However, to ensure best performance, remove the Performance Addon Operator from your OpenShift Container Platform 4.11 clusters.

Prerequisites

- Create a Git repository where you manage your custom site configuration data. The repository must be accessible from the hub cluster and be defined as a source repository for ArgoCD.
- Update to OpenShift Container Platform 4.11 or later.
- Log in as a user with **cluster-admin** privileges.

Procedure

1. Change the **complianceType** to **mustnothave** for the Performance Addon Operator namespace, Operator group, and subscription in the **acm-common-ranGen.yaml** file.

■

```

- name: group-du-sno-pg-subscriptions-policy
  policyAnnotations:
    ran.openshift.io/ztp-deploy-wave: "2"
  manifests:
    - path: source-crs/PaoSubscriptionNS.yaml
    - path: source-crs/PaoSubscriptionOperGroup.yaml
    - path: source-crs/PaoSubscription.yaml

```

- Merge the changes with your custom site repository and wait for the ArgoCD application to synchronize the change to the hub cluster. The status of the **common-subscriptions-policy** policy changes to **Non-Compliant**.
- Apply the change to your target clusters by using the Topology Aware Lifecycle Manager. For more information about rolling out configuration changes, see the "Additional resources" section.
- Monitor the process. When the status of the **common-subscriptions-policy** policy for a target cluster is **Compliant**, the Performance Addon Operator has been removed from the cluster. Get the status of the **common-subscriptions-policy** by running the following command:

```
$ oc get policy -n ztp-common common-subscriptions-policy
```

- Delete the Performance Addon Operator namespace, Operator group and subscription CRs from **policies.manifests** in the **acm-common-ranGen.yaml** file.
- Merge the changes with your custom site repository and wait for the ArgoCD application to synchronize the change to the hub cluster. The policy remains compliant.

9.3.7. Pre-caching user-specified images with TALM on single-node OpenShift clusters

You can pre-cache application-specific workload images on single-node OpenShift clusters before upgrading your applications.

You can specify the configuration options for the pre-caching jobs using the following custom resources (CR):

- **PreCachingConfig** CR
- **ClusterGroupUpgrade** CR



NOTE

All fields in the **PreCachingConfig** CR are optional.

Example PreCachingConfig CR

```

apiVersion: ran.openshift.io/v1alpha1
kind: PreCachingConfig
metadata:
  name: exampleconfig
  namespace: exampleconfig-ns
spec:
  overrides: ①

```

```

platformImage: quay.io/openshift-release-dev/ocp-
release@sha256:3d5800990dee7cd4727d3fe238a97e2d2976d3808fc925ada29c559a47e2e1ef
operatorsIndexes:
  - registry.example.com:5000/custom-redhat-operators:1.0.0
operatorsPackagesAndChannels:
  - local-storage-operator: stable
  - ptp-operator: stable
  - sriov-network-operator: stable
spaceRequired: 30 Gi 2
excludePrecachePatterns: 3
  - aws
  - vsphere
additionalImages: 4
  -
    quay.io/exampleconfig/application1@sha256:3d5800990dee7cd4727d3fe238a97e2d2976d3808fc925
    ada29c559a47e2e1ef
  -
    quay.io/exampleconfig/application2@sha256:3d5800123dee7cd4727d3fe238a97e2d2976d3808fc925
    ada29c559a47adfaef
  -
    quay.io/exampleconfig/applicationN@sha256:4fe1334adfafadsf987123adfffdaf1243340adfafdedga099
    1234afdadfsa09

```

- 1** By default, TALM automatically populates the **platformImage**, **operatorsIndexes**, and the **operatorsPackagesAndChannels** fields from the policies of the managed clusters. You can specify values to override the default TALM-derived values for these fields.
- 2** Specifies the minimum required disk space on the cluster. If unspecified, TALM defines a default value for OpenShift Container Platform images. The disk space field must include an integer value and the storage unit. For example: **40 GiB**, **200 MB**, **1 TiB**.
- 3** Specifies the images to exclude from pre-caching based on image name matching.
- 4** Specifies the list of additional images to pre-cache.

Example ClusterGroupUpgrade CR with PreCachingConfig CR reference

```

apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu
spec:
  preCaching: true 1
  preCachingConfigRef:
    name: exampleconfig 2
    namespace: exampleconfig-ns 3

```

- 1** The **preCaching** field set to **true** enables the pre-caching job.
- 2** The **preCachingConfigRef.name** field specifies the **PreCachingConfig** CR that you want to use.
- 3** The **preCachingConfigRef.namespace** specifies the namespace of the **PreCachingConfig** CR that you want to use.

9.3.7.1. Creating the custom resources for pre-caching

You must create the **PreCachingConfig** CR before or concurrently with the **ClusterGroupUpgrade** CR.

1. Create the **PreCachingConfig** CR with the list of additional images you want to pre-cache.

```
apiVersion: ran.openshift.io/v1alpha1
kind: PreCachingConfig
metadata:
  name: exampleconfig
  namespace: default ①
spec:
  [...]
  spaceRequired: 30Gi ②
  additionalImages:
    -
      quay.io/exampleconfig/application1@sha256:3d5800990dee7cd4727d3fe238a97e2d2976d38
      08fc925ada29c559a47e2e1ef
    -
      quay.io/exampleconfig/application2@sha256:3d5800123dee7cd4727d3fe238a97e2d2976d38
      08fc925ada29c559a47adfaef
    -
      quay.io/exampleconfig/applicationN@sha256:4fe1334adfafadsf987123adfffdaf1243340adfaf
      edga0991234afdadfsa09
```

- ① The **namespace** must be accessible to the hub cluster.
- ② It is recommended to set the minimum disk space required field to ensure that there is sufficient storage space for the pre-cached images.

2. Create a **ClusterGroupUpgrade** CR with the **preCaching** field set to **true** and specify the **PreCachingConfig** CR created in the previous step:

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu
  namespace: default
spec:
  clusters:
    - sno1
    - sno2
  preCaching: true
  preCachingConfigRef:
    - name: exampleconfig
      namespace: default
  managedPolicies:
    - du-upgrade-platform-upgrade
    - du-upgrade-operator-catsrc-policy
    - common-subscriptions-policy
  remediationStrategy:
    timeout: 240
```

**WARNING**

Once you install the images on the cluster, you cannot change or delete them.

- When you want to start pre-caching the images, apply the **ClusterGroupUpgrade** CR by running the following command:

```
$ oc apply -f cgu.yaml
```

TALM verifies the **ClusterGroupUpgrade** CR.

From this point, you can continue with the TALM pre-caching workflow.

**NOTE**

All sites are pre-cached concurrently.

Verification

- Check the pre-caching status on the hub cluster where the **ClusterUpgradeGroup** CR is applied by running the following command:

```
$ oc get cgu <cgu_name> -n <cgu_namespace> -oyaml
```

Example output

```

precaching:
spec:
  platformImage: quay.io/openshift-release-dev/ocp-
release@sha256:3d5800990dee7cd4727d3fe238a97e2d2976d3808fc925ada29c559a47e2e1
  ef
  operatorsIndexes:
    - registry.example.com:5000/custom-redhat-operators:1.0.0
  operatorsPackagesAndChannels:
    - local-storage-operator: stable
    - ptp-operator: stable
    - sriov-network-operator: stable
  excludePrecachePatterns:
    - aws
    - vsphere
  additionalImages:
    -
      quay.io/exampleconfig/application1@sha256:3d5800990dee7cd4727d3fe238a97e2d2976d38
      08fc925ada29c559a47e2e1ef
    -
      quay.io/exampleconfig/application2@sha256:3d5800123dee7cd4727d3fe238a97e2d2976d38
      08fc925ada29c559a47adfaef
    -
      quay.io/exampleconfig/applicationN@sha256:4fe1334adfafadfs987123adffffdaf1243340adfaf

```

```
edga0991234afdadfsa09
  spaceRequired: "30"
  status:
    sno1: Starting
    sno2: Starting
```

The pre-caching configurations are validated by checking if the managed policies exist. Valid configurations of the **ClusterGroupUpgrade** and the **PreCachingConfig** CRs result in the following statuses:

Example output of valid CRs

```
- lastTransitionTime: "2023-01-01T00:00:01Z"
  message: All selected clusters are valid
  reason: ClusterSelectionCompleted
  status: "True"
  type: ClusterSelected
- lastTransitionTime: "2023-01-01T00:00:02Z"
  message: Completed validation
  reason: ValidationCompleted
  status: "True"
  type: Validated
- lastTransitionTime: "2023-01-01T00:00:03Z"
  message: Precaching spec is valid and consistent
  reason: PrecacheSpecIsWellFormed
  status: "True"
  type: PrecacheSpecValid
- lastTransitionTime: "2023-01-01T00:00:04Z"
  message: Precaching in progress for 1 clusters
  reason: InProgress
  status: "False"
  type: PrecachingSucceeded
```

Example of an invalid PreCachingConfig CR

```
Type: "PrecacheSpecValid"
Status: False,
Reason: "PrecacheSpecIncomplete"
Message: "Precaching spec is incomplete: failed to get PreCachingConfig resource due to
PreCachingConfig.ran.openshift.io "<pre-caching_cr_name>" not found"
```

2. You can find the pre-caching job by running the following command on the managed cluster:

```
$ oc get jobs -n openshift-talo-pre-cache
```

Example of pre-caching job in progress

NAME	COMPLETIONS	DURATION	AGE
pre-cache	0/1	1s	1s

3. You can check the status of the pod created for the pre-caching job by running the following command:

```
$ oc describe pod pre-cache -n openshift-talo-pre-cache
```

Example of pre-caching job in progress

Type	Reason	Age	From	Message
Normal	SuccessfulCreate	19s	job-controller	Created pod: pre-cache-abcd1

4. You can get live updates on the status of the job by running the following command:

```
$ oc logs -f pre-cache-abcd1 -n openshift-talo-pre-cache
```

5. To verify the pre-cache job is successfully completed, run the following command:

```
$ oc describe pod pre-cache -n openshift-talo-pre-cache
```

Example of completed pre-cache job

Type	Reason	Age	From	Message
Normal	SuccessfulCreate	5m19s	job-controller	Created pod: pre-cache-abcd1
Normal	Completed	19s	job-controller	Job completed

6. To verify that the images are successfully pre-cached on the single-node OpenShift, do the following:

- a. Enter into the node in debug mode:

```
$ oc debug node/cnfdf00.example.lab
```

- b. Change root to **host**:

```
$ chroot /host/
```

- c. Search for the desired images:

```
$ sudo podman images | grep <operator_name>
```

Additional resources

- For more information about the TALM precaching workflow, see [Using the container image precache feature](#).

9.3.8. About the auto-created ClusterGroupUpgrade CR for GitOps ZTP

TALM has a controller called **ManagedClusterForCGU** that monitors the **Ready** state of the **ManagedCluster** CRs on the hub cluster and creates the **ClusterGroupUpgrade** CRs for GitOps Zero Touch Provisioning (ZTP).

For any managed cluster in the **Ready** state without a **ztp-done** label applied, the **ManagedClusterForCGU** controller automatically creates a **ClusterGroupUpgrade** CR in the **ztp-install** namespace with its associated RHACM policies that are created during the GitOps ZTP process. TALM then remediates the set of configuration policies that are listed in the auto-created **ClusterGroupUpgrade** CR to push the configuration CRs to the managed cluster.

If there are no policies for the managed cluster at the time when the cluster becomes **Ready**, a **ClusterGroupUpgrade** CR with no policies is created. Upon completion of the **ClusterGroupUpgrade** the managed cluster is labeled as **ztp-done**. If there are policies that you want to apply for that managed cluster, manually create a **ClusterGroupUpgrade** as a day-2 operation.

Example of an auto-created ClusterGroupUpgrade CR for GitOps ZTP

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  generation: 1
  name: spoke1
  namespace: ztp-install
  ownerReferences:
    - apiVersion: cluster.open-cluster-management.io/v1
      blockOwnerDeletion: true
      controller: true
      kind: ManagedCluster
      name: spoke1
      uid: 98fdb9b2-51ee-4ee7-8f57-a84f7f35b9d5
  resourceVersion: "46666836"
  uid: b8be9cd2-764f-4a62-87d6-6b767852c7da
spec:
  actions:
    afterCompletion:
      addClusterLabels:
        ztp-done: "" ①
    deleteClusterLabels:
      ztp-running: ""
    deleteObjects: true
  beforeEnable:
    addClusterLabels:
      ztp-running: "" ②
clusters:
  - spoke1
enable: true
managedPolicies:
  - common-spoke1-config-policy
  - common-spoke1-subscriptions-policy
  - group-spoke1-config-policy
  - spoke1-config-policy
  - group-spoke1-validator-du-policy
preCaching: false
remediationStrategy:
  maxConcurrency: 1
  timeout: 240
```

① Applied to the managed cluster when TALM completes the cluster configuration.

② Applied to the managed cluster when TALM starts deploying the configuration policies.

CHAPTER 10. MANAGING CLUSTER POLICIES WITH POLICYGENTEMPLATE RESOURCES

10.1. CONFIGURING MANAGED CLUSTER POLICIES BY USING POLICYGENTEMPLATE RESOURCES

Applied **Policy** custom resources (CRs) configure the managed clusters that you provision. You can customize how Red Hat Advanced Cluster Management (RHACM) uses **PolicyGenTemplate** CRs to generate the applied **Policy** CRs.



IMPORTANT

Using **PolicyGenTemplate** CRs to manage and deploy policies to managed clusters will be deprecated in an upcoming OpenShift Container Platform release. Equivalent and improved functionality is available using Red Hat Advanced Cluster Management (RHACM) and **PolicyGenerator** CRs.

For more information about **PolicyGenerator** resources, see the RHACM [Integrating Policy Generator](#) documentation.

Additional resources

- [Configuring managed cluster policies by using PolicyGenerator resources](#)
- [Comparing RHACM PolicyGenerator and PolicyGenTemplate resource patching](#)

10.1.1. About the PolicyGenTemplate CRD

The **PolicyGenTemplate** custom resource definition (CRD) tells the **PolicyGen** policy generator what custom resources (CRs) to include in the cluster configuration, how to combine the CRs into the generated policies, and what items in those CRs need to be updated with overlay content.

The following example shows a **PolicyGenTemplate** CR (**common-du-ranGen.yaml**) extracted from the **ztp-site-generate** reference container. The **common-du-ranGen.yaml** file defines two Red Hat Advanced Cluster Management (RHACM) policies. The policies manage a collection of configuration CRs, one for each unique value of **policyName** in the CR. **common-du-ranGen.yaml** creates a single placement binding and a placement rule to bind the policies to clusters based on the labels listed in the **spec.bindingRules** section.

Example PolicyGenTemplate CR - common-ranGen.yaml

```
apiVersion: ran.openshift.io/v1
kind: PolicyGenTemplate
metadata:
  name: "common-latest"
  namespace: "ztp-common"
spec:
  bindingRules:
    common: "true" 1
    du-profile: "latest"
  sourceFiles: 2
    - fileName: SriovSubscriptionNS.yaml
      policyName: "subscriptions-policy"
```

```

- fileName: SriovSubscriptionOperGroup.yaml
  policyName: "subscriptions-policy"
- fileName: SriovSubscription.yaml
  policyName: "subscriptions-policy"
- fileName: SriovOperatorStatus.yaml
  policyName: "subscriptions-policy"
- fileName: PtpSubscriptionNS.yaml
  policyName: "subscriptions-policy"
- fileName: PtpSubscriptionOperGroup.yaml
  policyName: "subscriptions-policy"
- fileName: PtpSubscription.yaml
  policyName: "subscriptions-policy"
- fileName: PtpOperatorStatus.yaml
  policyName: "subscriptions-policy"
- fileName: ClusterLogNS.yaml
  policyName: "subscriptions-policy"
- fileName: ClusterLogOperGroup.yaml
  policyName: "subscriptions-policy"
- fileName: ClusterLogSubscription.yaml
  policyName: "subscriptions-policy"
- fileName: ClusterLogOperatorStatus.yaml
  policyName: "subscriptions-policy"
- fileName: StorageNS.yaml
  policyName: "subscriptions-policy"
- fileName: StorageOperGroup.yaml
  policyName: "subscriptions-policy"
- fileName: StorageSubscription.yaml
  policyName: "subscriptions-policy"
- fileName: StorageOperatorStatus.yaml
  policyName: "subscriptions-policy"
- fileName: DefaultCatsrc.yaml 3
  policyName: "config-policy" 4
  metadata:
    name: redhat-operators-disconnected
  spec:
    displayName: disconnected-redhat-operators
    image: registry.example.com:5000/disconnected-redhat-operators/disconnected-redhat-
operator-index:v4.9
- fileName: DisconnectedICSP.yaml
  policyName: "config-policy"
  spec:
    repositoryDigestMirrors:
      - mirrors:
          - registry.example.com:5000
    source: registry.redhat.io

```

- 1 **common: "true"** applies the policies to all clusters with this label.
- 2 Files listed under **sourceFiles** create the Operator policies for installed clusters.
- 3 **DefaultCatsrc.yaml** configures the catalog source for the disconnected registry.
- 4 **policyName: "config-policy"** configures Operator subscriptions. The **OperatorHub** CR disables the default and this CR replaces **redhat-operators** with a **CatalogSource** CR that points to the disconnected registry.

A **PolicyGenTemplate** CR can be constructed with any number of included CRs. Apply the following example CR in the hub cluster to generate a policy containing a single CR:

```
apiVersion: ran.openshift.io/v1
kind: PolicyGenTemplate
metadata:
  name: "group-du-sno"
  namespace: "ztp-group"
spec:
  bindingRules:
    group-du-sno: ""
  mcp: "master"
  sourceFiles:
    - fileName: PtpConfigSlave.yaml
      policyName: "config-policy"
      metadata:
        name: "du-ptp-slave"
      spec:
        profile:
          - name: "slave"
            interface: "ens5f0"
            ptp4lOpts: "-2 -s --summary_interval -4"
            phc2sysOpts: "-a -r -n 24"
```

Using the source file **PtpConfigSlave.yaml** as an example, the file defines a **PtpConfig** CR. The generated policy for the **PtpConfigSlave** example is named **group-du-sno-config-policy**. The **PtpConfig** CR defined in the generated **group-du-sno-config-policy** is named **du-ptp-slave**. The **spec** defined in **PtpConfigSlave.yaml** is placed under **du-ptp-slave** along with the other **spec** items defined under the source file.

The following example shows the **group-du-sno-config-policy** CR:

```
apiVersion: policy.open-cluster-management.io/v1
kind: Policy
metadata:
  name: group-du-ptp-config-policy
  namespace: groups-sub
  annotations:
    policy.open-cluster-management.io/categories: CM Configuration Management
    policy.open-cluster-management.io/controls: CM-2 Baseline Configuration
    policy.open-cluster-management.io/standards: NIST SP 800-53
spec:
  remediationAction: inform
  disabled: false
  policy-templates:
    - objectDefinition:
        apiVersion: policy.open-cluster-management.io/v1
        kind: ConfigurationPolicy
        metadata:
          name: group-du-ptp-config-policy-config
  spec:
    remediationAction: inform
    severity: low
    namespaceselector:
      exclude:
```

```

- kube-*  

include:  

- '*'  

object-templates:  

- complianceType: musthave  

objectDefinition:  

apiVersion: ptp.openshift.io/v1  

kind: PtpConfig  

metadata:  

name: du-ptp-slave  

namespace: openshift-ptp  

spec:  

recommend:  

- match:  

- nodeLabel: node-role.kubernetes.io/worker-du  

priority: 4  

profile: slave  

profile:  

- interface: ens5f0  

name: slave  

phc2sysOpts: -a -r -n 24  

ptp4lConf: |  

[global]  

#  

# Default Data Set  

#  

twoStepFlag 1  

slaveOnly 0  

priority1 128  

priority2 128  

domainNumber 24

```

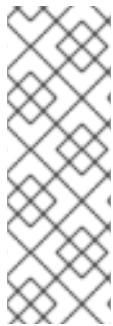
10.1.2. Recommendations when customizing PolicyGenTemplate CRs

Consider the following best practices when customizing site configuration **PolicyGenTemplate** custom resources (CRs):

- Use as few policies as are necessary. Using fewer policies requires less resources. Each additional policy creates increased CPU load for the hub cluster and the deployed managed cluster. CRs are combined into policies based on the **policyName** field in the **PolicyGenTemplate** CR. CRs in the same **PolicyGenTemplate** which have the same value for **policyName** are managed under a single policy.
- In disconnected environments, use a single catalog source for all Operators by configuring the registry as a single index containing all Operators. Each additional **CatalogSource** CR on the managed clusters increases CPU usage.
- **MachineConfig** CRs should be included as **extraManifests** in the **SiteConfig** CR so that they are applied during installation. This can reduce the overall time taken until the cluster is ready to deploy applications.
- **PolicyGenTemplate** CRs should override the channel field to explicitly identify the desired version. This ensures that changes in the source CR during upgrades does not update the generated subscription.

Additional resources

- For recommendations about scaling clusters with RHACM, see [Performance and scalability](#).



NOTE

When managing large numbers of spoke clusters on the hub cluster, minimize the number of policies to reduce resource consumption.

Grouping multiple configuration CRs into a single or limited number of policies is one way to reduce the overall number of policies on the hub cluster. When using the common, group, and site hierarchy of policies for managing site configuration, it is especially important to combine site-specific configurations into a single policy.

10.1.3. PolicyGenTemplate CRs for RAN deployments

Use **PolicyGenTemplate** custom resources (CRs) to customize the configuration applied to the cluster by using the GitOps Zero Touch Provisioning (ZTP) pipeline. The **PolicyGenTemplate** CR allows you to generate one or more policies to manage the set of configuration CRs on your fleet of clusters. The **PolicyGenTemplate** CR identifies the set of managed CRs, bundles them into policies, builds the policy wrapping around those CRs, and associates the policies with clusters by using label binding rules.

The reference configuration, obtained from the GitOps ZTP container, is designed to provide a set of critical features and node tuning settings that ensure the cluster can support the stringent performance and resource utilization constraints typical of RAN (Radio Access Network) Distributed Unit (DU) applications. Changes or omissions from the baseline configuration can affect feature availability, performance, and resource utilization. Use the reference **PolicyGenTemplate** CRs as the basis to create a hierarchy of configuration files tailored to your specific site requirements.

The baseline **PolicyGenTemplate** CRs that are defined for RAN DU cluster configuration can be extracted from the GitOps ZTP **ztp-site-generate** container. See "Preparing the GitOps ZTP site configuration repository" for further details.

The **PolicyGenTemplate** CRs can be found in the `./out/argocd/example/policygentemplates` folder. The reference architecture has common, group, and site-specific configuration CRs. Each **PolicyGenTemplate** CR refers to other CRs that can be found in the `./out/source-crs` folder.

The **PolicyGenTemplate** CRs relevant to RAN cluster configuration are described below. Variants are provided for the group **PolicyGenTemplate** CRs to account for differences in single-node, three-node compact, and standard cluster configurations. Similarly, site-specific configuration variants are provided for single-node clusters and multi-node (compact or standard) clusters. Use the group and site-specific configuration variants that are relevant for your deployment.

Table 10.1. PolicyGenTemplate CRs for RAN deployments

PolicyGenTemplate CR	Description
example-multinode-site.yaml	Contains a set of CRs that get applied to multi-node clusters. These CRs configure SR-IOV features typical for RAN installations.
example-sno-site.yaml	Contains a set of CRs that get applied to single-node OpenShift clusters. These CRs configure SR-IOV features typical for RAN installations.

PolicyGenTemplate CR	Description
common-mno-ranGen.yaml	Contains a set of common RAN policy configuration that get applied to multi-node clusters.
common-ranGen.yaml	Contains a set of common RAN CRs that get applied to all clusters. These CRs subscribe to a set of operators providing cluster features typical for RAN as well as baseline cluster tuning.
group-du-3node-ranGen.yaml	Contains the RAN policies for three-node clusters only.
group-du-sno-ranGen.yaml	Contains the RAN policies for single-node clusters only.
group-du-standard-ranGen.yaml	Contains the RAN policies for standard three control-plane clusters.
group-du-3node-validator-ranGen.yaml	PolicyGenTemplate CR used to generate the various policies required for three-node clusters.
group-du-standard-validator-ranGen.yaml	PolicyGenTemplate CR used to generate the various policies required for standard clusters.
group-du-sno-validator-ranGen.yaml	PolicyGenTemplate CR used to generate the various policies required for single-node OpenShift clusters.

Additional resources

- [Preparing the GitOps ZTP site configuration repository](#)

10.1.4. Customizing a managed cluster with PolicyGenTemplate CRs

Use the following procedure to customize the policies that get applied to the managed cluster that you provision using the GitOps Zero Touch Provisioning (ZTP) pipeline.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.
- You configured the hub cluster for generating the required installation and policy CRs.
- You created a Git repository where you manage your custom site configuration data. The repository must be accessible from the hub cluster and be defined as a source repository for the Argo CD application.

Procedure

1. Create a **PolicyGenTemplate** CR for site-specific configuration CRs.
 - a. Choose the appropriate example for your CR from the **out/argocd/example/policygentemplates** folder, for example, **example-sno-site.yaml** or **example-multinode-site.yaml**.
 - b. Change the **spec.bindingRules** field in the example file to match the site-specific label included in the **SiteConfig** CR. In the example **SiteConfig** file, the site-specific label is **sites: example-sno**.



NOTE

Ensure that the labels defined in your **PolicyGenTemplate** **spec.bindingRules** field correspond to the labels that are defined in the related managed clusters **SiteConfig** CR.

- c. Change the content in the example file to match the desired configuration.
2. Optional: Create a **PolicyGenTemplate** CR for any common configuration CRs that apply to the entire fleet of clusters.
 - a. Select the appropriate example for your CR from the **out/argocd/example/policygentemplates** folder, for example, **common-ranGen.yaml**.
 - b. Change the content in the example file to match the required configuration.

3. Optional: Create a **PolicyGenTemplate** CR for any group configuration CRs that apply to the certain groups of clusters in the fleet.

Ensure that the content of the overlaid spec files matches your required end state. As a reference, the **out/source-crs** directory contains the full list of source-crs available to be included and overlaid by your PolicyGenTemplate templates.



NOTE

Depending on the specific requirements of your clusters, you might need more than a single group policy per cluster type, especially considering that the example group policies each have a single **PerformancePolicy.yaml** file that can only be shared across a set of clusters if those clusters consist of identical hardware configurations.

- a. Select the appropriate example for your CR from the **out/argocd/example/policygentemplates** folder, for example, **group-du-sno-ranGen.yaml**.
- b. Change the content in the example file to match the required configuration.
4. Optional. Create a validator inform policy **PolicyGenTemplate** CR to signal when the GitOps ZTP installation and configuration of the deployed cluster is complete. For more information, see "Creating a validator inform policy".
5. Define all the policy namespaces in a YAML file similar to the example **out/argocd/example/policygentemplates/ns.yaml** file.



IMPORTANT

Do not include the **Namespace** CR in the same file with the **PolicyGenTemplate** CR.

6. Add the **PolicyGenTemplate** CRs and **Namespace** CR to the **kustomization.yaml** file in the generators section, similar to the example shown in [out/argocd/example/policygentemplateskustomization.yaml](#).
7. Commit the **PolicyGenTemplate** CRs, **Namespace** CR, and associated **kustomization.yaml** file in your Git repository and push the changes.
The ArgoCD pipeline detects the changes and begins the managed cluster deployment. You can push the changes to the **SiteConfig** CR and the **PolicyGenTemplate** CR simultaneously.

Additional resources

- [Signalling GitOps ZTP cluster deployment completion with validator inform policies](#)

10.1.5. Monitoring managed cluster policy deployment progress

The ArgoCD pipeline uses **PolicyGenTemplate** CRs in Git to generate the RHACM policies and then sync them to the hub cluster. You can monitor the progress of the managed cluster policy synchronization after the assisted service installs OpenShift Container Platform on the managed cluster.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.

Procedure

1. The Topology Aware Lifecycle Manager (TALM) applies the configuration policies that are bound to the cluster.

After the cluster installation is complete and the cluster becomes **Ready**, a **ClusterGroupUpgrade** CR corresponding to this cluster, with a list of ordered policies defined by the **ran.openshift.io/ztp-deploy-wave annotations**, is automatically created by the TALM. The cluster's policies are applied in the order listed in **ClusterGroupUpgrade** CR.

You can monitor the high-level progress of configuration policy reconciliation by using the following commands:

```
$ export CLUSTER=<clusterName>
$ oc get clustergroupupgrades -n ztp-install $CLUSTER -o jsonpath='{.status.conditions[-1:]}' | jq
```

Example output

```
{
  "lastTransitionTime": "2022-11-09T07:28:09Z",
  "message": "Remediating non-compliant policies",
  "reason": "InProgress",
```

```

    "status": "True",
    "type": "Progressing"
}
```

2. You can monitor the detailed cluster policy compliance status by using the RHACM dashboard or the command line.

- a. To check policy compliance by using **oc**, run the following command:

```
$ oc get policies -n $CLUSTER
```

Example output

NAME	REMEDIATION ACTION	COMPLIANCE STATE
AGE		
ztp-common.common-config-policy	inform	Compliant
3h42m		
ztp-common.common-subscriptions-policy	inform	NonCompliant
3h42m		
ztp-group.group-du-sno-config-policy	inform	NonCompliant
3h42m		
ztp-group.group-du-sno-validator-du-policy	inform	NonCompliant
3h42m		
ztp-install.example1-common-config-policy-pjz9s	enforce	Compliant
167m		
ztp-install.example1-common-subscriptions-policy-zzd9k	enforce	NonCompliant
164m		
ztp-site.example1-config-policy	inform	NonCompliant
ztp-site.example1-perf-policy	inform	NonCompliant
		3h42m
		3h42m

- b. To check policy status from the RHACM web console, perform the following actions:

- i. Click **Governance** → **Find policies**.
- ii. Click on a cluster policy to check its status.

When all of the cluster policies become compliant, GitOps ZTP installation and configuration for the cluster is complete. The **ztp-done** label is added to the cluster.

In the reference configuration, the final policy that becomes compliant is the one defined in the ***-du-validator-policy** policy. This policy, when compliant on a cluster, ensures that all cluster configuration, Operator installation, and Operator configuration is complete.

10.1.6. Validating the generation of configuration policy CRs

Policy custom resources (CRs) are generated in the same namespace as the **PolicyGenTemplate** from which they are created. The same troubleshooting flow applies to all policy CRs generated from a **PolicyGenTemplate** regardless of whether they are **ztp-common**, **ztp-group**, or **ztp-site** based, as shown using the following commands:

```
$ export NS=<namespace>
```

```
$ oc get policy -n $NS
```

The expected set of policy-wrapped CRs should be displayed.

If the policies failed synchronization, use the following troubleshooting steps.

Procedure

1. To display detailed information about the policies, run the following command:

```
$ oc describe -n openshift-gitops application policies
```

2. Check for **Status: Conditions**: to show the error logs. For example, setting an invalid **sourceFile** entry to **fileName**: generates the error shown below:

```
Status:  
Conditions:  
Last Transition Time: 2021-11-26T17:21:39Z  
Message:      rpc error: code = Unknown desc = `kustomize build  
/tmp/https____git.com/ran-sites/policies/ --enable-alpha-plugins` failed exit status 1:  
2021/11/26 17:21:40 Error could not find test.yaml under source-crs/: no such file or directory  
Error: failure in plugin configured via /tmp/kust-plugin-config-52463179; exit status 1: exit  
status 1  
Type: ComparisonError
```

3. Check for **Status: Sync**: If there are log errors at **Status: Conditions**, the **Status: Sync** shows **Unknown** or **Error**:

```
Status:  
Sync:  
Compared To:  
Destination:  
  Namespace: policies-sub  
  Server:   https://kubernetes.default.svc  
Source:  
  Path:      policies  
  Repo URL: https://git.com/ran-sites/policies/.git  
  Target Revision: master  
Status:      Error
```

4. When Red Hat Advanced Cluster Management (RHACM) recognizes that policies apply to a **ManagedCluster** object, the policy CR objects are applied to the cluster namespace. Check to see if the policies were copied to the cluster namespace:

```
$ oc get policy -n $CLUSTER
```

Example output

NAME	REMEDIATION ACTION	COMPLIANCE STATE	AGE
ztp-common.common-config-policy	inform	Compliant	13d
ztp-common.common-subscriptions-policy	inform	Compliant	13d
ztp-group.group-du-sno-config-policy	inform	Compliant	13d
ztp-group.group-du-sno-validator-du-policy	inform	Compliant	13d
ztp-site.example-sno-config-policy	inform	Compliant	13d

RHACM copies all applicable policies into the cluster namespace. The copied policy names have the format: <PolicyGenTemplate.Namespace>. <PolicyGenTemplate.Name>-<policyName>.

5. Check the placement rule for any policies not copied to the cluster namespace. The **matchSelector** in the **PlacementRule** for those policies should match labels on the **ManagedCluster** object:

```
$ oc get PlacementRule -n $NS
```

6. Note the **PlacementRule** name appropriate for the missing policy, common, group, or site, using the following command:

```
$ oc get PlacementRule -n $NS <placement_rule_name> -o yaml
```

- The status-decisions should include your cluster name.
- The key-value pair of the **matchSelector** in the spec must match the labels on your managed cluster.

7. Check the labels on the **ManagedCluster** object by using the following command:

```
$ oc get ManagedCluster $CLUSTER -o jsonpath='{.metadata.labels}' | jq
```

8. Check to see what policies are compliant by using the following command:

```
$ oc get policy -n $CLUSTER
```

If the **Namespace**, **OperatorGroup**, and **Subscription** policies are compliant but the Operator configuration policies are not, it is likely that the Operators did not install on the managed cluster. This causes the Operator configuration policies to fail to apply because the CRD is not yet applied to the spoke.

10.1.7. Restarting policy reconciliation

You can restart policy reconciliation when unexpected compliance issues occur, for example, when the **ClusterGroupUpgrade** custom resource (CR) has timed out.

Procedure

1. A **ClusterGroupUpgrade** CR is generated in the namespace **ztp-install** by the Topology Aware Lifecycle Manager after the managed cluster becomes **Ready**:

```
$ export CLUSTER=<clusterName>
```

```
$ oc get clustergroupupgrades -n ztp-install $CLUSTER
```

2. If there are unexpected issues and the policies fail to become complaint within the configured timeout (the default is 4 hours), the status of the **ClusterGroupUpgrade** CR shows **UpgradeTimedOut**:

```
$ oc get clustergroupupgrades -n ztp-install $CLUSTER -o jsonpath='{.status.conditions[?(@.type=="Ready")]}'
```

3. A **ClusterGroupUpgrade** CR in the **UpgradeTimedOut** state automatically restarts its policy reconciliation every hour. If you have changed your policies, you can start a retry immediately by deleting the existing **ClusterGroupUpgrade** CR. This triggers the automatic creation of a new **ClusterGroupUpgrade** CR that begins reconciling the policies immediately:

```
$ oc delete clustergroupupgrades -n ztp-install $CLUSTER
```

Note that when the **ClusterGroupUpgrade** CR completes with status **UpgradeCompleted** and the managed cluster has the label **ztp-done** applied, you can make additional configuration changes by using **PolicyGenTemplate**. Deleting the existing **ClusterGroupUpgrade** CR will not make the TALM generate a new CR.

At this point, GitOps ZTP has completed its interaction with the cluster and any further interactions should be treated as an update and a new **ClusterGroupUpgrade** CR created for remediation of the policies.

Additional resources

- For information about using Topology Aware Lifecycle Manager (TALM) to construct your own **ClusterGroupUpgrade** CR, see [About the ClusterGroupUpgrade CR](#).

10.1.8. Changing applied managed cluster CRs using policies

You can remove content from a custom resource (CR) that is deployed in a managed cluster through a policy.

By default, all **Policy** CRs created from a **PolicyGenTemplate** CR have the **complianceType** field set to **musthave**. A **musthave** policy without the removed content is still compliant because the CR on the managed cluster has all the specified content. With this configuration, when you remove content from a CR, TALM removes the content from the policy but the content is not removed from the CR on the managed cluster.

With the **complianceType** field to **mustonlyhave**, the policy ensures that the CR on the cluster is an exact match of what is specified in the policy.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.
- You have deployed a managed cluster from a hub cluster running RHACM.
- You have installed Topology Aware Lifecycle Manager on the hub cluster.

Procedure

1. Remove the content that you no longer need from the affected CRs. In this example, the **disableDrain: false** line was removed from the **SriovOperatorConfig** CR.

Example CR

```
apiVersion: sriovnetwork.openshift.io/v1
kind: SriovOperatorConfig
metadata:
```

```

name: default
namespace: openshift-sriov-network-operator
spec:
  configDaemonNodeSelector:
    "node-role.kubernetes.io/$mcp": ""
  disableDrain: true
  enableInjector: true
  enableOperatorWebhook: true

```

2. Change the **complianceType** of the affected policies to **mustonlyhave** in the **group-du-sno-ranGen.yaml** file.

Example YAML

```

- fileName: SriovOperatorConfig.yaml
  policyName: "config-policy"
  complianceType: mustonlyhave

```

3. Create a **ClusterGroupUpdates** CR and specify the clusters that must receive the CR changes::

Example ClusterGroupUpdates CR

```

apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-remove
  namespace: default
spec:
  managedPolicies:
    - ztp-group.group-du-sno-config-policy
  enable: false
  clusters:
    - spoke1
    - spoke2
  remediationStrategy:
    maxConcurrency: 2
    timeout: 240
  batchTimeoutAction:

```

4. Create the **ClusterGroupUpgrade** CR by running the following command:

```
$ oc create -f cgu-remove.yaml
```

5. When you are ready to apply the changes, for example, during an appropriate maintenance window, change the value of the **spec.enable** field to **true** by running the following command:

```
$ oc --namespace=default patch clustergroupupgrade.ran.openshift.io/cgu-remove \
--patch '{"spec":{"enable":true}}' --type=merge
```

Verification

1. Check the status of the policies by running the following command:

```
$ oc get <kind> <changed_cr_name>
```

Example output

NAMESPACE	NAME	REMEDIATION ACTION	
COMPLIANCE STATE	AGE		
default	cgu-ztp-group.group-du-sno-config-policy	enforce	17m
default	ztp-group.group-du-sno-config-policy	inform	NonCompliant
	15h		

When the **COMPLIANCE STATE** of the policy is **Compliant**, it means that the CR is updated and the unwanted content is removed.

- Check that the policies are removed from the targeted clusters by running the following command on the managed clusters:

```
$ oc get <kind> <changed_cr_name>
```

If there are no results, the CR is removed from the managed cluster.

10.1.9. Indication of done for GitOps ZTP installations

GitOps Zero Touch Provisioning (ZTP) simplifies the process of checking the GitOps ZTP installation status for a cluster. The GitOps ZTP status moves through three phases: cluster installation, cluster configuration, and GitOps ZTP done.

Cluster installation phase

The cluster installation phase is shown by the **ManagedClusterJoined** and **ManagedClusterAvailable** conditions in the **ManagedCluster** CR. If the **ManagedCluster** CR does not have these conditions, or the condition is set to **False**, the cluster is still in the installation phase. Additional details about installation are available from the **AgentClusterInstall** and **ClusterDeployment** CRs. For more information, see "Troubleshooting GitOps ZTP".

Cluster configuration phase

The cluster configuration phase is shown by a **ztp-running** label applied to the **ManagedCluster** CR for the cluster.

GitOps ZTP done

Cluster installation and configuration is complete in the GitOps ZTP done phase. This is shown by the removal of the **ztp-running** label and addition of the **ztp-done** label to the **ManagedCluster** CR. The **ztp-done** label shows that the configuration has been applied and the baseline DU configuration has completed cluster tuning.

The change to the GitOps ZTP done state is conditional on the compliant state of a Red Hat Advanced Cluster Management (RHACM) validator inform policy. This policy captures the existing criteria for a completed installation and validates that it moves to a compliant state only when GitOps ZTP provisioning of the managed cluster is complete.

The validator inform policy ensures the configuration of the cluster is fully applied and Operators have completed their initialization. The policy validates the following:

- The target **MachineConfigPool** contains the expected entries and has finished updating. All nodes are available and not degraded.
- The SR-IOV Operator has completed initialization as indicated by at least one **SriovNetworkNodeState** with **syncStatus: Succeeded**.

- The PTP Operator daemon set exists.

10.2. ADVANCED MANAGED CLUSTER CONFIGURATION WITH POLICYGENTEMPLATE RESOURCES

You can use **PolicyGenTemplate** CRs to deploy custom functionality in your managed clusters.



IMPORTANT

Using **PolicyGenTemplate** CRs to manage and deploy policies to managed clusters will be deprecated in an upcoming OpenShift Container Platform release. Equivalent and improved functionality is available using Red Hat Advanced Cluster Management (RHACM) and **PolicyGenerator** CRs.

For more information about **PolicyGenerator** resources, see the RHACM [Integrating Policy Generator](#) documentation.

Additional resources

- [Configuring managed cluster policies by using PolicyGenerator resources](#)
- [Comparing RHACM PolicyGenerator and PolicyGenTemplate resource patching](#)

10.2.1. Deploying additional changes to clusters

If you require cluster configuration changes outside of the base GitOps Zero Touch Provisioning (ZTP) pipeline configuration, there are three options:

Apply the additional configuration after the GitOps ZTP pipeline is complete

When the GitOps ZTP pipeline deployment is complete, the deployed cluster is ready for application workloads. At this point, you can install additional Operators and apply configurations specific to your requirements. Ensure that additional configurations do not negatively affect the performance of the platform or allocated CPU budget.

Add content to the GitOps ZTP library

The base source custom resources (CRs) that you deploy with the GitOps ZTP pipeline can be augmented with custom content as required.

Create extra manifests for the cluster installation

Extra manifests are applied during installation and make the installation process more efficient.



IMPORTANT

Providing additional source CRs or modifying existing source CRs can significantly impact the performance or CPU profile of OpenShift Container Platform.

10.2.2. Using PolicyGenTemplate CRs to override source CRs content

PolicyGenTemplate custom resources (CRs) allow you to overlay additional configuration details on top of the base source CRs provided with the GitOps plugin in the **ztp-site-generate** container. You can think of **PolicyGenTemplate** CRs as a logical merge or patch to the base CR. Use **PolicyGenTemplate** CRs to update a single field of the base CR, or overlay the entire contents of the base CR. You can update values and insert fields that are not in the base CR.

The following example procedure describes how to update fields in the generated **PerformanceProfile** CR for the reference configuration based on the **PolicyGenTemplate** CR in the **group-du-snoranGen.yaml** file. Use the procedure as a basis for modifying other parts of the **PolicyGenTemplate** based on your requirements.

Prerequisites

- Create a Git repository where you manage your custom site configuration data. The repository must be accessible from the hub cluster and be defined as a source repository for Argo CD.

Procedure

1. Review the baseline source CR for existing content. You can review the source CRs listed in the reference **PolicyGenTemplate** CRs by extracting them from the GitOps Zero Touch Provisioning (ZTP) container.

- a. Create an **/out** folder:

```
$ mkdir -p ./out
```

- b. Extract the source CRs:

```
$ podman run --log-driver=none --rm registry.redhat.io/openshift4/ztp-site-generate-rhel8:v4.18.1 extract /home/ztp --tar | tar x -C ./out
```

2. Review the baseline **PerformanceProfile** CR in **./out/source-crs/PerformanceProfile.yaml**:

```
apiVersion: performance.openshift.io/v2
kind: PerformanceProfile
metadata:
  name: $name
  annotations:
    ran.openshift.io/ztp-deploy-wave: "10"
spec:
  additionalKernelArgs:
    - "idle=poll"
    - "rcupdate.rcu_normal_after_boot=0"
  cpu:
    isolated: $isolated
    reserved: $reserved
  hugepages:
    defaultHugepagesSize: $defaultHugepagesSize
    pages:
      - size: $size
        count: $count
        node: $node
  machineConfigPoolSelector:
    pools.operator.machineconfiguration.openshift.io/$mcp: ""
  net:
    userLevelNetworking: true
  nodeSelector:
    node-role.kubernetes.io/$mcp: ""
  numa:
```

```
topologyPolicy: "restricted"
realTimeKernel:
  enabled: true
```



NOTE

Any fields in the source CR which contain `$...` are removed from the generated CR if they are not provided in the **PolicyGenTemplate** CR.

3. Update the **PolicyGenTemplate** entry for **PerformanceProfile** in the **group-du-snoranGen.yaml** reference file. The following example **PolicyGenTemplate** CR stanza supplies appropriate CPU specifications, sets the **hugepages** configuration, and adds a new field that sets **globallyDisableIRQLoadBalancing** to false.

```
- fileName: PerformanceProfile.yaml
  policyName: "config-policy"
  metadata:
    name: openshift-node-performance-profile
  spec:
    cpu:
      # These must be tailored for the specific hardware platform
      isolated: "2-19,22-39"
      reserved: "0-1,20-21"
    hugepages:
      defaultHugepagesSize: 1G
      pages:
        - size: 1G
          count: 10
    globallyDisableIRQLoadBalancing: false
```

4. Commit the **PolicyGenTemplate** change in Git, and then push to the Git repository being monitored by the GitOps ZTP argo CD application.

Example output

The GitOps ZTP application generates an RHACM policy that contains the generated **PerformanceProfile** CR. The contents of that CR are derived by merging the **metadata** and **spec** contents from the **PerformanceProfile** entry in the **PolicyGenTemplate** onto the source CR. The resulting CR has the following content:

```
---
apiVersion: performance.openshift.io/v2
kind: PerformanceProfile
metadata:
  name: openshift-node-performance-profile
spec:
  additionalKernelArgs:
    - idle=poll
    - rcupdate.rcu_normal_after_boot=0
  cpu:
    isolated: 2-19,22-39
    reserved: 0-1,20-21
  globallyDisableIRQLoadBalancing: false
  hugepages:
    defaultHugepagesSize: 1G
```

```

pages:
  - count: 10
    size: 1G
machineConfigPoolSelector:
  pools.operator.machineconfiguration.openshift.io/master: ""
net:
  userLevelNetworking: true
nodeSelector:
  node-role.kubernetes.io/master: ""
numa:
  topologyPolicy: restricted
realTimeKernel:
  enabled: true

```

NOTE

In the `/source-crs` folder that you extract from the `ztp-site-generate` container, the `$` syntax is not used for template substitution as implied by the syntax. Rather, if the **policyGen** tool sees the `$` prefix for a string and you do not specify a value for that field in the related **PolicyGenTemplate** CR, the field is omitted from the output CR entirely.

An exception to this is the `$mcp` variable in `/source-crs` YAML files that is substituted with the specified value for `mcp` from the **PolicyGenTemplate** CR. For example, in `example/policygentemplates/group-du-standard-ranGen.yaml`, the value for `mcp` is `worker`:

```

spec:
  bindingRules:
    group-du-standard: ""
  mcp: "worker"

```

The **policyGen** tool replace instances of `$mcp` with `worker` in the output CRs.

10.2.3. Adding custom content to the GitOps ZTP pipeline

Perform the following procedure to add new content to the GitOps ZTP pipeline.

Procedure

1. Create a subdirectory named **source-crs** in the directory that contains the **kustomization.yaml** file for the **PolicyGenTemplate** custom resource (CR).
2. Add your user-provided CRs to the **source-crs** subdirectory, as shown in the following example:

```

example
└── policygentemplates
    ├── dev.yaml
    ├── kustomization.yaml
    ├── mec-edge-sno1.yaml
    ├── sno.yaml
    └── source-crs ①
        ├── PaoCatalogSource.yaml
        ├── PaoSubscription.yaml
        └── custom-crs

```

```

    |   └── apiserver-config.yaml
    |   └── disable-nic-lldp.yaml
    └── elasticsearch
        └── ElasticsearchNS.yaml
        └── ElasticsearchOperatorGroup.yaml

```

- 1** The **source-crs** subdirectory must be in the same directory as the **kustomization.yaml** file.
3. Update the required **PolicyGenTemplate** CRs to include references to the content you added in the **source-crs/custom-crs** and **source-crs/elasticsearch** directories. For example:

```

apiVersion: ran.openshift.io/v1
kind: PolicyGenTemplate
metadata:
  name: "group-dev"
  namespace: "ztp-clusters"
spec:
  bindingRules:
    dev: "true"
    mcp: "master"
  sourceFiles:
    # These policies/CRs come from the internal container Image
    #Cluster Logging
    - fileName: ClusterLogNS.yaml
      remediationAction: inform
      policyName: "group-dev-cluster-log-ns"
    - fileName: ClusterLogOperGroup.yaml
      remediationAction: inform
      policyName: "group-dev-cluster-log-operator-group"
    - fileName: ClusterLogSubscription.yaml
      remediationAction: inform
      policyName: "group-dev-cluster-log-sub"
    #Local Storage Operator
    - fileName: StorageNS.yaml
      remediationAction: inform
      policyName: "group-dev-lso-ns"
    - fileName: StorageOperGroup.yaml
      remediationAction: inform
      policyName: "group-dev-lso-operator-group"
    - fileName: StorageSubscription.yaml
      remediationAction: inform
      policyName: "group-dev-lso-sub"
    #These are custom local policies that come from the source-crs directory in the git repo
    # Performance Addon Operator
    - fileName: PaoSubscriptionNS.yaml
      remediationAction: inform
      policyName: "group-dev-pao-ns"
    - fileName: PaoSubscriptionCatalogSource.yaml
      remediationAction: inform
      policyName: "group-dev-pao-cat-source"
  spec:
    image: <container_image_url>
    - fileName: PaoSubscription.yaml
      remediationAction: inform

```

```

policyName: "group-dev-pao-sub"
#Elasticsearch Operator
- fileName:.elasticsearch/ElasticsearchNS.yaml ①
  remediationAction: inform
  policyName: "group-dev-elasticsearch-ns"
- fileName:.elasticsearch/ElasticsearchOperatorGroup.yaml
  remediationAction: inform
  policyName: "group-dev-elasticsearch-operator-group"
#Custom Resources
- fileName: custom-crs/apiserver-config.yaml ②
  remediationAction: inform
  policyName: "group-dev-apiserver-config"
- fileName: custom-crs/disable-nic-lldp.yaml
  remediationAction: inform
  policyName: "group-dev-disable-nic-lldp"

```

① ② Set **fileName** to include the relative path to the file from the **/source-crs** parent directory.

- Commit the **PolicyGenTemplate** change in Git, and then push to the Git repository that is monitored by the GitOps ZTP Argo CD policies application.
- Update the **ClusterGroupUpgrade** CR to include the changed **PolicyGenTemplate** and save it as **cgu-test.yaml**. The following example shows a generated **cgu-test.yaml** file.

```

apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: custom-source-cr
  namespace: ztp-clusters
spec:
  managedPolicies:
    - group-dev-config-policy
  enable: true
  clusters:
    - cluster1
  remediationStrategy:
    maxConcurrency: 2
    timeout: 240

```

- Apply the updated **ClusterGroupUpgrade** CR by running the following command:

```
$ oc apply -f cgu-test.yaml
```

Verification

- Check that the updates have succeeded by running the following command:

```
$ oc get cgu -A
```

Example output

NAMESPACE	NAME	AGE	STATE	DETAILS
ztp-clusters	custom-source-cr	6s	InProgress	Remediating non-compliant policies

```
ztp-install cluster1      19h Completed All clusters are compliant with all the managed policies
```

10.2.4. Configuring policy compliance evaluation timeouts for PolicyGenTemplate CRs

Use Red Hat Advanced Cluster Management (RHACM) installed on a hub cluster to monitor and report on whether your managed clusters are compliant with applied policies. RHACM uses policy templates to apply predefined policy controllers and policies. Policy controllers are Kubernetes custom resource definition (CRD) instances.

You can override the default policy evaluation intervals with **PolicyGenTemplate** custom resources (CRs). You configure duration settings that define how long a **ConfigurationPolicy** CR can be in a state of policy compliance or non-compliance before RHACM re-evaluates the applied cluster policies.

The GitOps Zero Touch Provisioning (ZTP) policy generator generates **ConfigurationPolicy** CR policies with pre-defined policy evaluation intervals. The default value for the **noncompliant** state is 10 seconds. The default value for the **compliant** state is 10 minutes. To disable the evaluation interval, set the value to **never**.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.
- You have created a Git repository where you manage your custom site configuration data.

Procedure

1. To configure the evaluation interval for all policies in a **PolicyGenTemplate** CR, set appropriate **compliant** and **noncompliant** values for the **evaluationInterval** field. For example:

```
spec:
  evaluationInterval:
    compliant: 30m
    noncompliant: 20s
```



NOTE

You can also set **compliant** and **noncompliant** fields to **never** to stop evaluating the policy after it reaches particular compliance state.

2. To configure the evaluation interval for an individual policy object in a **PolicyGenTemplate** CR, add the **evaluationInterval** field and set appropriate values. For example:

```
spec:
  sourceFiles:
    - fileName: SriovSubscription.yaml
      policyName: "sriov-sub-policy"
      evaluationInterval:
        compliant: never
        noncompliant: 10s
```

3. Commit the **PolicyGenTemplate** CRs files in the Git repository and push your changes.

Verification

Check that the managed spoke cluster policies are monitored at the expected intervals.

1. Log in as a user with **cluster-admin** privileges on the managed cluster.
2. Get the pods that are running in the **open-cluster-management-agent-addon** namespace. Run the following command:

```
$ oc get pods -n open-cluster-management-agent-addon
```

Example output

NAME	READY	STATUS	RESTARTS	AGE
config-policy-controller-858b894c68-v4xdb	1/1	Running	22	22 (5d8h ago) 10d

3. Check the applied policies are being evaluated at the expected interval in the logs for the **config-policy-controller** pod:

```
$ oc logs -n open-cluster-management-agent-addon config-policy-controller-858b894c68-v4xdb
```

Example output

```
2022-05-10T15:10:25.280Z    info  configuration-policy-controller
controllers/configurationpolicy_controller.go:166    Skipping the policy evaluation due to the
policy not reaching the evaluation interval {"policy": "compute-1-config-policy-config"}
2022-05-10T15:10:25.280Z    info  configuration-policy-controller
controllers/configurationpolicy_controller.go:166    Skipping the policy evaluation due to the
policy not reaching the evaluation interval {"policy": "compute-1-common-compute-1-catalog-
policy-config"}
```

10.2.5. Signalling GitOps ZTP cluster deployment completion with validator inform policies

Create a validator inform policy that signals when the GitOps Zero Touch Provisioning (ZTP) installation and configuration of the deployed cluster is complete. This policy can be used for deployments of single-node OpenShift clusters, three-node clusters, and standard clusters.

Procedure

1. Create a standalone **PolicyGenTemplate** custom resource (CR) that contains the source file **validatorCRs/informDuValidator.yaml**. You only need one standalone **PolicyGenTemplate** CR for each cluster type. For example, this CR applies a validator inform policy for single-node OpenShift clusters:

Example single-node cluster validator inform policy CR (group-du-sno-validator-ranGen.yaml)

```
apiVersion: ran.openshift.io/v1
kind: PolicyGenTemplate
```

```

metadata:
  name: "group-du-sno-validator" ①
  namespace: "ztp-group" ②
spec:
  bindingRules:
    group-du-sno: "" ③
  bindingExcludedRules:
    ztp-done: "" ④
    mcp: "master" ⑤
  sourceFiles:
    - fileName: validatorCRs/informDuValidator.yaml
      remediationAction: inform ⑥
    policyName: "du-policy" ⑦

```

- ① The name of the **{policy-gen-crs}** object. This name is also used as part of the names for the **placementBinding**, **placementRule**, and **policy** that are created in the requested **namespace**.
- ② This value should match the **namespace** used in the group **policy-gen-crs**.
- ③ The **group-du-*** label defined in **bindingRules** must exist in the **SiteConfig** files.
- ④ The label defined in **bindingExcludedRules** must be `ztp-done:`. The **ztp-done** label is used in coordination with the Topology Aware Lifecycle Manager.
- ⑤ **mcp** defines the **MachineConfigPool** object that is used in the source file **validatorCRs/informDuValidator.yaml**. It should be **master** for single node and three-node cluster deployments and **worker** for standard cluster deployments.
- ⑥ Optional. The default value is **inform**.
- ⑦ This value is used as part of the name for the generated RHACM policy. The generated validator policy for the single node example is **group-du-sno-validator-du-policy**.

2. Commit the **PolicyGenTemplate** CR file in your Git repository and push the changes.

Additional resources

- [Upgrading GitOps ZTP](#)

10.2.6. Configuring power states using PolicyGenTemplate CRs

For low latency and high-performance edge deployments, it is necessary to disable or limit C-states and P-states. With this configuration, the CPU runs at a constant frequency, which is typically the maximum turbo frequency. This ensures that the CPU is always running at its maximum speed, which results in high performance and low latency. This leads to the best latency for workloads. However, this also leads to the highest power consumption, which might not be necessary for all workloads.

Workloads can be classified as critical or non-critical, with critical workloads requiring disabled C-state and P-state settings for high performance and low latency, while non-critical workloads use C-state and P-state settings for power savings at the expense of some latency and performance. You can configure the following three power states using GitOps Zero Touch Provisioning (ZTP):

- High-performance mode provides ultra low latency at the highest power consumption.

- Performance mode provides low latency at a relatively high power consumption.
- Power saving balances reduced power consumption with increased latency.

The default configuration is for a low latency, performance mode.

PolicyGenTemplate custom resources (CRs) allow you to overlay additional configuration details onto the base source CRs provided with the GitOps plugin in the **ztp-site-generate** container.

Configure the power states by updating the **workloadHints** fields in the generated **PerformanceProfile** CR for the reference configuration, based on the **PolicyGenTemplate** CR in the **group-du-sno-ranGen.yaml**.

The following common prerequisites apply to configuring all three power states.

Prerequisites

- You have created a Git repository where you manage your custom site configuration data. The repository must be accessible from the hub cluster and be defined as a source repository for Argo CD.
- You have followed the procedure described in "Preparing the GitOps ZTP site configuration repository".

Additional resources

- [Configuring node power consumption and realtime processing with workload hints](#)

10.2.6.1. Configuring performance mode using PolicyGenTemplate CRs

Follow this example to set performance mode by updating the **workloadHints** fields in the generated **PerformanceProfile** CR for the reference configuration, based on the **PolicyGenTemplate** CR in the **group-du-sno-ranGen.yaml**.

Performance mode provides low latency at a relatively high power consumption.

Prerequisites

- You have configured the BIOS with performance related settings by following the guidance in "Configuring host firmware for low latency and high performance".

Procedure

1. Update the **PolicyGenTemplate** entry for **PerformanceProfile** in the **group-du-sno-ranGen.yaml** reference file in **out/argocd/example/policygentemplates//** as follows to set performance mode.

```

- fileName: PerformanceProfile.yaml
  policyName: "config-policy"
  metadata:
    # ...
  spec:
    # ...
  workloadHints:
```

```

realTime: true
highPowerConsumption: false
perPodPowerManagement: false

```

- Commit the **PolicyGenTemplate** change in Git, and then push to the Git repository being monitored by the GitOps ZTP Argo CD application.

10.2.6.2. Configuring high-performance mode using PolicyGenTemplate CRs

Follow this example to set high performance mode by updating the **workloadHints** fields in the generated **PerformanceProfile** CR for the reference configuration, based on the **PolicyGenTemplate** CR in the **group-du-sno-ranGen.yaml**.

High performance mode provides ultra low latency at the highest power consumption.

Prerequisites

- You have configured the BIOS with performance related settings by following the guidance in "Configuring host firmware for low latency and high performance".

Procedure

- Update the **PolicyGenTemplate** entry for **PerformanceProfile** in the **group-du-sno-ranGen.yaml** reference file in **out/argocd/example/policygentemplates/** as follows to set high-performance mode.

```

- fileName: PerformanceProfile.yaml
  policyName: "config-policy"
  metadata:
    # ...
  spec:
    # ...
    workloadHints:
      realTime: true
      highPowerConsumption: true
      perPodPowerManagement: false

```

- Commit the **PolicyGenTemplate** change in Git, and then push to the Git repository being monitored by the GitOps ZTP Argo CD application.
- [Configuring host firmware for low latency and high performance](#)

10.2.6.3. Configuring power saving mode using PolicyGenTemplate CRs

Follow this example to set power saving mode by updating the **workloadHints** fields in the generated **PerformanceProfile** CR for the reference configuration, based on the **PolicyGenTemplate** CR in the **group-du-sno-ranGen.yaml**.

The power saving mode balances reduced power consumption with increased latency.

Prerequisites

- You enabled C-states and OS-controlled P-states in the BIOS.

Procedure

1. Update the **PolicyGenTemplate** entry for **PerformanceProfile** in the **group-du-sno-ranGen.yaml** reference file in **out/argocd/example/policygentemplates/** as follows to configure power saving mode. It is recommended to configure the CPU governor for the power saving mode through the additional kernel arguments object.

```
- fileName: PerformanceProfile.yaml
  policyName: "config-policy"
  metadata:
    # ...
  spec:
    # ...
    workloadHints:
      realTime: true
      highPowerConsumption: false
      perPodPowerManagement: true
    # ...
    additionalKernelArgs:
      - # ...
      - "cpufreq.default_governor=schedutil" ①
```

- ① The **schedutil** governor is recommended, however, other governors that can be used include **ondemand** and **powersave**.

2. Commit the **PolicyGenTemplate** change in Git, and then push to the Git repository being monitored by the GitOps ZTP Argo CD application.

Verification

1. Select a worker node in your deployed cluster from the list of nodes identified by using the following command:

```
$ oc get nodes
```

2. Log in to the node by using the following command:

```
$ oc debug node/<node-name>
```

Replace **<node-name>** with the name of the node you want to verify the power state on.

3. Set **/host** as the root directory within the debug shell. The debug pod mounts the host's root file system in **/host** within the pod. By changing the root directory to **/host**, you can run binaries contained in the host's executable paths as shown in the following example:

```
# chroot /host
```

4. Run the following command to verify the applied power state:

```
# cat /proc/cmdline
```

Expected output

- For power saving mode the **intel_pstate=passive**.

Additional resources

- Configuring power saving for nodes that run colocated high and low priority workloads
- Configuring host firmware for low latency and high performance
- Preparing the GitOps ZTP site configuration repository

10.2.6.4. Maximizing power savings

Limiting the maximum CPU frequency is recommended to achieve maximum power savings. Enabling C-states on the non-critical workload CPUs without restricting the maximum CPU frequency negates much of the power savings by boosting the frequency of the critical CPUs.

Maximize power savings by updating the **sysfs** plugin fields, setting an appropriate value for **max_perf_pct** in the **TunedPerformancePatch** CR for the reference configuration. This example based on the **group-du-sno-ranGen.yaml** describes the procedure to follow to restrict the maximum CPU frequency.

Prerequisites

- You have configured power savings mode as described in "Using PolicyGenTemplate CRs to configure power savings mode".

Procedure

1. Update the **PolicyGenTemplate** entry for **TunedPerformancePatch** in the **group-du-sno-ranGen.yaml** reference file in **out/argocd/example/policygentemplates/**. To maximize power savings, add **max_perf_pct** as shown in the following example:

```
- fileName: TunedPerformancePatch.yaml
  policyName: "config-policy"
  spec:
    profile:
      - name: performance-patch
        data: |
          # ...
          [sysfs]
          /sys/devices/system/cpu/intel_pstate/max_perf_pct=<x> ①
```

- 1 The **max_perf_pct** controls the maximum frequency the **cpufreq** driver is allowed to set as a percentage of the maximum supported CPU frequency. This value applies to all CPUs. You can check the maximum supported frequency in **/sys/devices/system/cpu/cpu0/cpufreq/cpuinfo_max_freq**. As a starting point, you can use a percentage that caps all CPUs at the **All Cores Turbo** frequency. The **All Cores Turbo** frequency is the frequency that all cores will run at when the cores are all fully occupied.

**NOTE**

To maximize power savings, set a lower value. Setting a lower value for **max_perf_pct** limits the maximum CPU frequency, thereby reducing power consumption, but also potentially impacting performance. Experiment with different values and monitor the system's performance and power consumption to find the optimal setting for your use-case.

- Commit the **PolicyGenTemplate** change in Git, and then push to the Git repository being monitored by the GitOps ZTP Argo CD application.

10.2.7. Configuring LVM Storage using PolicyGenTemplate CRs

You can configure Logical Volume Manager (LVM) Storage for managed clusters that you deploy with GitOps Zero Touch Provisioning (ZTP).

**NOTE**

You use LVM Storage to persist event subscriptions when you use PTP events or bare-metal hardware events with HTTP transport.

Use the Local Storage Operator for persistent storage that uses local volumes in distributed units.

Prerequisites

- Install the OpenShift CLI (**oc**).
- Log in as a user with **cluster-admin** privileges.
- Create a Git repository where you manage your custom site configuration data.

Procedure

- To configure LVM Storage for new managed clusters, add the following YAML to **spec.sourceFiles** in the **common-ranGen.yaml** file:

```

- fileName: StorageLVMOSubscriptionNS.yaml
  policyName: subscription-policies
- fileName: StorageLVMOSubscriptionOperGroup.yaml
  policyName: subscription-policies
- fileName: StorageLVMOSubscription.yaml
  spec:
    name: lvms-operator
    channel: stable-4.18
  policyName: subscription-policies

```



NOTE

The Storage LVMO subscription is deprecated. In future releases of OpenShift Container Platform, the storage LVMO subscription will not be available. Instead, you must use the Storage LVMS subscription.

In OpenShift Container Platform 4.18, you can use the Storage LVMS subscription instead of the LVMO subscription. The LVMS subscription does not require manual overrides in the **common-ranGen.yaml** file. Add the following YAML to **spec.sourceFiles** in the **common-ranGen.yaml** file to use the Storage LVMS subscription:

```
- fileName: StorageLVMSSubscriptionNS.yaml
  policyName: subscription-policies
- fileName: StorageLVMSSubscriptionOperGroup.yaml
  policyName: subscription-policies
- fileName: StorageLVMSSubscription.yaml
  policyName: subscription-policies
```

2. Add the **LVMCluster** CR to **spec.sourceFiles** in your specific group or individual site configuration file. For example, in the **group-du-sno-ranGen.yaml** file, add the following:

```
- fileName: StorageLVMCluster.yaml
  policyName: "lvms-config"
  spec:
    storage:
      deviceClasses:
        - name: vg1
      thinPoolConfig:
        name: thin-pool-1
        sizePercent: 90
        overprovisionRatio: 10
```

This example configuration creates a volume group (**vg1**) with all the available devices, except the disk where OpenShift Container Platform is installed. A thin-pool logical volume is also created.

3. Merge any other required changes and files with your custom site repository.
4. Commit the **PolicyGenTemplate** changes in Git, and then push the changes to your site configuration repository to deploy LVM Storage to new sites using GitOps ZTP.

10.2.8. Configuring PTP events with PolicyGenTemplate CRs

You can use the GitOps ZTP pipeline to configure PTP events that use HTTP transport.

10.2.8.1. Configuring PTP events that use HTTP transport

You can configure PTP events that use HTTP transport on managed clusters that you deploy with the GitOps Zero Touch Provisioning (ZTP) pipeline.

Prerequisites

- You have installed the OpenShift CLI (**oc**).

- You have logged in as a user with **cluster-admin** privileges.
- You have created a Git repository where you manage your custom site configuration data.

Procedure

1. Apply the following **PolicyGenTemplate** changes to **group-du-3node-ranGen.yaml**, **group-du-sno-ranGen.yaml**, or **group-du-standard-ranGen.yaml** files according to your requirements:

- a. In **spec.sourceFiles**, add the **PtpOperatorConfig** CR file that configures the transport host:

```
- fileName: PtpOperatorConfigForEvent.yaml
  policyName: "config-policy"
  spec:
    daemonNodeSelector: {}
    ptpEventConfig:
      enableEventPublisher: true
      transportHost: http://ptp-event-publisher-service-NODE_NAME.openshift-
ptp.svc.cluster.local:9043
```



NOTE

In OpenShift Container Platform 4.13 or later, you do not need to set the **transportHost** field in the **PtpOperatorConfig** resource when you use HTTP transport with PTP events.

- b. Configure the **linuxptp** and **phc2sys** for the PTP clock type and interface. For example, add the following YAML into **spec.sourceFiles**:

```
- fileName: PtpConfigSlave.yaml ①
  policyName: "config-policy"
  metadata:
    name: "du-ptp-slave"
  spec:
    profile:
      - name: "slave"
        interface: "ens5f1" ②
        ptp4lOpts: "-2 -s --summary_interval -4" ③
        phc2sysOpts: "-a -r -m -n 24 -N 8 -R 16" ④
      ptpClockThreshold: ⑤
        holdOverTimeout: 30 # seconds
        maxOffsetThreshold: 100 # nano seconds
        minOffsetThreshold: -100
```

- ① Can be **PtpConfigMaster.yaml** or **PtpConfigSlave.yaml** depending on your requirements. For configurations based on **group-du-sno-ranGen.yaml** or **group-du-3node-ranGen.yaml**, use **PtpConfigSlave.yaml**.
- ② Device specific interface name.
- ③ You must append the **--summary_interval -4** value to **ptp4lOpts** in **.spec.sourceFiles.spec.profile** to enable PTP fast events.

- ④ Required **phc2sysOpts** values. **-m** prints messages to **stdout**. The **linuxptp-daemon DaemonSet** parses the logs and generates Prometheus metrics.
- ⑤ Optional. If the **ptpClockThreshold** stanza is not present, default values are used for the **ptpClockThreshold** fields. The stanza shows default **ptpClockThreshold** values. The **ptpClockThreshold** values configure how long after the PTP master clock is disconnected before PTP events are triggered. **holdOverTimeout** is the time value in seconds before the PTP clock event state changes to **FREERUN** when the PTP master clock is disconnected. The **maxOffsetThreshold** and **minOffsetThreshold** settings configure offset values in nanoseconds that compare against the values for **CLOCK_REALTIME (phc2sys)** or master offset (**ptp4l**). When the **ptp4l** or **phc2sys** offset value is outside this range, the PTP clock state is set to **FREERUN**. When the offset value is within this range, the PTP clock state is set to **LOCKED**.

2. Merge any other required changes and files with your custom site repository.
3. Push the changes to your site configuration repository to deploy PTP fast events to new sites using GitOps ZTP.

Additional resources

- [Using PolicyGenTemplate CRs to override source CRs content](#)

Additional resources

- [OpenShift image registry overview](#)

10.2.9. Configuring the Image Registry Operator for local caching of images

OpenShift Container Platform manages image caching using a local registry. In edge computing use cases, clusters are often subject to bandwidth restrictions when communicating with centralized image registries, which might result in long image download times.

Long download times are unavoidable during initial deployment. Over time, there is a risk that CRI-O will erase the **/var/lib/containers/storage** directory in the case of an unexpected shutdown. To address long image download times, you can create a local image registry on remote managed clusters using GitOps Zero Touch Provisioning (ZTP). This is useful in Edge computing scenarios where clusters are deployed at the far edge of the network.

Before you can set up the local image registry with GitOps ZTP, you need to configure disk partitioning in the **SiteConfig** CR that you use to install the remote managed cluster. After installation, you configure the local image registry using a **PolicyGenTemplate** CR. Then, the GitOps ZTP pipeline creates Persistent Volume (PV) and Persistent Volume Claim (PVC) CRs and patches the **imageregistry** configuration.



NOTE

The local image registry can only be used for user application images and cannot be used for the OpenShift Container Platform or Operator Lifecycle Manager operator images.

Additional resources

- [OpenShift Container Platform registry overview](#)

10.2.9.1. Configuring disk partitioning with SiteConfig

Configure disk partitioning for a managed cluster using a **SiteConfig** CR and GitOps Zero Touch Provisioning (ZTP). The disk partition details in the **SiteConfig** CR must match the underlying disk.



IMPORTANT

You must complete this procedure at installation time.

Prerequisites

- Install Butane.

Procedure

1. Create the **storage.bu** file.

```
variant: fcos
version: 1.3.0
storage:
  disks:
    - device: /dev/disk/by-path/pci-0000:01:00.0-scsi-0:2:0:0 ①
      wipe_table: false
    partitions:
      - label: var-lib-containers
        start_mib: <start_of_partition> ②
        size_mib: <partition_size> ③
  filesystems:
    - path: /var/lib/containers
      device: /dev/disk/by-partlabel/var-lib-containers
      format: xfs
      wipe_filesystem: true
      with_mount_unit: true
      mount_options:
        - defaults
        - prjquota
```

- 1 Specify the root disk.
- 2 Specify the start of the partition in MiB. If the value is too small, the installation fails.
- 3 Specify the size of the partition. If the value is too small, the deployments fails.

2. Convert the **storage.bu** to an Ignition file by running the following command:

```
$ butane storage.bu
```

Example output

```
{"ignition":{"version":"3.2.0"},"storage":{"disks":[{"device":"/dev/disk/by-path/pci-0000:01:00.0-scsi-0:2:0:0","partitions":[{"label":"var-lib-containers","sizeMiB":0,"startMiB":250000}],"wipeTable":false}],"filesystems":[{"device":"/dev/disk/by-partlabel/var-lib-containers","format":"xfs","mountOptions":
```

```
[{"defaults","prjquota"],"path":"/var/lib/containers","wipeFilesystem":true}}],"systemd":{"units":[{"contents": "# # Generated by Butane\n[Unit]\nRequires=systemd-fsck@dev-disk-by\\x2dpartlabel-var\\x2dlib\\x2dcontainers.service\nAfter=systemd-fsck@dev-disk-by\\x2dpartlabel-var\\x2dlib\\x2dcontainers.service\n[Mount]\nWhere=/var/lib/containers\nWhat=/dev/disk/by-partlabel/var-lib-containers\nType=xfs\nOptions=defaults,prjquota\n[Install]\nRequiredBy=local-fs.target","enabled":true,"name":"var-lib-containers.mount"}]}}
```

3. Use a tool such as [JSON Pretty Print](#) to convert the output into JSON format.
4. Copy the output into the **.spec.clusters.nodes.ignitionConfigOverride** field in the **SiteConfig** CR.

Example

```
[...]
spec:
  clusters:
    - nodes:
        - ignitionConfigOverride: |
            {
              "ignition": {
                "version": "3.2.0"
              },
              "storage": {
                "disks": [
                  {
                    "device": "/dev/disk/by-path/pci-0000:01:00.0-scsi-0:2:0:0",
                    "partitions": [
                      {
                        "label": "var-lib-containers",
                        "sizeMiB": 0,
                        "startMiB": 250000
                      }
                    ],
                    "wipeTable": false
                  }
                ],
                "filesystems": [
                  {
                    "device": "/dev/disk/by-partlabel/var-lib-containers",
                    "format": "xfs",
                    "mountOptions": [
                      "defaults",
                      "prjquota"
                    ],
                    "path": "/var/lib/containers",
                    "wipeFilesystem": true
                  }
                ]
              },
              "systemd": {
                "units": [
                  {
                    "contents": "# # Generated by Butane\n[Unit]\nRequires=systemd-fsck@dev-disk-
```

```

by\\x2dpartlabel-var\\x2dlib\\x2dcontainers.service\\nAfter=systemd-fsck@dev-disk-
by\\x2dpartlabel-
var\\x2dlib\\x2dcontainers.service\\n\\n[Mount]\\nWhere=/var/lib/containers\\nWhat=/dev/disk/by-
partlabel/var-lib-
containers\\nType=xfs\\nOptions=defaults,prjquota\\n\\n[Install]\\nRequiredBy=local-fs.target",
    "enabled": true,
    "name": "var-lib-containers.mount"
}
]
}
...

```

**NOTE**

If the `.spec.clusters.nodes.ignitionConfigOverride` field does not exist, create it.

Verification

1. During or after installation, verify on the hub cluster that the **BareMetalHost** object shows the annotation by running the following command:

```
$ oc get bmh -n my-sno-ns my-sno -ojson | jq '.metadata.annotations["bmac.agent-
install.openshift.io/ignition-config-overrides"]'
```

Example output

```
"{"ignition":{"version":"3.2.0"},"storage":{"disks":[{"device":"/dev/disk/by-id/wwn-
0x6b07b250ebb9d0002a33509f24af1f62","partitions":[{"label":"var-lib-
containers","sizeMiB":0,"startMiB":250000}],"wipeTable":false}],"filesystems": [
{"device":"/dev/disk/by-partlabel/var-lib-containers","format":"xfs","mountOptions": 
["defaults","prjquota"],"path":"/var/lib/containers","wipeFilesystem":true}}],"systemd": 
{"units":[{"contents": "# Generated by Butane\\n[Unit]\\nRequires=systemd-fsck@dev-disk-
by\\\\\\x2dpartlabel-var\\\\\\x2dlib\\\\\\x2dcontainers.service\\nAfter=systemd-fsck@dev-disk-
by\\\\\\x2dpartlabel-
var\\\\\\x2dlib\\\\\\x2dcontainers.service\\n\\n[Mount]\\nWhere=/var/lib/containers\\nWhat=/dev/disk/
by-partlabel/var-lib-
containers\\nType=xfs\\nOptions=defaults,prjquota\\n\\n[Install]\\nRequiredBy=local-
fs.target","enabled":true,"name":"var-lib-containers.mount"}]}}}
```

2. After installation, check the single-node OpenShift disk status.

- a. Enter into a debug session on the single-node OpenShift node by running the following command. This step instantiates a debug pod called `<node_name>-debug`:

```
$ oc debug node/my-sno-node
```

- b. Set `/host` as the root directory within the debug shell by running the following command. The debug pod mounts the host's root file system in `/host` within the pod. By changing the root directory to `/host`, you can run binaries contained in the host's executable paths:

```
# chroot /host
```

- c. List information about all available block devices by running the following command:

```
# lsblk
```

Example output

NAME	MAJ:MIN	RM	SIZE	RO	TYPE	MOUNTPOINTS
sda	8:0	0	446.6G	0	disk	
	sda1	8:1	0	1M	part	
	sda2	8:2	0	127M	part	
	sda3	8:3	0	384M	part	/boot
	sda4	8:4	0	243.6G	part	/var /sysroot/ostree/deploy/rhcos/var /usr /etc / /sysroot
	sda5	8:5	0	202.5G	part	/var/lib/containers

- d. Display information about the file system disk space usage by running the following command:

```
# df -h
```

Example output

Filesystem	Size	Used	Avail	Use%	Mounted on
devtmpfs	4.0M	0	4.0M	0%	/dev
tmpfs	126G	84K	126G	1%	/dev/shm
tmpfs	51G	93M	51G	1%	/run
/dev/sda4	244G	5.2G	239G	3%	/sysroot
tmpfs	126G	4.0K	126G	1%	/tmp
/dev/sda5	203G	119G	85G	59%	/var/lib/containers
/dev/sda3	350M	110M	218M	34%	/boot
tmpfs	26G	0	26G	0%	/run/user/1000

10.2.9.2. Configuring the image registry using PolicyGenTemplate CRs

Use **PolicyGenTemplate** (PGT) CRs to apply the CRs required to configure the image registry and patch the **imageregistry** configuration.

Prerequisites

- You have configured a disk partition in the managed cluster.
- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.
- You have created a Git repository where you manage your custom site configuration data for use with GitOps Zero Touch Provisioning (ZTP).

Procedure

- Configure the storage class, persistent volume claim, persistent volume, and image registry configuration in the appropriate **PolicyGenTemplate** CR. For example, to configure an individual site, add the following YAML to the file **example-sno-site.yaml**:

```

sourceFiles:
  # storage class
  - fileName: StorageClass.yaml
    policyName: "sc-for-image-registry"
    metadata:
      name: image-registry-sc
    annotations:
      ran.openshift.io/ztp-deploy-wave: "100" ①
  # persistent volume claim
  - fileName: StoragePVC.yaml
    policyName: "pvc-for-image-registry"
    metadata:
      name: image-registry-pvc
      namespace: openshift-image-registry
    annotations:
      ran.openshift.io/ztp-deploy-wave: "100"
  spec:
    accessModes:
      - ReadWriteMany
    resources:
      requests:
        storage: 100Gi
    storageClassName: image-registry-sc
    volumeMode: Filesystem
  # persistent volume
  - fileName: ImageRegistryPV.yaml ②
    policyName: "pv-for-image-registry"
    metadata:
      annotations:
        ran.openshift.io/ztp-deploy-wave: "100"
    - fileName: ImageRegistryConfig.yaml
      policyName: "config-for-image-registry"
      complianceType: musthave
      metadata:
        annotations:
          ran.openshift.io/ztp-deploy-wave: "100"
    spec:
      storage:
        pvc:
          claim: "image-registry-pvc"

```

- Set the appropriate value for **ztp-deploy-wave** depending on whether you are configuring image registries at the site, common, or group level. **ztp-deploy-wave: "100"** is suitable for development or testing because it allows you to group the referenced source files together.
- In **ImageRegistryPV.yaml**, ensure that the **spec.local.path** field is set to **/var/imageregistry** to match the value set for the **mount_point** field in the **SiteConfig** CR.



IMPORTANT

Do not set **complianceType: mustonlyhave** for the - **fileName: ImageRegistryConfig.yaml** configuration. This can cause the registry pod deployment to fail.

2. Commit the **PolicyGenTemplate** change in Git, and then push to the Git repository being monitored by the GitOps ZTP ArgoCD application.

Verification

Use the following steps to troubleshoot errors with the local image registry on the managed clusters:

- Verify successful login to the registry while logged in to the managed cluster. Run the following commands:
 - a. Export the managed cluster name:


```
$ cluster=<managed_cluster_name>
```
 - b. Get the managed cluster **kubeconfig** details:


```
$ oc get secret -n $cluster $cluster-admin-password -o jsonpath='{.data.password}' | base64 -d > kubeadmin-password-$cluster
```
 - c. Download and export the cluster **kubeconfig**:


```
$ oc get secret -n $cluster $cluster-admin-kubeconfig -o jsonpath='{.data.kubeconfig}' | base64 -d > kubeconfig-$cluster && export KUBECONFIG=./kubeconfig-$cluster
```
 - d. Verify access to the image registry from the managed cluster. See "Accessing the registry".
- Check that the **Config** CRD in the **imageregistry.operator.openshift.io** group instance is not reporting errors. Run the following command while logged in to the managed cluster:


```
$ oc get image.config.openshift.io cluster -o yaml
```

Example output

```
apiVersion: config.openshift.io/v1
kind: Image
metadata:
  annotations:
    include.release.openshift.io/ibm-cloud-managed: "true"
    include.release.openshift.io/self-managed-high-availability: "true"
    include.release.openshift.io/single-node-developer: "true"
    release.openshift.io/create-only: "true"
  creationTimestamp: "2021-10-08T19:02:39Z"
  generation: 5
  name: cluster
  resourceVersion: "688678648"
  uid: 0406521b-39c0-4cda-ba75-873697da75a4
spec:
  additionalTrustedCA:
    name: acm-ice
```

- Check that the **PersistentVolumeClaim** on the managed cluster is populated with data. Run the following command while logged in to the managed cluster:


```
$ oc get pv image-registry-sc
```
- Check that the **registry*** pod is running and is located under the **openshift-image-registry** namespace.


```
$ oc get pods -n openshift-image-registry | grep registry*
```

Example output

```
cluster-image-registry-operator-68f5c9c589-42cfg 1/1 Running 0 8d
image-registry-5f8987879-6nx6h 1/1 Running 0 8d
```

- Check that the disk partition on the managed cluster is correct:

- Open a debug shell to the managed cluster:

```
$ oc debug node/sno-1.example.com
```

- Run **lsblk** to check the host disk partitions:

```
sh-4.4# lsblk
NAME MAJ:MIN RM SIZE RO TYPE MOUNTPOINT
sda 8:0 0 446.6G 0 disk
|-sda1 8:1 0 1M 0 part
|-sda2 8:2 0 127M 0 part
|-sda3 8:3 0 384M 0 part /boot
|-sda4 8:4 0 336.3G 0 part /sysroot
`-sda5 8:5 0 100.1G 0 part /var/imageregistry ①
sdb 8:16 0 446.6G 0 disk
sr0 11:0 1 104M 0 rom
```

① **/var/imageregistry** indicates that the disk is correctly partitioned.

Additional resources

- [Accessing the registry](#)

10.3. UPDATING MANAGED CLUSTERS IN A DISCONNECTED ENVIRONMENT WITH POLICYGENTEMPLATE RESOURCES AND TALM

You can use the Topology Aware Lifecycle Manager (TALM) to manage the software lifecycle of managed clusters that you have deployed by using GitOps Zero Touch Provisioning (ZTP) and Topology Aware Lifecycle Manager (TALM). TALM uses Red Hat Advanced Cluster Management (RHACM) PolicyGenTemplate policies to manage and control changes applied to target clusters.



IMPORTANT

Using **PolicyGenTemplate** CRs to manage and deploy policies to managed clusters will be deprecated in an upcoming OpenShift Container Platform release. Equivalent and improved functionality is available using Red Hat Advanced Cluster Management (RHACM) and **PolicyGenerator** CRs.

For more information about **PolicyGenerator** resources, see the RHACM [Integrating Policy Generator](#) documentation.

Additional resources

- [Configuring managed cluster policies by using PolicyGenerator resources](#)
- [Comparing RHACM PolicyGenerator and PolicyGenTemplate resource patching](#)
- [About the Topology Aware Lifecycle Manager](#)

10.3.1. Setting up the disconnected environment

TALM can perform both platform and Operator updates.

You must mirror both the platform image and Operator images that you want to update to in your mirror registry before you can use TALM to update your disconnected clusters. Complete the following steps to mirror the images:

- For platform updates, you must perform the following steps:
 1. Mirror the desired OpenShift Container Platform image repository. Ensure that the desired platform image is mirrored by following the "Mirroring the OpenShift Container Platform image repository" procedure linked in the Additional resources. Save the contents of the **imageContentSources** section in the **imageContentSources.yaml** file:

Example output

```
imageContentSources:
- mirrors:
  - mirror-ocp-registry.ibmcloud.io.cpak:5000/openshift-release-dev/openshift4
    source: quay.io/openshift-release-dev/ocp-release
- mirrors:
  - mirror-ocp-registry.ibmcloud.io.cpak:5000/openshift-release-dev/openshift4
    source: quay.io/openshift-release-dev/ocp-v4.0-art-dev
```

2. Save the image signature of the desired platform image that was mirrored. You must add the image signature to the **PolicyGenTemplate** CR for platform updates. To get the image signature, perform the following steps:
 - a. Specify the desired OpenShift Container Platform tag by running the following command:

```
$ OCP_RELEASE_NUMBER=<release_version>
```

- b. Specify the architecture of the cluster by running the following command:

```
$ ARCHITECTURE=<cluster_architecture> ①
```

- 1** Specify the architecture of the cluster, such as **x86_64**, **aarch64**, **s390x**, or **ppc64le**.

- c. Get the release image digest from Quay by running the following command

```
$ DIGEST=$(oc adm release info quay.io/openshift-release-dev/ocp-release:${OCP_RELEASE_NUMBER}-${ARCHITECTURE} | sed -n 's/Pull From:.*@//p')"
```

- d. Set the digest algorithm by running the following command:

```
$ DIGEST_ALGO="${DIGEST%%:*}"
```

- e. Set the digest signature by running the following command:

```
$ DIGEST_ENCODED="${DIGEST#*:}"
```

- f. Get the image signature from the mirror.openshift.com website by running the following command:

```
$ SIGNATURE_BASE64=$(curl -s "https://mirror.openshift.com/pub/openshift-v4/signatures/openshift/release/${DIGEST_ALGO}=${DIGEST_ENCODED}/signature-1" | base64 -w0 && echo)
```

- g. Save the image signature to the **checksum-<OCP_RELEASE_NUMBER>.yaml** file by running the following commands:

```
$ cat >checksum-${OCP_RELEASE_NUMBER}.yaml <<EOF
${DIGEST_ALGO}-${DIGEST_ENCODED}: ${SIGNATURE_BASE64}
EOF
```

3. Prepare the update graph. You have two options to prepare the update graph:

- a. Use the OpenShift Update Service.

For more information about how to set up the graph on the hub cluster, see [Deploy the operator for OpenShift Update Service](#) and [Build the graph data init container](#).

- b. Make a local copy of the upstream graph. Host the update graph on an **http** or **https** server in the disconnected environment that has access to the managed cluster. To download the update graph, use the following command:

```
$ curl -s https://api.openshift.com/api/upgrades_info/v1/graph?channel=stable-4.18 -o ~/upgrade-graph_stable-4.18
```

- For Operator updates, you must perform the following task:

- Mirror the Operator catalogs. Ensure that the desired operator images are mirrored by following the procedure in the "Mirroring Operator catalogs for use with disconnected clusters" section.

Additional resources

- [Upgrading GitOps ZTP](#)

- Mirroring the OpenShift Container Platform image repository
- Mirroring Operator catalogs for use with disconnected clusters
- Preparing the disconnected environment
- Understanding update channels and releases

10.3.2. Performing a platform update with PolicyGenTemplate CRs

You can perform a platform update with the TALM.

Prerequisites

- Install the Topology Aware Lifecycle Manager (TALM).
- Update GitOps Zero Touch Provisioning (ZTP) to the latest version.
- Provision one or more managed clusters with GitOps ZTP.
- Mirror the desired image repository.
- Log in as a user with **cluster-admin** privileges.
- Create RHACM policies in the hub cluster.

Procedure

1. Create a **PolicyGenTemplate** CR for the platform update:
 - a. Save the following **PolicyGenTemplate** CR in the **du-upgrade.yaml** file:

Example of PolicyGenTemplate for platform update

```
apiVersion: ran.openshift.io/v1
kind: PolicyGenTemplate
metadata:
  name: "du-upgrade"
  namespace: "ztp-group-du-sno"
spec:
  bindingRules:
    group-du-sno: ""
    mcp: "master"
  remediationAction: inform
  sourceFiles:
    - fileName: ImageSignature.yaml 1
      policyName: "platform-upgrade-prep"
      binaryData:
        ${DIGEST_ALGO}-${DIGEST_ENCODED}: ${SIGNATURE_BASE64} 2
    - fileName: DisconnectedICSP.yaml
      policyName: "platform-upgrade-prep"
      metadata:
        name: disconnected-internal-icsp-for-ocp
      spec:
        repositoryDigestMirrors: 3
```

```

- mirrors:
  - quay-intern.example.com/ocp4/openshift-release-dev
    source: quay.io/openshift-release-dev/ocp-release
- mirrors:
  - quay-intern.example.com/ocp4/openshift-release-dev
    source: quay.io/openshift-release-dev/ocp-v4.0-art-dev
- fileName: ClusterVersion.yaml ④
  policyName: "platform-upgrade"
  metadata:
    name: version
  spec:
    channel: "stable-4.18"
    upstream: http://upgrade.example.com/images/upgrade-graph_stable-4.18
    desiredUpdate:
      version: 4.18.4
  status:
    history:
      - version: 4.18.4
    state: "Completed"

```

- 1 The **ConfigMap** CR contains the signature of the desired release image to update to.
- 2 Shows the image signature of the desired OpenShift Container Platform release. Get the signature from the **checksum-\${OCP_RELEASE_NUMBER}.yaml** file you saved when following the procedures in the "Setting up the environment" section.
- 3 Shows the mirror repository that contains the desired OpenShift Container Platform image. Get the mirrors from the **imageContentSources.yaml** file that you saved when following the procedures in the "Setting up the environment" section.
- 4 Shows the **ClusterVersion** CR to trigger the update. The **channel**, **upstream**, and **desiredVersion** fields are all required for image pre-caching.

The **PolicyGenTemplate** CR generates two policies:

- The **du-upgrade-platform-upgrade-prep** policy does the preparation work for the platform update. It creates the **ConfigMap** CR for the desired release image signature, creates the image content source of the mirrored release image repository, and updates the cluster version with the desired update channel and the update graph reachable by the managed cluster in the disconnected environment.
 - The **du-upgrade-platform-upgrade** policy is used to perform platform upgrade.
- b. Add the **du-upgrade.yaml** file contents to the **kustomization.yaml** file located in the GitOps ZTP Git repository for the **PolicyGenTemplate** CRs and push the changes to the Git repository.
ArgoCD pulls the changes from the Git repository and generates the policies on the hub cluster.
 - c. Check the created policies by running the following command:

```
$ oc get policies -A | grep platform-upgrade
```
2. Create the **ClusterGroupUpdate** CR for the platform update with the **spec.enable** field set to **false**.

- a. Save the content of the platform update **ClusterGroupUpdate** CR with the **du-upgrade-platform-upgrade-prep** and the **du-upgrade-platform-upgrade** policies and the target clusters to the **cgu-platform-upgrade.yml** file, as shown in the following example:

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-platform-upgrade
  namespace: default
spec:
  managedPolicies:
    - du-upgrade-platform-upgrade-prep
    - du-upgrade-platform-upgrade
  preCaching: false
  clusters:
    - spoke1
  remediationStrategy:
    maxConcurrency: 1
  enable: false
```

- b. Apply the **ClusterGroupUpdate** CR to the hub cluster by running the following command:

```
$ oc apply -f cgu-platform-upgrade.yml
```

3. Optional: Pre-cache the images for the platform update.

- a. Enable pre-caching in the **ClusterGroupUpdate** CR by running the following command:

```
$ oc --namespace=default patch clustergroupupgrade.ran.openshift.io/cgu-platform-upgrade \
--patch '{"spec":{"preCaching": true}}' --type=merge
```

- b. Monitor the update process and wait for the pre-caching to complete. Check the status of pre-caching by running the following command on the hub cluster:

```
$ oc get cgu cgu-platform-upgrade -o jsonpath='{.status.precaching.status}'
```

4. Start the platform update:

- a. Enable the **cgu-platform-upgrade** policy and disable pre-caching by running the following command:

```
$ oc --namespace=default patch clustergroupupgrade.ran.openshift.io/cgu-platform-upgrade \
--patch '{"spec":{"enable":true, "preCaching": false}}' --type=merge
```

- b. Monitor the process. Upon completion, ensure that the policy is compliant by running the following command:

```
$ oc get policies --all-namespaces
```

Additional resources

- [Preparing the disconnected environment](#)

10.3.3. Performing an Operator update with PolicyGenTemplate CRs

You can perform an Operator update with the TALM.

Prerequisites

- Install the Topology Aware Lifecycle Manager (TALM).
- Update GitOps Zero Touch Provisioning (ZTP) to the latest version.
- Provision one or more managed clusters with GitOps ZTP.
- Mirror the desired index image, bundle images, and all Operator images referenced in the bundle images.
- Log in as a user with **cluster-admin** privileges.
- Create RHACM policies in the hub cluster.

Procedure

1. Update the **PolicyGenTemplate** CR for the Operator update.
 - a. Update the **du-upgrade PolicyGenTemplate** CR with the following additional contents in the **du-upgrade.yaml** file:

```
apiVersion: ran.openshift.io/v1
kind: PolicyGenTemplate
metadata:
  name: "du-upgrade"
  namespace: "ztp-group-du-sno"
spec:
  bindingRules:
    group-du-sno: ""
    mcp: "master"
  remediationAction: inform
  sourceFiles:
    - fileName: DefaultCatsrc.yaml
      remediationAction: inform
      policyName: "operator-catsrc-policy"
      metadata:
        name: redhat-operators-disconnected
    spec:
      displayName: Red Hat Operators Catalog
      image: registry.example.com:5000/olm/redhat-operators-disconnected:v4.18 ①
      updateStrategy: ②
        registryPoll:
          interval: 1h
      status:
        connectionState:
          lastObservedState: READY ③
```

① The index image URL contains the desired Operator images. If the index images are always pushed to the same image name and tag, this change is not needed.

- 2 Set how frequently the Operator Lifecycle Manager (OLM) polls the index image for new Operator versions with the **registryPoll.interval** field. This change is not needed if a new index image tag is always pushed for y-stream and z-stream Operator updates. The **registryPoll.interval** field can be set to a shorter interval to expedite the update, however shorter intervals increase computational load. To counteract this behavior, you can restore **registryPoll.interval** to the default value once the update is complete.
 - 3 Last observed state of the catalog connection. The **READY** value ensures that the **CatalogSource** policy is ready, indicating that the index pod is pulled and is running. This way, TALM upgrades the Operators based on up-to-date policy compliance states.
- b. This update generates one policy, **du-upgrade-operator-catsrc-policy**, to update the **redhat-operators-disconnected** catalog source with the new index images that contain the desired Operators images.



NOTE

If you want to use the image pre-caching for Operators and there are Operators from a different catalog source other than **redhat-operators-disconnected**, you must perform the following tasks:

- Prepare a separate catalog source policy with the new index image or registry poll interval update for the different catalog source.
- Prepare a separate subscription policy for the desired Operators that are from the different catalog source.

For example, the desired SRIOV-FEC Operator is available in the **certified-operators** catalog source. To update the catalog source and the Operator subscription, add the following contents to generate two policies, **du-upgrade-fec-catsrc-policy** and **du-upgrade-subscriptions-fec-policy**:

```
apiVersion: ran.openshift.io/v1
kind: PolicyGenTemplate
metadata:
  name: "du-upgrade"
  namespace: "ztp-group-du-sno"
spec:
  bindingRules:
    group-du-sno: ""
    mcp: "master"
  remediationAction: inform
  sourceFiles:
    #
    - fileName: DefaultCatsrc.yaml
      remediationAction: inform
      policyName: "fec-catsrc-policy"
      metadata:
        name: certified-operators
  spec:
    displayName: Intel SRIOV-FEC Operator
    image: registry.example.com:5000/olm/far-edge-sriov-fec:v4.10
```

```

updateStrategy:
  registryPoll:
    interval: 10m
  - fileName: AcceleratorsSubscription.yaml
    policyName: "subscriptions-fec-policy"
    spec:
      channel: "stable"
      source: certified-operators
  
```

- c. Remove the specified subscriptions channels in the common **PolicyGenTemplate** CR, if they exist. The default subscriptions channels from the GitOps ZTP image are used for the update.



NOTE

The default channel for the Operators applied through GitOps ZTP 4.18 is **stable**, except for the **performance-addon-operator**. As of OpenShift Container Platform 4.11, the **performance-addon-operator** functionality was moved to the **node-tuning-operator**. For the 4.10 release, the default channel for PAO is **v4.10**. You can also specify the default channels in the common **PolicyGenTemplate** CR.

- d. Push the **PolicyGenTemplate** CRs updates to the GitOps ZTP Git repository. ArgoCD pulls the changes from the Git repository and generates the policies on the hub cluster.
- e. Check the created policies by running the following command:

```
$ oc get policies -A | grep -E "catsrc-policy|subscription"
```

2. Apply the required catalog source updates before starting the Operator update.

- a. Save the content of the **ClusterGroupUpgrade** CR named **operator-upgrade-prep** with the catalog source policies and the target managed clusters to the **cgu-operator-upgrade-prep.yml** file:

```

apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-operator-upgrade-prep
  namespace: default
spec:
  clusters:
  - spoke1
  enable: true
  managedPolicies:
  - du-upgrade-operator-catsrc-policy
  remediationStrategy:
    maxConcurrency: 1
  
```

- b. Apply the policy to the hub cluster by running the following command:

```
$ oc apply -f cgu-operator-upgrade-prep.yml
```

- c. Monitor the update process. Upon completion, ensure that the policy is compliant by running the following command:

```
$ oc get policies -A | grep -E "catsrc-policy"
```

3. Create the **ClusterGroupUpgrade** CR for the Operator update with the **spec.enable** field set to **false**.

- a. Save the content of the Operator update **ClusterGroupUpgrade** CR with the **du-upgrade-operator-catsrc-policy** policy and the subscription policies created from the common **PolicyGenTemplate** and the target clusters to the **cgu-operator-upgrade.yml** file, as shown in the following example:

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-operator-upgrade
  namespace: default
spec:
  managedPolicies:
    - du-upgrade-operator-catsrc-policy ①
    - common-subscriptions-policy ②
  preCaching: false
  clusters:
    - spoke1
  remediationStrategy:
    maxConcurrency: 1
  enable: false
```

- ① The policy is needed by the image pre-caching feature to retrieve the operator images from the catalog source.
- ② The policy contains Operator subscriptions. If you have followed the structure and content of the reference **PolicyGenTemplates**, all Operator subscriptions are grouped into the **common-subscriptions-policy** policy.



NOTE

One **ClusterGroupUpgrade** CR can only pre-cache the images of the desired Operators defined in the subscription policy from one catalog source included in the **ClusterGroupUpgrade** CR. If the desired Operators are from different catalog sources, such as in the example of the SRIOV-FEC Operator, another **ClusterGroupUpgrade** CR must be created with **du-upgrade-fec-catsrc-policy** and **du-upgrade-subscriptions-fec-policy** policies for the SRIOV-FEC Operator images pre-caching and update.

- b. Apply the **ClusterGroupUpgrade** CR to the hub cluster by running the following command:

```
$ oc apply -f cgu-operator-upgrade.yml
```

4. Optional: Pre-cache the images for the Operator update.

- Before starting image pre-caching, verify the subscription policy is **NonCompliant** at this point by running the following command:

```
$ oc get policy common-subscriptions-policy -n <policy_namespace>
```

Example output

NAME	REMEDIATION ACTION	COMPLIANCE STATE	AGE
common-subscriptions-policy	inform	NonCompliant	27d

- Enable pre-caching in the **ClusterGroupUpgrade** CR by running the following command:

```
$ oc --namespace=default patch clustergroupupgrade.ran.openshift.io/cgu-operator-upgrade \
--patch '{"spec":{"preCaching": true}}' --type=merge
```

- Monitor the process and wait for the pre-caching to complete. Check the status of pre-caching by running the following command on the managed cluster:

```
$ oc get cgu cgu-operator-upgrade -o jsonpath='{.status.precaching.status}'
```

- Check if the pre-caching is completed before starting the update by running the following command:

```
$ oc get cgu -n default cgu-operator-upgrade -ojsonpath='{.status.conditions}' | jq
```

Example output

```
[
  {
    "lastTransitionTime": "2022-03-08T20:49:08.000Z",
    "message": "The ClusterGroupUpgrade CR is not enabled",
    "reason": "UpgradeNotStarted",
    "status": "False",
    "type": "Ready"
  },
  {
    "lastTransitionTime": "2022-03-08T20:55:30.000Z",
    "message": "Precaching is completed",
    "reason": "PrecachingCompleted",
    "status": "True",
    "type": "PrecachingDone"
  }
]
```

- Start the Operator update.

- Enable the **cgu-operator-upgrade ClusterGroupUpgrade** CR and disable pre-caching to start the Operator update by running the following command:

```
$ oc --namespace=default patch clustergroupupgrade.ran.openshift.io/cgu-operator-upgrade \
--patch '{"spec":{"enable":true, "preCaching": false}}' --type=merge
```

- b. Monitor the process. Upon completion, ensure that the policy is compliant by running the following command:

```
$ oc get policies --all-namespaces
```

Additional resources

- [Upgrading GitOps ZTP](#)

10.3.4. Troubleshooting missed Operator updates with PolicyGenTemplate CRs

In some scenarios, Topology Aware Lifecycle Manager (TALM) might miss Operator updates due to an out-of-date policy compliance state.

After a catalog source update, it takes time for the Operator Lifecycle Manager (OLM) to update the subscription status. The status of the subscription policy might continue to show as compliant while TALM decides whether remediation is needed. As a result, the Operator specified in the subscription policy does not get upgraded.

To avoid this scenario, add another catalog source configuration to the **PolicyGenTemplate** and specify this configuration in the subscription for any Operators that require an update.

Procedure

1. Add a catalog source configuration in the **PolicyGenTemplate** resource:

```
- fileName: DefaultCatsrc.yaml
  remediationAction: inform
  policyName: "operator-catsrc-policy"
  metadata:
    name: redhat-operators-disconnected
  spec:
    displayName: Red Hat Operators Catalog
    image: registry.example.com:5000/olm/redhat-operators-disconnected:v{product-
version}
    updateStrategy:
      registryPoll:
        interval: 1h
    status:
      connectionState:
        lastObservedState: READY
- fileName: DefaultCatsrc.yaml
  remediationAction: inform
  policyName: "operator-catsrc-policy"
  metadata:
    name: redhat-operators-disconnected-v2 ①
  spec:
    displayName: Red Hat Operators Catalog v2 ②
    image: registry.example.com:5000/olm/redhat-operators-disconnected:<version> ③
    updateStrategy:
      registryPoll:
        interval: 1h
```

```

status:
connectionState:
lastObservedState: READY

```

- 1 Update the name for the new configuration.
- 2 Update the display name for the new configuration.
- 3 Update the index image URL. This **fileName.spec.image** field overrides any configuration in the **DefaultCatsrc.yaml** file.

2. Update the **Subscription** resource to point to the new configuration for Operators that require an update:

```

apiVersion: operators.coreos.com/v1alpha1
kind: Subscription
metadata:
  name: operator-subscription
  namespace: operator-namespace
# ...
spec:
  source: redhat-operators-disconnected-v2 1
# ...

```

- 1 Enter the name of the additional catalog source configuration that you defined in the **PolicyGenTemplate** resource.

10.3.5. Performing a platform and an Operator update together

You can perform a platform and an Operator update at the same time.

Prerequisites

- Install the Topology Aware Lifecycle Manager (TALM).
- Update GitOps Zero Touch Provisioning (ZTP) to the latest version.
- Provision one or more managed clusters with GitOps ZTP.
- Log in as a user with **cluster-admin** privileges.
- Create RHACM policies in the hub cluster.

Procedure

1. Create the **PolicyGenTemplate** CR for the updates by following the steps described in the "Performing a platform update" and "Performing an Operator update" sections.
2. Apply the prep work for the platform and the Operator update.
 - a. Save the content of the **ClusterGroupUpgrade** CR with the policies for platform update preparation work, catalog source updates, and target clusters to the **cgu-platform-operator-upgrade-prep.yml** file, for example:

```

apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-platform-operator-upgrade-prep
  namespace: default
spec:
  managedPolicies:
    - du-upgrade-platform-upgrade-prep
    - du-upgrade-operator-catsrc-policy
  clusterSelector:
    - group-du-sno
  remediationStrategy:
    maxConcurrency: 10
  enable: true

```

- b. Apply the **cgu-platform-operator-upgrade-prep.yml** file to the hub cluster by running the following command:

```
$ oc apply -f cgu-platform-operator-upgrade-prep.yml
```

- c. Monitor the process. Upon completion, ensure that the policy is compliant by running the following command:

```
$ oc get policies --all-namespaces
```

3. Create the **ClusterGroupUpdate** CR for the platform and the Operator update with the **spec.enable** field set to **false**.

- a. Save the contents of the platform and Operator update **ClusterGroupUpdate** CR with the policies and the target clusters to the **cgu-platform-operator-upgrade.yml** file, as shown in the following example:

```

apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-du-upgrade
  namespace: default
spec:
  managedPolicies:
    - du-upgrade-platform-upgrade ①
    - du-upgrade-operator-catsrc-policy ②
    - common-subscriptions-policy ③
  preCaching: true
  clusterSelector:
    - group-du-sno
  remediationStrategy:
    maxConcurrency: 1
  enable: false

```

① This is the platform update policy.

② This is the policy containing the catalog source information for the Operators to be updated. It is needed for the pre-caching feature to determine which Operator images to download to the managed cluster.

3 This is the policy to update the Operators.

- b. Apply the **cgu-platform-operator-upgrade.yml** file to the hub cluster by running the following command:

```
$ oc apply -f cgu-platform-operator-upgrade.yml
```

- 4. Optional: Pre-cache the images for the platform and the Operator update.

- a. Enable pre-caching in the **ClusterGroupUpgrade** CR by running the following command:

```
$ oc --namespace=default patch clustergroupupgrade.ran.openshift.io/cgu-du-upgrade \
--patch '{"spec":{"preCaching": true}}' --type=merge
```

- b. Monitor the update process and wait for the pre-caching to complete. Check the status of pre-caching by running the following command on the managed cluster:

```
$ oc get jobs,pods -n openshift-talm-pre-cache
```

- c. Check if the pre-caching is completed before starting the update by running the following command:

```
$ oc get cgu cgu-du-upgrade -ojsonpath='{.status.conditions}'
```

- 5. Start the platform and Operator update.

- a. Enable the **cgu-du-upgrade ClusterGroupUpgrade** CR to start the platform and the Operator update by running the following command:

```
$ oc --namespace=default patch clustergroupupgrade.ran.openshift.io/cgu-du-upgrade \
--patch '{"spec":{"enable":true, "preCaching": false}}' --type=merge
```

- b. Monitor the process. Upon completion, ensure that the policy is compliant by running the following command:

```
$ oc get policies --all-namespaces
```



NOTE

The CRs for the platform and Operator updates can be created from the beginning by configuring the setting to **spec.enable: true**. In this case, the update starts immediately after pre-caching completes and there is no need to manually enable the CR.

Both pre-caching and the update create extra resources, such as policies, placement bindings, placement rules, managed cluster actions, and managed cluster view, to help complete the procedures. Setting the **afterCompletion.deleteObjects** field to **true** deletes all these resources after the updates complete.

10.3.6. Removing Performance Addon Operator subscriptions from deployed clusters with PolicyGenTemplate CRs

In earlier versions of OpenShift Container Platform, the Performance Addon Operator provided automatic, low latency performance tuning for applications. In OpenShift Container Platform 4.11 or later, these functions are part of the Node Tuning Operator.

Do not install the Performance Addon Operator on clusters running OpenShift Container Platform 4.11 or later. If you upgrade to OpenShift Container Platform 4.11 or later, the Node Tuning Operator automatically removes the Performance Addon Operator.



NOTE

You need to remove any policies that create Performance Addon Operator subscriptions to prevent a re-installation of the Operator.

The reference DU profile includes the Performance Addon Operator in the **PolicyGenTemplate** CR **common-ranGen.yaml**. To remove the subscription from deployed managed clusters, you must update **common-ranGen.yaml**.



NOTE

If you install Performance Addon Operator 4.10.3-5 or later on OpenShift Container Platform 4.11 or later, the Performance Addon Operator detects the cluster version and automatically hibernates to avoid interfering with the Node Tuning Operator functions. However, to ensure best performance, remove the Performance Addon Operator from your OpenShift Container Platform 4.11 clusters.

Prerequisites

- Create a Git repository where you manage your custom site configuration data. The repository must be accessible from the hub cluster and be defined as a source repository for ArgoCD.
- Update to OpenShift Container Platform 4.11 or later.
- Log in as a user with **cluster-admin** privileges.

Procedure

1. Change the **complianceType** to **mustnothave** for the Performance Addon Operator namespace, Operator group, and subscription in the **common-ranGen.yaml** file.

```
- fileName: PaoSubscriptionNS.yaml
  policyName: "subscriptions-policy"
  complianceType: mustnothave
- fileName: PaoSubscriptionOperGroup.yaml
  policyName: "subscriptions-policy"
  complianceType: mustnothave
- fileName: PaoSubscription.yaml
  policyName: "subscriptions-policy"
  complianceType: mustnothave
```

2. Merge the changes with your custom site repository and wait for the ArgoCD application to synchronize the change to the hub cluster. The status of the **common-subscriptions-policy** policy changes to **Non-Compliant**.

3. Apply the change to your target clusters by using the Topology Aware Lifecycle Manager. For more information about rolling out configuration changes, see the "Additional resources" section.
4. Monitor the process. When the status of the **common-subscriptions-policy** policy for a target cluster is **Compliant**, the Performance Addon Operator has been removed from the cluster. Get the status of the **common-subscriptions-policy** by running the following command:

```
$ oc get policy -n ztp-common common-subscriptions-policy
```

5. Delete the Performance Addon Operator namespace, Operator group and subscription CRs from **spec.sourceFiles** in the **common-ranGen.yaml** file.
6. Merge the changes with your custom site repository and wait for the ArgoCD application to synchronize the change to the hub cluster. The policy remains compliant.

10.3.7. Pre-caching user-specified images with TALM on single-node OpenShift clusters

You can pre-cache application-specific workload images on single-node OpenShift clusters before upgrading your applications.

You can specify the configuration options for the pre-caching jobs using the following custom resources (CR):

- **PreCachingConfig** CR
- **ClusterGroupUpgrade** CR



NOTE

All fields in the **PreCachingConfig** CR are optional.

Example PreCachingConfig CR

```
apiVersion: ran.openshift.io/v1alpha1
kind: PreCachingConfig
metadata:
  name: exampleconfig
  namespace: exampleconfig-ns
spec:
  overrides: 1
    platformImage: quay.io/openshift-release-dev/ocp-release@sha256:3d5800990dee7cd4727d3fe238a97e2d2976d3808fc925ada29c559a47e2e1ef
    operatorsIndexes:
      - registry.example.com:5000/custom-redhat-operators:1.0.0
  operatorsPackagesAndChannels:
    - local-storage-operator: stable
    - ptp-operator: stable
    - sriov-network-operator: stable
  spaceRequired: 30 Gi 2
  excludePrecachePatterns: 3
    - aws
    - vsphere
```

additionalImages: ④

```
- quay.io/exampleconfig/application1@sha256:3d5800990dee7cd4727d3fe238a97e2d2976d3808fc925
ada29c559a47e2e1ef
-
quay.io/exampleconfig/application2@sha256:3d5800123dee7cd4727d3fe238a97e2d2976d3808fc925
ada29c559a47adfaef
-
quay.io/exampleconfig/applicationN@sha256:4fe1334adfafadsf987123adfffdaf1243340adfafdedga099
1234afdadfsa09
```

- ① By default, TALM automatically populates the **platformImage**, **operatorsIndexes**, and the **operatorsPackagesAndChannels** fields from the policies of the managed clusters. You can specify values to override the default TALM-derived values for these fields.
- ② Specifies the minimum required disk space on the cluster. If unspecified, TALM defines a default value for OpenShift Container Platform images. The disk space field must include an integer value and the storage unit. For example: **40 GiB**, **200 MB**, **1 TiB**.
- ③ Specifies the images to exclude from pre-caching based on image name matching.
- ④ Specifies the list of additional images to pre-cache.

Example ClusterGroupUpgrade CR with PreCachingConfig CR reference

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu
spec:
  preCaching: true ①
  preCachingConfigRef:
    name: exampleconfig ②
  namespace: exampleconfig-ns ③
```

- ① The **preCaching** field set to **true** enables the pre-caching job.
- ② The **preCachingConfigRef.name** field specifies the **PreCachingConfig** CR that you want to use.
- ③ The **preCachingConfigRef.namespace** specifies the namespace of the **PreCachingConfig** CR that you want to use.

10.3.7.1. Creating the custom resources for pre-caching

You must create the **PreCachingConfig** CR before or concurrently with the **ClusterGroupUpgrade** CR.

1. Create the **PreCachingConfig** CR with the list of additional images you want to pre-cache.

```
apiVersion: ran.openshift.io/v1alpha1
kind: PreCachingConfig
metadata:
  name: exampleconfig
```

```

namespace: default ①
spec:
[...]
spaceRequired: 30Gi ②
additionalImages:
-
quay.io/exampleconfig/application1@sha256:3d5800990dee7cd4727d3fe238a97e2d2976d3808fc925ada29c559a47e2e1ef
-
quay.io/exampleconfig/application2@sha256:3d5800123dee7cd4727d3fe238a97e2d2976d3808fc925ada29c559a47adfaef
-
quay.io/exampleconfig/applicationN@sha256:4fe1334adfafadsf987123adffffdaf1243340adfafdega0991234afdadfsa09

```

- ① The **namespace** must be accessible to the hub cluster.
- ② It is recommended to set the minimum disk space required field to ensure that there is sufficient storage space for the pre-cached images.

2. Create a **ClusterGroupUpgrade** CR with the **preCaching** field set to **true** and specify the **PreCachingConfig** CR created in the previous step:

```

apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu
  namespace: default
spec:
  clusters:
    - sno1
    - sno2
  preCaching: true
  preCachingConfigRef:
    - name: exampleconfig
      namespace: default
  managedPolicies:
    - du-upgrade-platform-upgrade
    - du-upgrade-operator-catsrc-policy
    - common-subscriptions-policy
  remediationStrategy:
    timeout: 240

```



WARNING

Once you install the images on the cluster, you cannot change or delete them.

- When you want to start pre-caching the images, apply the **ClusterGroupUpgrade** CR by running the following command:

```
$ oc apply -f cgu.yaml
```

TALM verifies the **ClusterGroupUpgrade** CR.

From this point, you can continue with the TALM pre-caching workflow.



NOTE

All sites are pre-cached concurrently.

Verification

- Check the pre-caching status on the hub cluster where the **ClusterUpgradeGroup** CR is applied by running the following command:

```
$ oc get cgu <cgu_name> -n <cgu_namespace> -oyaml
```

Example output

```
precaching:
  spec:
    platformImage: quay.io/openshift-release-dev/ocp-
release@sha256:3d5800990dee7cd4727d3fe238a97e2d2976d3808fc925ada29c559a47e2e1
    ef
    operatorsIndexes:
      - registry.example.com:5000/custom-redhat-operators:1.0.0
    operatorsPackagesAndChannels:
      - local-storage-operator: stable
      - ptp-operator: stable
      - sriov-network-operator: stable
    excludePrecachePatterns:
      - aws
      - vsphere
    additionalImages:
      -
        quay.io/exampleconfig/application1@sha256:3d5800990dee7cd4727d3fe238a97e2d2976d38
        08fc925ada29c559a47e2e1ef
      -
        quay.io/exampleconfig/application2@sha256:3d5800123dee7cd4727d3fe238a97e2d2976d38
        08fc925ada29c559a47adfaef
      -
        quay.io/exampleconfig/applicationN@sha256:4fe1334adfafadsf987123adfffdaf1243340adfaf
        edga0991234afdadfsa09
        spaceRequired: "30"
    status:
      sno1: Starting
      sno2: Starting
```

The pre-caching configurations are validated by checking if the managed policies exist. Valid configurations of the **ClusterGroupUpgrade** and the **PreCachingConfig** CRs result in the following statuses:

Example output of valid CRs

```

- lastTransitionTime: "2023-01-01T00:00:01Z"
  message: All selected clusters are valid
  reason: ClusterSelectionCompleted
  status: "True"
  type: ClusterSelected
- lastTransitionTime: "2023-01-01T00:00:02Z"
  message: Completed validation
  reason: ValidationCompleted
  status: "True"
  type: Validated
- lastTransitionTime: "2023-01-01T00:00:03Z"
  message: Precaching spec is valid and consistent
  reason: PrecacheSpecIsWellFormed
  status: "True"
  type: PrecacheSpecValid
- lastTransitionTime: "2023-01-01T00:00:04Z"
  message: Precaching in progress for 1 clusters
  reason: InProgress
  status: "False"
  type: PrecachingSucceeded

```

Example of an invalid PreCachingConfig CR

```

Type: "PrecacheSpecValid"
Status: False,
Reason: "PrecacheSpecIncomplete"
Message: "Precaching spec is incomplete: failed to get PreCachingConfig resource due to
PreCachingConfig.ran.openshift.io "<pre-caching_cr_name>" not found"

```

2. You can find the pre-caching job by running the following command on the managed cluster:

```
$ oc get jobs -n openshift-talo-pre-cache
```

Example of pre-caching job in progress

NAME	COMPLETIONS	DURATION	AGE
pre-cache	0/1	1s	1s

3. You can check the status of the pod created for the pre-caching job by running the following command:

```
$ oc describe pod pre-cache -n openshift-talo-pre-cache
```

Example of pre-caching job in progress

Type	Reason	Age	From	Message
Normal	SuccesfulCreate	19s	job-controller	Created pod: pre-cache-abcd1

4. You can get live updates on the status of the job by running the following command:

```
$ oc logs -f pre-cache-abcd1 -n openshift-talo-pre-cache
```

5. To verify the pre-cache job is successfully completed, run the following command:

```
$ oc describe pod pre-cache -n openshift-talo-pre-cache
```

Example of completed pre-cache job

Type	Reason	Age	From	Message
Normal	SuccessfulCreate	5m19s	job-controller	Created pod: pre-cache-abcd1
Normal	Completed	19s	job-controller	Job completed

6. To verify that the images are successfully pre-cached on the single-node OpenShift, do the following:

- a. Enter into the node in debug mode:

```
$ oc debug node/cnfdf00.example.lab
```

- b. Change root to **host**:

```
$ chroot /host/
```

- c. Search for the desired images:

```
$ sudo podman images | grep <operator_name>
```

Additional resources

- [Using the container image precache feature](#)

10.3.8. About the auto-created ClusterGroupUpgrade CR for GitOps ZTP

TALM has a controller called **ManagedClusterForCGU** that monitors the **Ready** state of the **ManagedCluster** CRs on the hub cluster and creates the **ClusterGroupUpgrade** CRs for GitOps Zero Touch Provisioning (ZTP).

For any managed cluster in the **Ready** state without a **ztp-done** label applied, the **ManagedClusterForCGU** controller automatically creates a **ClusterGroupUpgrade** CR in the **ztp-install** namespace with its associated RHACM policies that are created during the GitOps ZTP process. TALM then remediates the set of configuration policies that are listed in the auto-created **ClusterGroupUpgrade** CR to push the configuration CRs to the managed cluster.

If there are no policies for the managed cluster at the time when the cluster becomes **Ready**, a **ClusterGroupUpgrade** CR with no policies is created. Upon completion of the **ClusterGroupUpgrade** the managed cluster is labeled as **ztp-done**. If there are policies that you want to apply for that managed cluster, manually create a **ClusterGroupUpgrade** as a day-2 operation.

Example of an auto-created ClusterGroupUpgrade CR for GitOps ZTP

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  generation: 1
```

```

name: spoke1
namespace: ztp-install
ownerReferences:
- apiVersion: cluster.open-cluster-management.io/v1
  blockOwnerDeletion: true
  controller: true
  kind: ManagedCluster
  name: spoke1
  uid: 98fdb9b2-51ee-4ee7-8f57-a84f7f35b9d5
resourceVersion: "46666836"
uid: b8be9cd2-764f-4a62-87d6-6b767852c7da
spec:
  actions:
    afterCompletion:
      addClusterLabels:
        ztp-done: "" ①
    deleteClusterLabels:
      ztp-running: ""
    deleteObjects: true
  beforeEnable:
    addClusterLabels:
      ztp-running: "" ②
clusters:
- spoke1
enable: true
managedPolicies:
- common-spoke1-config-policy
- common-spoke1-subscriptions-policy
- group-spoke1-config-policy
- spoke1-config-policy
- group-spoke1-validator-du-policy
preCaching: false
remediationStrategy:
  maxConcurrency: 1
  timeout: 240

```

① Applied to the managed cluster when TALM completes the cluster configuration.

② Applied to the managed cluster when TALM starts deploying the configuration policies.

CHAPTER 11. USING HUB TEMPLATES IN POLICYGENERATOR OR POLICYGENTEMPLATE CRS

Topology Aware Lifecycle Manager supports Red Hat Advanced Cluster Management (RHACM) hub cluster template functions in configuration policies used with GitOps Zero Touch Provisioning (ZTP).

Hub-side cluster templates allow you to define configuration policies that can be dynamically customized to the target clusters. This reduces the need to create separate policies for many clusters with similar configurations but with different values.



IMPORTANT

Policy templates are restricted to the same namespace as the namespace where the policy is defined. This means you must create the objects referenced in the hub template in the same namespace where the policy is created.



IMPORTANT

Using **PolicyGenTemplate** CRs to manage and deploy policies to managed clusters will be deprecated in an upcoming OpenShift Container Platform release. Equivalent and improved functionality is available using Red Hat Advanced Cluster Management (RHACM) and **PolicyGenerator** CRs.

For more information about **PolicyGenerator** resources, see the RHACM [Integrating Policy Generator](#) documentation.

Additional resources

- [Configuring managed cluster policies by using PolicyGenerator resources](#)
- [Comparing RHACM PolicyGenerator and PolicyGenTemplate resource patching](#)
- [RHACM support for template processing in configuration policies](#)

11.1. SPECIFYING GROUP AND SITE CONFIGURATIONS IN GROUP POLICYGENERATOR OR POLICYGENTEMPLATE CRS

You can manage the configuration of fleets of clusters with **ConfigMap** CRs by using hub templates to populate the group and site values in the generated policies that get applied to the managed clusters. Using hub templates in site **PolicyGenerator** or **PolicyGentemplate** CRs means that you do not need to create a policy CR for each site.

You can group the clusters in a fleet in various categories, depending on the use case, for example hardware type or region. Each cluster should have a label corresponding to the group or groups that the cluster is in. If you manage the configuration values for each group in different **ConfigMap** CRs, then you require only one group policy CR to apply the changes to all the clusters in the group by using hub templates.

The following example shows you how to use three **ConfigMap** CRs and one **PolicyGenerator** CR to apply both site and group configuration to clusters grouped by hardware type and region.



NOTE

There is a [1 MiB size limit](#) (Kubernetes documentation) for **ConfigMap** CRs. The effective size for the **ConfigMap** CRs is further limited by the **last-applied-configuration** annotation. To avoid the **last-applied-configuration** limitation, add the following annotation to the template **ConfigMap**:

```
argocd.argoproj.io/sync-options: Replace=true
```

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.
- You have created a Git repository where you manage your custom site configuration data. The repository must be accessible from the hub cluster and be defined as a source repository for the GitOps ZTP ArgoCD application.

Procedure

1. Create three **ConfigMap** CRs that contain the group and site configuration:
 - a. Create a **ConfigMap** CR named **group-hardware-types-configmap** to hold the hardware-specific configuration. For example:

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: group-hardware-types-configmap
  namespace: ztp-group
  annotations:
    argocd.argoproj.io/sync-options: Replace=true ①
data:
  # SriosvNetworkNodePolicy.yaml
  hardware-type-1-sriov-node-policy-pfNames-1: "[\"ens5f0\"]"
  hardware-type-1-sriov-node-policy-pfNames-2: "[\"ens7f0\"]"
  # PerformanceProfile.yaml
  hardware-type-1-cpu-isolated: "2-31,34-63"
  hardware-type-1-cpu-reserved: "0-1,32-33"
  hardware-type-1-hugepages-default: "1G"
  hardware-type-1-hugepages-size: "1G"
  hardware-type-1-hugepages-count: "32"
```

- ① The **argocd.argoproj.io/sync-options** annotation is required only if the **ConfigMap** is larger than 1 MiB in size.

- b. Create a **ConfigMap** CR named **group-zones-configmap** to hold the regional configuration. For example:

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: group-zones-configmap
```

```

    namespace: ztp-group
  data:
    # ClusterLogForwarder.yaml
    zone-1-cluster-log-fwd-outputs: "[{\"type\":\"kafka\", \"name\":\"kafka-open\",
    \"url\":\"tcp://10.46.55.190:9092/test\"}]"
    zone-1-cluster-log-fwd-pipelines: "[{\\"inputRefs\\": [\"audit\", \"infrastructure\"], \\"labels\\":
    {\"label1\": \"test1\", \"label2\": \"test2\", \"label3\": \"test3\", \"label4\": \"test4\"}, \\"name\\\":
    \"all-to-default\", \\"outputRefs\\\": [\"kafka-open\"]}]"
  
```

- c. Create a **ConfigMap** CR named **site-data-configmap** to hold the site-specific configuration. For example:

```

apiVersion: v1
kind: ConfigMap
metadata:
  name: site-data-configmap
  namespace: ztp-group
data:
  # SriosvNetwork.yaml
  du-sno-1-zone-1-sriov-network-vlan-1: "140"
  du-sno-1-zone-1-sriov-network-vlan-2: "150"
  
```



NOTE

Each **ConfigMap** CR must be in the same namespace as the policy to be generated from the group **PolicyGenerator** CR.

2. Commit the **ConfigMap** CRs in Git, and then push to the Git repository being monitored by the Argo CD application.
3. Apply the hardware type and region labels to the clusters. The following command applies to a single cluster named **du-sno-1-zone-1** and the labels chosen are **"hardware-type": "hardware-type-1"** and **"group-du-sno-zone": "zone-1"**:

```
$ oc patch managedclusters.cluster.open-cluster-management.io/du-sno-1-zone-1 --type
merge -p '{"metadata":{"labels":{"hardware-type": "hardware-type-1", "group-du-sno-zone": "zone-1"}}}'
```

4. Depending on your requirements, Create a group **PolicyGenerator** or **PolicyGentemplate** CR that uses hub templates to obtain the required data from the **ConfigMap** objects:

- a. Create a group **PolicyGenerator** CR. This example **PolicyGenerator** CR configures logging, VLAN IDs, NICs and Performance Profile for the clusters that match the labels listed the under **policyDefaults.placement** field:

```

---
apiVersion: policy.open-cluster-management.io/v1
kind: PolicyGenerator
metadata:
  name: group-du-sno-pgt
placementBindingDefaults:
  name: group-du-sno-pgt-placement-binding
policyDefaults:
  placement:
    
```

```

labelSelector:
  matchExpressions:
    - key: group-du-sno-zone
      operator: In
      values:
        - zone-1
    - key: hardware-type
      operator: In
      values:
        - hardware-type-1
  remediationAction: inform
  severity: low
  namespaceSelector:
    exclude:
      - kube-*
    include:
      - '*'
  evaluationInterval:
    compliant: 10m
    noncompliant: 10s
  policies:
    - name: group-du-sno-pgt-group-du-sno-cfg-policy
      policyAnnotations:
        ran.openshift.io/ztp-deploy-wave: "10"
      manifests:
        - path: source-crs/ClusterLogForwarder.yaml
          patches:
            - spec:
                outputs: '{{hub fromConfigMap "" "group-zones-configmap" (printf "%s-cluster-log-fwd-outputs" (index .ManagedClusterLabels "group-du-sno-zone")) | toLiteral hub}}'
                pipelines: '{{hub fromConfigMap "" "group-zones-configmap" (printf "%s-cluster-log-fwd-pipelines" (index .ManagedClusterLabels "group-du-sno-zone")) | toLiteral hub}}'
        - path: source-crs/PerformanceProfile-MCP-master.yaml
          patches:
            - metadata:
                name: openshift-node-performance-profile
            spec:
              additionalKernelArgs:
                - rcupdate.rcu_normal_after_boot=0
                - vfio_pci.enable_sriov=1
                - vfio_pci.disable_idle_d3=1
                - efi=runtime
              cpu:
                isolated: '{{hub fromConfigMap "" "group-hardware-types-configmap" (printf "%s-cpu-isolated" (index .ManagedClusterLabels "hardware-type")) hub}}'
                reserved: '{{hub fromConfigMap "" "group-hardware-types-configmap" (printf "%s-cpu-reserved" (index .ManagedClusterLabels "hardware-type")) hub}}'
              hugepages:
                defaultHugepagesSize: '{{hub fromConfigMap "" "group-hardware-types-configmap" (printf "%s-hugepages-default" (index .ManagedClusterLabels "hardware-type")) hub}}'
                pages:
                  - count: '{{hub fromConfigMap "" "group-hardware-types-configmap" (printf "%s-hugepages-count" (index .ManagedClusterLabels "hardware-type")) | toInt hub}}'
                size: '{{hub fromConfigMap "" "group-hardware-types-configmap" (printf

```

```

"%s-hugepages-size" (index .ManagedClusterLabels "hardware-type")) hub}}'
    realTimeKernel:
        enabled: true
    - name: group-du-sno-pgt-group-du-sno-sriov-policy
      policyAnnotations:
        ran.openshift.io/ztp-deploy-wave: "100"
      manifests:
        - path: source-crs/SriovNetwork.yaml
          patches:
            - metadata:
                name: sriov-nw-du-fh
              spec:
                resourceName: du_fh
                vlan: '{{hub fromConfigMap "" "site-data-configmap" (printf "%s-sriov-network-vlan-1" .ManagedClusterName) | toInt hub}}'
            - path: source-crs/SriovNetworkNodePolicy-MCP-master.yaml
              patches:
                - metadata:
                    name: sriov-nnp-du-fh
                  spec:
                    deviceType: netdevice
                    isRdma: false
                    nicSelector:
                      pfNames: '{{hub fromConfigMap "" "group-hardware-types-configmap" (printf "%s-sriov-node-policy-pfNames-1" (index .ManagedClusterLabels "hardware-type")) | toLiteral hub}}'
                      numVfs: 8
                      priority: 10
                      resourceName: du_fh
                - path: source-crs/SriovNetwork.yaml
                  patches:
                    - metadata:
                        name: sriov-nw-du-mh
                      spec:
                        resourceName: du_mh
                        vlan: '{{hub fromConfigMap "" "site-data-configmap" (printf "%s-sriov-network-vlan-2" .ManagedClusterName) | toInt hub}}'
                    - path: source-crs/SriovNetworkNodePolicy-MCP-master.yaml
                      patches:
                        - metadata:
                            name: sriov-nw-du-fh
                          spec:
                            deviceType: netdevice
                            isRdma: false
                            nicSelector:
                              pfNames: '{{hub fromConfigMap "" "group-hardware-types-configmap" (printf "%s-sriov-node-policy-pfNames-2" (index .ManagedClusterLabels "hardware-type")) | toLiteral hub}}'
                              numVfs: 8
                              priority: 10
                              resourceName: du_fh

```

- b. Create a group **PolicyGenTemplate** CR. This example **PolicyGenTemplate** CR configures logging, VLAN IDs, NICs and Performance Profile for the clusters that match the labels listed under **spec.bindingRules**:

```

apiVersion: ran.openshift.io/v1
kind: PolicyGenTemplate
metadata:
  name: group-du-sno-pgt
  namespace: ztp-group
spec:
  bindingRules:
    # These policies will correspond to all clusters with these labels
    group-du-sno-zone: "zone-1"
    hardware-type: "hardware-type-1"
  mcp: "master"
  sourceFiles:
    - fileName: ClusterLogForwarder.yaml # wave 10
      policyName: "group-du-sno-cfg-policy"
      spec:
        outputs: '{{hub fromConfigMap "" "group-zones-configmap" (printf "%s-cluster-log-fwd-outputs" (index .ManagedClusterLabels "group-du-sno-zone")) | toLiteral hub}}'
        pipelines: '{{hub fromConfigMap "" "group-zones-configmap" (printf "%s-cluster-log-fwd-pipelines" (index .ManagedClusterLabels "group-du-sno-zone")) | toLiteral hub}}'

    - fileName: PerformanceProfile.yaml # wave 10
      policyName: "group-du-sno-cfg-policy"
      metadata:
        name: openshift-node-performance-profile
      spec:
        additionalKernelArgs:
          - rcupdate.rcu_normal_after_boot=0
          - vfio_pci.enable_sriov=1
          - vfio_pci.disable_idle_d3=1
          - efi=runtime
        cpu:
          isolated: '{{hub fromConfigMap "" "group-hardware-types-configmap" (printf "%s-cpu-isolated" (index .ManagedClusterLabels "hardware-type")) hub}}'
          reserved: '{{hub fromConfigMap "" "group-hardware-types-configmap" (printf "%s-cpu-reserved" (index .ManagedClusterLabels "hardware-type")) hub}}'
        hugepages:
          defaultHugepagesSize: '{{hub fromConfigMap "" "group-hardware-types-configmap" (printf "%s-hugepages-default" (index .ManagedClusterLabels "hardware-type")) hub}}'
        pages:
          - size: '{{hub fromConfigMap "" "group-hardware-types-configmap" (printf "%s-hugepages-size" (index .ManagedClusterLabels "hardware-type")) hub}}'
            count: '{{hub fromConfigMap "" "group-hardware-types-configmap" (printf "%s-hugepages-count" (index .ManagedClusterLabels "hardware-type")) | toInt hub}}'
        realTimeKernel:
          enabled: true

    - fileName: SriovNetwork.yaml # wave 100
      policyName: "group-du-sno-sriov-policy"
      metadata:
        name: sriov-nw-du-fh
      spec:
        resourceName: du_fh
        vlan: '{{hub fromConfigMap "" "site-data-configmap" (printf "%s-sriov-network-vlan-1" .ManagedClusterName) | toInt hub}}'

```

```

- fileName: SriovNetworkNodePolicy.yaml # wave 100
  policyName: "group-du-sno-sriov-policy"
  metadata:
    name: sriov-nnp-du-fh
  spec:
    deviceType: netdevice
    isRdma: false
    nicSelector:
      pfNames: '{{hub fromConfigMap "" "group-hardware-types-configmap" (printf "%s-sriov-node-policy-pfNames-1" (index .ManagedClusterLabels "hardware-type")) | toLiteral hub}}'
      numVfs: 8
      priority: 10
      resourceName: du_fh

- fileName: SriovNetwork.yaml # wave 100
  policyName: "group-du-sno-sriov-policy"
  metadata:
    name: sriov-nw-du-mh
  spec:
    resourceName: du_mh
    vlan: '{{hub fromConfigMap "" "site-data-configmap" (printf "%s-sriov-network-vlan-2" .ManagedClusterName) | toInt hub}}'

- fileName: SriovNetworkNodePolicy.yaml # wave 100
  policyName: "group-du-sno-sriov-policy"
  metadata:
    name: sriov-nw-du-fh
  spec:
    deviceType: netdevice
    isRdma: false
    nicSelector:
      pfNames: '{{hub fromConfigMap "" "group-hardware-types-configmap" (printf "%s-sriov-node-policy-pfNames-2" (index .ManagedClusterLabels "hardware-type")) | toLiteral hub}}'
      numVfs: 8
      priority: 10
      resourceName: du_fh

```



NOTE

To retrieve site-specific configuration values, use the **.ManagedClusterName** field. This is a template context value set to the name of the target managed cluster.

To retrieve group-specific configuration, use the **.ManagedClusterLabels** field. This is a template context value set to the value of the managed cluster's labels.

5. Commit the site **PolicyGenerator** or **PolicyGentemplate** CR in Git and push to the Git repository that is monitored by the ArgoCD application.

**NOTE**

Subsequent changes to the referenced **ConfigMap** CR are not automatically synced to the applied policies. You need to manually sync the new **ConfigMap** changes to update existing **PolicyGenerator** CRs. See "Syncing new ConfigMap changes to existing PolicyGenerator or PolicyGenTemplate CRs".

You can use the same **PolicyGenerator** or **PolicyGentemplate** CR for multiple clusters. If there is a configuration change, then the only modifications you need to make are to the **ConfigMap** objects that hold the configuration for each cluster and the labels of the managed clusters.

11.2. SYNCING NEW CONFIGMAP CHANGES TO EXISTING POLICYGENERATOR OR POLICYGENTEMPLATE CRS

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.
- You have created a **PolicyGenerator** or **PolicyGentemplate** CR that pulls information from a **ConfigMap** CR using hub cluster templates.

Procedure

1. Update the contents of your **ConfigMap** CR, and apply the changes in the hub cluster.
2. To sync the contents of the updated **ConfigMap** CR to the deployed policy, do either of the following:
 - a. Option 1: Delete the existing policy. ArgoCD uses the **PolicyGenerator** or **PolicyGentemplate** CR to immediately recreate the deleted policy. For example, run the following command:


```
$ oc delete policy <policy_name> -n <policy_namespace>
```
 - b. Option 2: Apply a special annotation **policy.open-cluster-management.io/trigger-update** to the policy with a different value every time when you update the **ConfigMap**. For example:


```
$ oc annotate policy <policy_name> -n <policy_namespace> policy.open-cluster-management.io/trigger-update="1"
```

**NOTE**

You must apply the updated policy for the changes to take effect. For more information, see [Special annotation for reprocessing](#).

3. Optional: If it exists, delete the **ClusterGroupUpdate** CR that contains the policy. For example:


```
$ oc delete clustergroupupgrade <cgu_name> -n <cgu_namespace>
```

- a. Create a new **ClusterGroupUpdate** CR that includes the policy to apply with the updated **ConfigMap** changes. For example, add the following YAML to the file **cgr-example.yaml**:

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: <cgr_name>
  namespace: <policy_namespace>
spec:
  managedPolicies:
    - <managed_policy>
  enable: true
  clusters:
    - <managed_cluster_1>
    - <managed_cluster_2>
  remediationStrategy:
    maxConcurrency: 2
    timeout: 240
```

- b. Apply the updated policy:

```
$ oc apply -f cgr-example.yaml
```

CHAPTER 12. UPDATING MANAGED CLUSTERS WITH THE TOPOLOGY AWARE LIFECYCLE MANAGER

You can use the Topology Aware Lifecycle Manager (TALM) to manage the software lifecycle of multiple clusters. TALM uses Red Hat Advanced Cluster Management (RHACM) policies to perform changes on the target clusters.



IMPORTANT

Using PolicyGenerator resources with GitOps ZTP 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](#).

12.1. ABOUT THE TOPOLOGY AWARE LIFECYCLE MANAGER CONFIGURATION

The Topology Aware Lifecycle Manager (TALM) manages the deployment of Red Hat Advanced Cluster Management (RHACM) policies for one or more OpenShift Container Platform clusters. Using TALM in a large network of clusters allows the phased rollout of policies to the clusters in limited batches. This helps to minimize possible service disruptions when updating. With TALM, you can control the following actions:

- The timing of the update
- The number of RHACM-managed clusters
- The subset of managed clusters to apply the policies to
- The update order of the clusters
- The set of policies remediated to the cluster
- The order of policies remediated to the cluster
- The assignment of a canary cluster

For single-node OpenShift, the Topology Aware Lifecycle Manager (TALM) offers pre-caching images for clusters with limited bandwidth.

TALM supports the orchestration of the OpenShift Container Platform y-stream and z-stream updates, and day-two operations on y-streams and z-streams.

12.2. ABOUT MANAGED POLICIES USED WITH TOPOLOGY AWARE LIFECYCLE MANAGER

The Topology Aware Lifecycle Manager (TALM) uses RHACM policies for cluster updates.

TALM can be used to manage the rollout of any policy CR where the **remediationAction** field is set to **inform**. Supported use cases include the following:

- Manual user creation of policy CRs
- Automatically generated policies from the **PolicyGenerator** or **PolicyGentemplate** custom resource definition (CRD)

For policies that update an Operator subscription with manual approval, TALM provides additional functionality that approves the installation of the updated Operator.

For more information about managed policies, see [Policy Overview](#) in the RHACM documentation.

Additional resources

- [About the PolicyGenerator CRD](#)

12.3. INSTALLING THE TOPOLOGY AWARE LIFECYCLE MANAGER BY USING THE WEB CONSOLE

You can use the OpenShift Container Platform web console to install the Topology Aware Lifecycle Manager.

Prerequisites

- Install the latest version of the RHACM Operator.
- TALM requires RHACM 2.9 or later.
- Set up a hub cluster with a disconnected registry.
- Log in as a user with **cluster-admin** privileges.

Procedure

1. In the OpenShift Container Platform web console, navigate to **Operators** → **OperatorHub**.
2. Search for the **Topology Aware Lifecycle Manager** from the list of available Operators, and then click **Install**.
3. Keep the default selection of **Installation mode** ["All namespaces on the cluster (default)"] and **Installed Namespace** ("openshift-operators") to ensure that the Operator is installed properly.
4. Click **Install**.

Verification

To confirm that the installation is successful:

1. Navigate to the **Operators** → **Installed Operators** page.
2. Check that the Operator is installed in the **All Namespaces** namespace and its status is **Succeeded**.

If the Operator is not installed successfully:

1. Navigate to the **Operators → Installed Operators** page and inspect the **Status** column for any errors or failures.
2. Navigate to the **Workloads → Pods** page and check the logs in any containers in the **cluster-group-upgrades-controller-manager** pod that are reporting issues.

12.4. INSTALLING THE TOPOLOGY AWARE LIFECYCLE MANAGER BY USING THE CLI

You can use the OpenShift CLI (**oc**) to install the Topology Aware Lifecycle Manager (TALM).

Prerequisites

- Install the OpenShift CLI (**oc**).
- Install the latest version of the RHACM Operator.
- TALM requires RHACM 2.9 or later.
- Set up a hub cluster with disconnected registry.
- Log in as a user with **cluster-admin** privileges.

Procedure

1. Create a **Subscription** CR:

a. Define the **Subscription** CR and save the YAML file, for example, **talm-subscription.yaml**:

```
apiVersion: operators.coreos.com/v1alpha1
kind: Subscription
metadata:
  name: openshift-topology-aware-lifecycle-manager-subscription
  namespace: openshift-operators
spec:
  channel: "stable"
  name: topology-aware-lifecycle-manager
  source: redhat-operators
  sourceNamespace: openshift-marketplace
```

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

```
$ oc create -f talm-subscription.yaml
```

Verification

1. Verify that the installation succeeded by inspecting the CSV resource:

```
$ oc get csv -n openshift-operators
```

Example output

NAME	DISPLAY	VERSION

REPLACES	PHASE
topology-aware-lifecycle-manager.4.18.x	Topology Aware Lifecycle Manager 4.18.x
Succeeded	

2. Verify that the TALM is up and running:

```
$ oc get deploy -n openshift-operators
```

Example output

NAMESPACE	NAME	READY	UP-TO-
DATE AVAILABLE AGE			
openshift-operators 1 1 14s	cluster-group-upgrades-controller-manager	1/1	

12.5. ABOUT THE CLUSTERGROUPUPGRADE CR

The Topology Aware Lifecycle Manager (TALM) builds the remediation plan from the **ClusterGroupUpgrade** CR for a group of clusters. You can define the following specifications in a **ClusterGroupUpgrade** CR:

- Clusters in the group
- Blocking **ClusterGroupUpgrade** CRs
- Applicable list of managed policies
- Number of concurrent updates
- Applicable canary updates
- Actions to perform before and after the update
- Update timing

You can control the start time of an update using the **enable** field in the **ClusterGroupUpgrade** CR. For example, if you have a scheduled maintenance window of four hours, you can prepare a **ClusterGroupUpgrade** CR with the **enable** field set to **false**.

You can set the timeout by configuring the **spec.remediationStrategy.timeout** setting as follows:

```
spec
  remediationStrategy:
    maxConcurrency: 1
    timeout: 240
```

You can use the **batchTimeoutAction** to determine what happens if an update fails for a cluster. You can specify **continue** to skip the failing cluster and continue to upgrade other clusters, or **abort** to stop policy remediation for all clusters. Once the timeout elapses, TALM removes all **enforce** policies to ensure that no further updates are made to clusters.

To apply the changes, you set the **enabled** field to **true**.

For more information see the "Applying update policies to managed clusters" section.

As TALM works through remediation of the policies to the specified clusters, the **ClusterGroupUpgrade** CR can report true or false statuses for a number of conditions.



NOTE

After TALM completes a cluster update, the cluster does not update again under the control of the same **ClusterGroupUpgrade** CR. You must create a new **ClusterGroupUpgrade** CR in the following cases:

- When you need to update the cluster again
- When the cluster changes to non-compliant with the **inform** policy after being updated

12.5.1. Selecting clusters

TALM builds a remediation plan and selects clusters based on the following fields:

- The **clusterLabelSelector** field specifies the labels of the clusters that you want to update. This consists of a list of the standard label selectors from **k8s.io/apimachinery/pkg/apis/meta/v1**. Each selector in the list uses either label value pairs or label expressions. Matches from each selector are added to the final list of clusters along with the matches from the **clusterSelector** field and the **cluster** field.
- The **clusters** field specifies a list of clusters to update.
- The **canaries** field specifies the clusters for canary updates.
- The **maxConcurrency** field specifies the number of clusters to update in a batch.
- The **actions** field specifies **beforeEnable** actions that TALM takes as it begins the update process, and **afterCompletion** actions that TALM takes as it completes policy remediation for each cluster.

You can use the **clusters**, **clusterLabelSelector**, and **clusterSelector** fields together to create a combined list of clusters.

The remediation plan starts with the clusters listed in the **canaries** field. Each canary cluster forms a single-cluster batch.

Sample ClusterGroupUpgrade CR with the enabled field set to false

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  creationTimestamp: '2022-11-18T16:27:15Z'
  finalizers:
    - ran.openshift.io/cleanup-finalizer
  generation: 1
  name: talm-cgu
  namespace: talm-namespace
  resourceVersion: '40451823'
  uid: cca245a5-4bca-45fa-89c0-aa6af81a596c
spec:
  actions:
    afterCompletion: 1
```

```
addClusterLabels:  
  upgrade-done: ""  
deleteClusterLabels:  
  upgrade-running: ""  
deleteObjects: true  
beforeEnable: ②  
addClusterLabels:  
  upgrade-running: ""  
clusters: ③  
  - spoke1  
enable: false ④  
managedPolicies: ⑤  
  - talm-policy  
preCaching: false  
remediationStrategy: ⑥  
canaries: ⑦  
  - spoke1  
maxConcurrency: 2 ⑧  
timeout: 240  
clusterLabelSelectors: ⑨  
  - matchExpressions:  
    - key: label1  
      operator: In  
      values:  
        - value1a  
        - value1b  
batchTimeoutAction: ⑩  
status: ⑪  
  computedMaxConcurrency: 2  
  conditions:  
    - lastTransitionTime: '2022-11-18T16:27:15Z'  
      message: All selected clusters are valid  
      reason: ClusterSelectionCompleted  
      status: 'True'  
    type: ClustersSelected ⑫  
    - lastTransitionTime: '2022-11-18T16:27:15Z'  
      message: Completed validation  
      reason: ValidationCompleted  
      status: 'True'  
    type: Validated ⑬  
    - lastTransitionTime: '2022-11-18T16:37:16Z'  
      message: Not enabled  
      reason: NotEnabled  
      status: 'False'  
    type: Progressing  
  managedPoliciesForUpgrade:  
    - name: talm-policy  
      namespace: talm-namespace  
  managedPoliciesNs:  
    talm-policy: talm-namespace  
  remediationPlan:  
    - - spoke1
```

```

    - - spoke2
    - spoke3
status:
```

- 1** Specifies the action that TALM takes when it completes policy remediation for each cluster.
- 2** Specifies the action that TALM takes as it begins the update process.
- 3** Defines the list of clusters to update.
- 4** The **enable** field is set to **false**.
- 5** Lists the user-defined set of policies to remediate.
- 6** Defines the specifics of the cluster updates.
- 7** Defines the clusters for canary updates.
- 8** Defines the maximum number of concurrent updates in a batch. The number of remediation batches is the number of canary clusters, plus the number of clusters, except the canary clusters, divided by the **maxConcurrency** value. The clusters that are already compliant with all the managed policies are excluded from the remediation plan.
- 9** Displays the parameters for selecting clusters.
- 10** Controls what happens if a batch times out. Possible values are **abort** or **continue**. If unspecified, the default is **continue**.
- 11** Displays information about the status of the updates.
- 12** The **ClustersSelected** condition shows that all selected clusters are valid.
- 13** The **Validated** condition shows that all selected clusters have been validated.



NOTE

Any failures during the update of a canary cluster stops the update process.

When the remediation plan is successfully created, you can set the **enable** field to **true** and TALM starts to update the non-compliant clusters with the specified managed policies.



NOTE

You can only make changes to the **spec** fields if the **enable** field of the **ClusterGroupUpgrade** CR is set to **false**.

12.5.2. Validating

TALM checks that all specified managed policies are available and correct, and uses the **Validated** condition to report the status and reasons as follows:

- **true**
Validation is completed.

- **false**

Policies are missing or invalid, or an invalid platform image has been specified.

12.5.3. Pre-caching

Clusters might have limited bandwidth to access the container image registry, which can cause a timeout before the updates are completed. On single-node OpenShift clusters, you can use pre-caching to avoid this. The container image pre-caching starts when you create a **ClusterGroupUpgrade** CR with the **preCaching** field set to **true**. TALM compares the available disk space with the estimated OpenShift Container Platform image size to ensure that there is enough space. If a cluster has insufficient space, TALM cancels pre-caching for that cluster and does not remediate policies on it.

TALM uses the **PrecacheSpecValid** condition to report status information as follows:

- **true**
The pre-caching spec is valid and consistent.
- **false**
The pre-caching spec is incomplete.

TALM uses the **PrecachingSucceeded** condition to report status information as follows:

- **true**
TALM has concluded the pre-caching process. If pre-caching fails for any cluster, the update fails for that cluster but proceeds for all other clusters. A message informs you if pre-caching has failed for any clusters.
- **false**
Pre-caching is still in progress for one or more clusters or has failed for all clusters.

For more information see the "Using the container image pre-cache feature" section.

12.5.4. Updating clusters

TALM enforces the policies following the remediation plan. Enforcing the policies for subsequent batches starts immediately after all the clusters of the current batch are compliant with all the managed policies. If the batch times out, TALM moves on to the next batch. The timeout value of a batch is the **spec.timeout** field divided by the number of batches in the remediation plan.

TALM uses the **Progressing** condition to report the status and reasons as follows:

- **true**
TALM is remediating non-compliant policies.
- **false**
The update is not in progress. Possible reasons for this are:
 - All clusters are compliant with all the managed policies.
 - The update timed out as policy remediation took too long.
 - Blocking CRs are missing from the system or have not yet completed.
 - The **ClusterGroupUpgrade** CR is not enabled.



NOTE

The managed policies apply in the order that they are listed in the **managedPolicies** field in the **ClusterGroupUpgrade** CR. One managed policy is applied to the specified clusters at a time. When a cluster complies with the current policy, the next managed policy is applied to it.

Sample ClusterGroupUpgrade CR in the Progressing state

```

apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  creationTimestamp: '2022-11-18T16:27:15Z'
  finalizers:
    - ran.openshift.io/cleanup-finalizer
  generation: 1
  name: talm-cgu
  namespace: talm-namespace
  resourceVersion: '40451823'
  uid: cca245a5-4bca-45fa-89c0-aa6af81a596c
spec:
  actions:
    afterCompletion:
      deleteObjects: true
    beforeEnable: {}
  clusters:
    - spoke1
  enable: true
  managedPolicies:
    - talm-policy
  preCaching: true
  remediationStrategy:
    canaries:
      - spoke1
    maxConcurrency: 2
    timeout: 240
  clusterLabelSelectors:
    - matchExpressions:
        - key: label1
          operator: In
        values:
          - value1a
          - value1b
  batchTimeoutAction:
  status:
    clusters:
      - name: spoke1
        state: complete
    computedMaxConcurrency: 2
    conditions:
      - lastTransitionTime: '2022-11-18T16:27:15Z'
        message: All selected clusters are valid
        reason: ClusterSelectionCompleted
        status: 'True'
        type: ClustersSelected

```

```

- lastTransitionTime: '2022-11-18T16:27:15Z'
  message: Completed validation
  reason: ValidationCompleted
  status: 'True'
  type: Validated
- lastTransitionTime: '2022-11-18T16:37:16Z'
  message: Remediating non-compliant policies
  reason: InProgress
  status: 'True'
  type: Progressing ①
managedPoliciesForUpgrade:
- name: talm-policy
  namespace: talm-namespace
managedPoliciesNs:
  talm-policy: talm-namespace
remediationPlan:
  - - spoke1
  - - spoke2
  - - spoke3
status:
  currentBatch: 2
  currentBatchRemediationProgress:
    spoke2:
      state: Completed
    spoke3:
      policyIndex: 0
      state: InProgress
currentBatchStartedAt: '2022-11-18T16:27:16Z'
startedAt: '2022-11-18T16:27:15Z'

```

- ① The **Progressing** fields show that TALM is in the process of remediating policies.

12.5.5. Update status

TALM uses the **Succeeded** condition to report the status and reasons as follows:

- **true**
All clusters are compliant with the specified managed policies.
- **false**
Policy remediation failed as there were no clusters available for remediation, or because policy remediation took too long for one of the following reasons:
 - The current batch contains canary updates and the cluster in the batch does not comply with all the managed policies within the batch timeout.
 - Clusters did not comply with the managed policies within the **timeout** value specified in the **remediationStrategy** field.

Sample ClusterGroupUpgrade CR in the Succeeded state

```

apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:

```

```

name: cgu-upgrade-complete
namespace: default
spec:
clusters:
- spoke1
- spoke4
enable: true
managedPolicies:
- policy1-common-cluster-version-policy
- policy2-common-pao-sub-policy
remediationStrategy:
maxConcurrency: 1
timeout: 240
status: ①
clusters:
- name: spoke1
state: complete
- name: spoke4
state: complete
conditions:
- message: All selected clusters are valid
reason: ClusterSelectionCompleted
status: "True"
type: ClustersSelected
- message: Completed validation
reason: ValidationCompleted
status: "True"
type: Validated
- message: All clusters are compliant with all the managed policies
reason: Completed
status: "False"
type: Progressing ②
- message: All clusters are compliant with all the managed policies
reason: Completed
status: "True"
type: Succeeded ③
managedPoliciesForUpgrade:
- name: policy1-common-cluster-version-policy
namespace: default
- name: policy2-common-pao-sub-policy
namespace: default
remediationPlan:
- - spoke1
- - spoke4
status:
completedAt: '2022-11-18T16:27:16Z'
startedAt: '2022-11-18T16:27:15Z'

```

- ② In the **Progressing** fields, the status is **false** as the update has completed; clusters are compliant with all the managed policies.
- ③ The **Succeeded** fields show that the validations completed successfully.
- ① The **status** field includes a list of clusters and their respective statuses. The status of a cluster can be **complete** or **timedout**.

Sample ClusterGroupUpgrade CR in the timedout state

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  creationTimestamp: '2022-11-18T16:27:15Z'
  finalizers:
    - ran.openshift.io/cleanup-finalizer
  generation: 1
  name: talm-cgu
  namespace: talm-namespace
  resourceVersion: '40451823'
  uid: cca245a5-4bca-45fa-89c0-aa6af81a596c
spec:
  actions:
    afterCompletion:
      deleteObjects: true
    beforeEnable: {}
  clusters:
    - spoke1
    - spoke2
  enable: true
  managedPolicies:
    - talm-policy
  preCaching: false
  remediationStrategy:
    maxConcurrency: 2
    timeout: 240
status:
  clusters:
    - name: spoke1
      state: complete
    - currentPolicy: ①
      name: talm-policy
      status: NonCompliant
    name: spoke2
    state: timedout
  computedMaxConcurrency: 2
conditions:
  - lastTransitionTime: '2022-11-18T16:27:15Z'
    message: All selected clusters are valid
    reason: ClusterSelectionCompleted
    status: 'True'
    type: ClustersSelected
  - lastTransitionTime: '2022-11-18T16:27:15Z'
    message: Completed validation
    reason: ValidationCompleted
    status: 'True'
    type: Validated
  - lastTransitionTime: '2022-11-18T16:37:16Z'
    message: Policy remediation took too long
    reason: TimedOut
    status: 'False'
    type: Progressing
  - lastTransitionTime: '2022-11-18T16:37:16Z'
    message: Policy remediation took too long
```

```

reason: TimedOut
status: 'False'
type: Succeeded ②
managedPoliciesForUpgrade:
  - name: talm-policy
    namespace: talm-namespace
managedPoliciesNs:
  talm-policy: talm-namespace
remediationPlan:
  - - spoke1
  - spoke2
status:
  startedAt: '2022-11-18T16:27:15Z'
  completedAt: '2022-11-18T20:27:15Z'

```

- ① If a cluster's state is **timedout**, the **currentPolicy** field shows the name of the policy and the policy status.
- ② The status for **succeeded** is **false** and the message indicates that policy remediation took too long.

12.5.6. Blocking ClusterGroupUpgrade CRs

You can create multiple **ClusterGroupUpgrade** CRs and control their order of application.

For example, if you create **ClusterGroupUpgrade** CR C that blocks the start of **ClusterGroupUpgrade** CR A, then **ClusterGroupUpgrade** CR A cannot start until the status of **ClusterGroupUpgrade** CR C becomes **UpgradeComplete**.

One **ClusterGroupUpgrade** CR can have multiple blocking CRs. In this case, all the blocking CRs must complete before the upgrade for the current CR can start.

Prerequisites

- Install the Topology Aware Lifecycle Manager (TALM).
- Provision one or more managed clusters.
- Log in as a user with **cluster-admin** privileges.
- Create RHACM policies in the hub cluster.

Procedure

1. Save the content of the **ClusterGroupUpgrade** CRs in the **cgu-a.yaml**, **cgu-b.yaml**, and **cgu-c.yaml** files.

```

apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-a
  namespace: default
spec:
  blockingCRs: ①

```

```

- name: cgu-c
  namespace: default
clusters:
- spoke1
- spoke2
- spoke3
enable: false
managedPolicies:
- policy1-common-cluster-version-policy
- policy2-common-pao-sub-policy
- policy3-common-ptp-sub-policy
remediationStrategy:
canaries:
- spoke1
maxConcurrency: 2
timeout: 240
status:
conditions:
- message: The ClusterGroupUpgrade CR is not enabled
  reason: UpgradeNotStarted
  status: "False"
  type: Ready
managedPoliciesForUpgrade:
- name: policy1-common-cluster-version-policy
  namespace: default
- name: policy2-common-pao-sub-policy
  namespace: default
- name: policy3-common-ptp-sub-policy
  namespace: default
placementBindings:
- cgu-a-policy1-common-cluster-version-policy
- cgu-a-policy2-common-pao-sub-policy
- cgu-a-policy3-common-ptp-sub-policy
placementRules:
- cgu-a-policy1-common-cluster-version-policy
- cgu-a-policy2-common-pao-sub-policy
- cgu-a-policy3-common-ptp-sub-policy
remediationPlan:
- - spoke1
- - spoke2

```

- 1 Defines the blocking CRs. The **cgu-a** update cannot start until **cgu-c** is complete.

```

apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-b
  namespace: default
spec:
  blockingCRs: 1
  - name: cgu-a
    namespace: default
clusters:
- spoke4
- spoke5

```

```

enable: false
managedPolicies:
- policy1-common-cluster-version-policy
- policy2-common-pao-sub-policy
- policy3-common-ptp-sub-policy
- policy4-common-sriov-sub-policy
remediationStrategy:
  maxConcurrency: 1
  timeout: 240
status:
  conditions:
    - message: The ClusterGroupUpgrade CR is not enabled
      reason: UpgradeNotStarted
      status: "False"
      type: Ready
  managedPoliciesForUpgrade:
    - name: policy1-common-cluster-version-policy
      namespace: default
    - name: policy2-common-pao-sub-policy
      namespace: default
    - name: policy3-common-ptp-sub-policy
      namespace: default
    - name: policy4-common-sriov-sub-policy
      namespace: default
  placementBindings:
    - cgu-b-policy1-common-cluster-version-policy
    - cgu-b-policy2-common-pao-sub-policy
    - cgu-b-policy3-common-ptp-sub-policy
    - cgu-b-policy4-common-sriov-sub-policy
  placementRules:
    - cgu-b-policy1-common-cluster-version-policy
    - cgu-b-policy2-common-pao-sub-policy
    - cgu-b-policy3-common-ptp-sub-policy
    - cgu-b-policy4-common-sriov-sub-policy
  remediationPlan:
    - - spoke4
    - - spoke5
  status: {}

```

- 1 The **cgu-b** update cannot start until **cgu-a** is complete.

```

apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-c
  namespace: default
spec: ①
  clusters:
    - spoke6
  enable: false
  managedPolicies:
    - policy1-common-cluster-version-policy
    - policy2-common-pao-sub-policy
    - policy3-common-ptp-sub-policy
    - policy4-common-sriov-sub-policy

```

```

remediationStrategy:
  maxConcurrency: 1
  timeout: 240
status:
  conditions:
    - message: The ClusterGroupUpgrade CR is not enabled
      reason: UpgradeNotStarted
      status: "False"
      type: Ready
  managedPoliciesCompliantBeforeUpgrade:
    - policy2-common-pao-sub-policy
    - policy3-common-ptp-sub-policy
  managedPoliciesForUpgrade:
    - name: policy1-common-cluster-version-policy
      namespace: default
    - name: policy4-common-sriov-sub-policy
      namespace: default
  placementBindings:
    - cgu-c-policy1-common-cluster-version-policy
    - cgu-c-policy4-common-sriov-sub-policy
  placementRules:
    - cgu-c-policy1-common-cluster-version-policy
    - cgu-c-policy4-common-sriov-sub-policy
  remediationPlan:
    - -- spoke6
  status: {}

```

- 1 The **cgu-c** update does not have any blocking CRs. TALM starts the **cgu-c** update when the **enable** field is set to **true**.

- Create the **ClusterGroupUpgrade** CRs by running the following command for each relevant CR:

```
$ oc apply -f <name>.yaml
```

- Start the update process by running the following command for each relevant CR:

```
$ oc --namespace=default patch clustergroupupgrade.ran.openshift.io/<name> \
--type merge -p '{"spec":{"enable":true}}'
```

The following examples show **ClusterGroupUpgrade** CRs where the **enable** field is set to **true**:

Example for **cgu-a** with blocking CRs

```

apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-a
  namespace: default
spec:
  blockingCRs:
    - name: cgu-c
      namespace: default
  clusters:

```

```

- spoke1
- spoke2
- spoke3
enable: true
managedPolicies:
- policy1-common-cluster-version-policy
- policy2-common-pao-sub-policy
- policy3-common-ptp-sub-policy
remediationStrategy:
canaries:
- spoke1
maxConcurrency: 2
timeout: 240
status:
conditions:
- message: 'The ClusterGroupUpgrade CR is blocked by other CRs that have not yet
completed: [cgu-c]' ①
reason: UpgradeCannotStart
status: "False"
type: Ready
managedPoliciesForUpgrade:
- name: policy1-common-cluster-version-policy
namespace: default
- name: policy2-common-pao-sub-policy
namespace: default
- name: policy3-common-ptp-sub-policy
namespace: default
placementBindings:
- cgu-a-policy1-common-cluster-version-policy
- cgu-a-policy2-common-pao-sub-policy
- cgu-a-policy3-common-ptp-sub-policy
placementRules:
- cgu-a-policy1-common-cluster-version-policy
- cgu-a-policy2-common-pao-sub-policy
- cgu-a-policy3-common-ptp-sub-policy
remediationPlan:
-- spoke1
-- spoke2
status: {}

```

- ① Shows the list of blocking CRs.

Example for cgu-b with blocking CRs

```

apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
name: cgu-b
namespace: default
spec:
blockingCRs:
- name: cgu-a
namespace: default
clusters:

```

```

- spoke4
- spoke5
enable: true
managedPolicies:
- policy1-common-cluster-version-policy
- policy2-common-pao-sub-policy
- policy3-common-ptp-sub-policy
- policy4-common-sriov-sub-policy
remediationStrategy:
  maxConcurrency: 1
  timeout: 240
status:
conditions:
- message: 'The ClusterGroupUpgrade CR is blocked by other CRs that have not yet
  completed: [cgu-a]' ①
reason: UpgradeCannotStart
status: "False"
type: Ready
managedPoliciesForUpgrade:
- name: policy1-common-cluster-version-policy
  namespace: default
- name: policy2-common-pao-sub-policy
  namespace: default
- name: policy3-common-ptp-sub-policy
  namespace: default
- name: policy4-common-sriov-sub-policy
  namespace: default
placementBindings:
- cgu-b-policy1-common-cluster-version-policy
- cgu-b-policy2-common-pao-sub-policy
- cgu-b-policy3-common-ptp-sub-policy
- cgu-b-policy4-common-sriov-sub-policy
placementRules:
- cgu-b-policy1-common-cluster-version-policy
- cgu-b-policy2-common-pao-sub-policy
- cgu-b-policy3-common-ptp-sub-policy
- cgu-b-policy4-common-sriov-sub-policy
remediationPlan:
- - spoke4
- - spoke5
status: {}

```

- ① Shows the list of blocking CRs.

Example for cgu-c with blocking CRs

```

apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-c
  namespace: default
spec:
  clusters:
    - spoke6

```

```

enable: true
managedPolicies:
- policy1-common-cluster-version-policy
- policy2-common-pao-sub-policy
- policy3-common-ptp-sub-policy
- policy4-common-sriov-sub-policy
remediationStrategy:
  maxConcurrency: 1
  timeout: 240
status:
  conditions:
    - message: The ClusterGroupUpgrade CR has upgrade policies that are still non compliant
①
  reason: UpgradeNotCompleted
  status: "False"
  type: Ready
managedPoliciesCompliantBeforeUpgrade:
- policy2-common-pao-sub-policy
- policy3-common-ptp-sub-policy
managedPoliciesForUpgrade:
- name: policy1-common-cluster-version-policy
  namespace: default
- name: policy4-common-sriov-sub-policy
  namespace: default
placementBindings:
- cgu-c-policy1-common-cluster-version-policy
- cgu-c-policy4-common-sriov-sub-policy
placementRules:
- cgu-c-policy1-common-cluster-version-policy
- cgu-c-policy4-common-sriov-sub-policy
remediationPlan:
- -- spoke6
status:
  currentBatch: 1
  remediationPlanForBatch:
    spoke6: 0

```

- ① The **cgu-c** update does not have any blocking CRs.

12.6. UPDATE POLICIES ON MANAGED CLUSTERS

The Topology Aware Lifecycle Manager (TALM) remediates a set of **inform** policies for the clusters specified in the **ClusterGroupUpgrade** custom resource (CR). TALM remediates **inform** policies by controlling the **remediationAction** specification in a **Policy** CR through the **bindingOverrides.remediationAction** and **subFilter** specifications in the **PlacementBinding** CR. Each policy has its own corresponding RHACM placement rule and RHACM placement binding.

One by one, TALM adds each cluster from the current batch to the placement rule that corresponds with the applicable managed policy. If a cluster is already compliant with a policy, TALM skips applying that policy on the compliant cluster. TALM then moves on to applying the next policy to the non-compliant cluster. After TALM completes the updates in a batch, all clusters are removed from the placement rules associated with the policies. Then, the update of the next batch starts.

If a spoke cluster does not report any compliant state to RHACM, the managed policies on the hub cluster can be missing status information that TALM needs. TALM handles these cases in the following ways:

- If a policy's **status.compliant** field is missing, TALM ignores the policy and adds a log entry. Then, TALM continues looking at the policy's **status.status** field.
- If a policy's **status.status** is missing, TALM produces an error.
- If a cluster's compliance status is missing in the policy's **status.status** field, TALM considers that cluster to be non-compliant with that policy.

The **ClusterGroupUpgrade** CR's **batchTimeoutAction** determines what happens if an upgrade fails for a cluster. You can specify **continue** to skip the failing cluster and continue to upgrade other clusters, or specify **abort** to stop the policy remediation for all clusters. Once the timeout elapses, TALM removes all the resources it created to ensure that no further updates are made to clusters.

Example upgrade policy

```
apiVersion: policy.open-cluster-management.io/v1
kind: Policy
metadata:
  name: ocp-4.4.18.4
  namespace: platform-upgrade
spec:
  disabled: false
  policy-templates:
    - objectDefinition:
        apiVersion: policy.open-cluster-management.io/v1
        kind: ConfigurationPolicy
        metadata:
          name: upgrade
        spec:
          namespacesSelector:
            exclude:
              - kube-*
            include:
              - '*'
        object-templates:
          - complianceType: musthave
            objectDefinition:
              apiVersion: config.openshift.io/v1
              kind: ClusterVersion
              metadata:
                name: version
              spec:
                channel: stable-4.18
                desiredUpdate:
                  version: 4.4.18.4
                upstream: https://api.openshift.com/api/upgrades_info/v1/graph
            status:
              history:
                - state: Completed
                  version: 4.4.18.4
```

```

remediationAction: inform
severity: low
remediationAction: inform

```

For more information about RHACM policies, see [Policy overview](#).

Additional resources

- [About the PolicyGenerator CRD](#)

12.6.1. Configuring Operator subscriptions for managed clusters that you install with TALM

Topology Aware Lifecycle Manager (TALM) can only approve the install plan for an Operator if the **Subscription** custom resource (CR) of the Operator contains the **status.state.AtLatestKnown** field.

Procedure

1. Add the **status.state.AtLatestKnown** field to the **Subscription** CR of the Operator:

Example Subscription CR

```

apiVersion: operators.coreos.com/v1alpha1
kind: Subscription
metadata:
  name: cluster-logging
  namespace: openshift-logging
  annotations:
    ran.openshift.io/ztp-deploy-wave: "2"
spec:
  channel: "stable"
  name: cluster-logging
  source: redhat-operators
  sourceNamespace: openshift-marketplace
  installPlanApproval: Manual
status:
  state: AtLatestKnown ①

```

- ① The **status.state: AtLatestKnown** field is used for the latest Operator version available from the Operator catalog.



NOTE

When a new version of the Operator is available in the registry, the associated policy becomes non-compliant.

2. Apply the changed **Subscription** policy to your managed clusters with a **ClusterGroupUpgrade** CR.

12.6.2. Applying update policies to managed clusters

You can update your managed clusters by applying your policies.

Prerequisites

- Install the Topology Aware Lifecycle Manager (TALM).
- TALM requires RHACM 2.9 or later.
- Provision one or more managed clusters.
- Log in as a user with **cluster-admin** privileges.
- Create RHACM policies in the hub cluster.

Procedure

1. Save the contents of the **ClusterGroupUpgrade** CR in the **cgu-1.yaml** file.

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-1
  namespace: default
spec:
  managedPolicies: ①
    - policy1-common-cluster-version-policy
    - policy2-common-nto-sub-policy
    - policy3-common-ptp-sub-policy
    - policy4-common-sriov-sub-policy
  enable: false
  clusters: ②
    - spoke1
    - spoke2
    - spoke5
    - spoke6
  remediationStrategy:
    maxConcurrency: 2 ③
    timeout: 240 ④
  batchTimeoutAction: ⑤
```

- ① The name of the policies to apply.
- ② The list of clusters to update.
- ③ The **maxConcurrency** field signifies the number of clusters updated at the same time.
- ④ The update timeout in minutes.
- ⑤ Controls what happens if a batch times out. Possible values are **abort** or **continue**. If unspecified, the default is **continue**.

2. Create the **ClusterGroupUpgrade** CR by running the following command:

```
$ oc create -f cgu-1.yaml
```

- a. Check if the **ClusterGroupUpgrade** CR was created in the hub cluster by running the following command:

```
$ oc get cgu --all-namespaces
```

Example output

NAMESPACE	NAME	AGE	STATE	DETAILS
default	cgu-1	8m55	NotEnabled	Not Enabled

- b. Check the status of the update by running the following command:

```
$ oc get cgu -n default cgu-1 -ojsonpath='{.status}' | jq
```

Example output

```
{
  "computedMaxConcurrency": 2,
  "conditions": [
    {
      "lastTransitionTime": "2022-02-25T15:34:07Z",
      "message": "Not enabled", ①
      "reason": "NotEnabled",
      "status": "False",
      "type": "Progressing"
    }
  ],
  "managedPoliciesContent": {
    "policy1-common-cluster-version-policy": "null",
    "policy2-common-nto-sub-policy": "[{\"kind\":\"Subscription\",\"name\":\"node-tuning-operator\",\"namespace\":\"openshift-cluster-node-tuning-operator\"}]",
    "policy3-common-ptp-sub-policy": "[{\"kind\":\"Subscription\",\"name\":\"ptp-operator-subscription\",\"namespace\":\"openshift-ptp\"}]",
    "policy4-common-sriov-sub-policy": "[{\"kind\":\"Subscription\",\"name\":\"sriov-network-operator-subscription\",\"namespace\":\"openshift-sriov-network-operator\"}]"
  },
  "managedPoliciesForUpgrade": [
    {
      "name": "policy1-common-cluster-version-policy",
      "namespace": "default"
    },
    {
      "name": "policy2-common-nto-sub-policy",
      "namespace": "default"
    },
    {
      "name": "policy3-common-ptp-sub-policy",
      "namespace": "default"
    },
    {
      "name": "policy4-common-sriov-sub-policy",
      "namespace": "default"
    }
  ]
},
```

```

"managedPoliciesNs": {
    "policy1-common-cluster-version-policy": "default",
    "policy2-common-nto-sub-policy": "default",
    "policy3-common-ptp-sub-policy": "default",
    "policy4-common-sriov-sub-policy": "default"
},
"placementBindings": [
    "cgu-policy1-common-cluster-version-policy",
    "cgu-policy2-common-nto-sub-policy",
    "cgu-policy3-common-ptp-sub-policy",
    "cgu-policy4-common-sriov-sub-policy"
],
"placementRules": [
    "cgu-policy1-common-cluster-version-policy",
    "cgu-policy2-common-nto-sub-policy",
    "cgu-policy3-common-ptp-sub-policy",
    "cgu-policy4-common-sriov-sub-policy"
],
"remediationPlan": [
    [
        "spoke1",
        "spoke2"
    ],
    [
        "spoke5",
        "spoke6"
    ]
],
"status": {}
}

```

- ① The **spec.enable** field in the **ClusterGroupUpgrade** CR is set to **false**.

3. Change the value of the **spec.enable** field to **true** by running the following command:

```
$ oc --namespace=default patch clustergroupupgrade.ran.openshift.io/cgu-1 \
--patch '{"spec":{"enable":true}}' --type=merge
```

Verification

1. Check the status of the update by running the following command:

```
$ oc get cgu -n default cgu-1 -ojsonpath='{.status}' | jq
```

Example output

```
{
    "computedMaxConcurrency": 2,
    "conditions": [ ①
        {
            "lastTransitionTime": "2022-02-25T15:33:07Z",
            "message": "All selected clusters are valid",
            "reason": "ClusterSelectionCompleted",
            "status": "True"
        }
    ],
    "status": "True"
}
```

```

    "status": "True",
    "type": "ClustersSelected"
},
{
  "lastTransitionTime": "2022-02-25T15:33:07Z",
  "message": "Completed validation",
  "reason": "ValidationCompleted",
  "status": "True",
  "type": "Validated"
},
{
  "lastTransitionTime": "2022-02-25T15:34:07Z",
  "message": "Remediating non-compliant policies",
  "reason": "InProgress",
  "status": "True",
  "type": "Progressing"
}
],
"managedPoliciesContent": {
  "policy1-common-cluster-version-policy": "null",
  "policy2-common-nto-sub-policy": "[{\\"kind\\":\\"Subscription\\",\\"name\\":\\"node-tuning-operator\\",\\"namespace\\":\\"openshift-cluster-node-tuning-operator\\"}]",
  "policy3-common-ptp-sub-policy": "[{\\"kind\\":\\"Subscription\\",\\"name\\":\\"ptp-operator-subscription\\",\\"namespace\\":\\"openshift-ptp\\"}]",
  "policy4-common-sriov-sub-policy": "[{\\"kind\\":\\"Subscription\\",\\"name\\":\\"sriov-network-operator-subscription\\",\\"namespace\\":\\"openshift-sriov-network-operator\\"}]"
},
"managedPoliciesForUpgrade": [
  {
    "name": "policy1-common-cluster-version-policy",
    "namespace": "default"
  },
  {
    "name": "policy2-common-nto-sub-policy",
    "namespace": "default"
  },
  {
    "name": "policy3-common-ptp-sub-policy",
    "namespace": "default"
  },
  {
    "name": "policy4-common-sriov-sub-policy",
    "namespace": "default"
  }
],
"managedPoliciesNs": {
  "policy1-common-cluster-version-policy": "default",
  "policy2-common-nto-sub-policy": "default",
  "policy3-common-ptp-sub-policy": "default",
  "policy4-common-sriov-sub-policy": "default"
},
"placementBindings": [
  "cgu-policy1-common-cluster-version-policy",
  "cgu-policy2-common-nto-sub-policy",
  "cgu-policy3-common-ptp-sub-policy",
  "cgu-policy4-common-sriov-sub-policy"
]

```

```
[  
  "placementRules": [  
    "cgu-policy1-common-cluster-version-policy",  
    "cgu-policy2-common-nto-sub-policy",  
    "cgu-policy3-common-ptp-sub-policy",  
    "cgu-policy4-common-sriov-sub-policy"  
  ],  
  "remediationPlan": [  
    [  
      "spoke1",  
      "spoke2"  
    ],  
    [  
      "spoke5",  
      "spoke6"  
    ]  
  ],  
  "status": {  
    "currentBatch": 1,  
    "currentBatchRemediationProgress": {  
      "spoke1": {  
        "policyIndex": 1,  
        "state": "InProgress"  
      },  
      "spoke2": {  
        "policyIndex": 1,  
        "state": "InProgress"  
      }  
    },  
    "currentBatchStartedAt": "2022-02-25T15:54:16Z",  
    "startedAt": "2022-02-25T15:54:16Z"  
  }  
}
```

- 1 Reflects the update progress of the current batch. Run this command again to receive updated information about the progress.

2. Check the status of the policies by running the following command:

```
oc get policies -A
```

Example output

NAMESPACE	NAME	REMEDIATION ACTION	COMPLIANCE
STATE	AGE		
spoke1	default.policy1-common-cluster-version-policy	enforce	Compliant
18m			
spoke1	default.policy2-common-nto-sub-policy	enforce	NonCompliant
18m			
spoke2	default.policy1-common-cluster-version-policy	enforce	Compliant
18m			
spoke2	default.policy2-common-nto-sub-policy	enforce	NonCompliant
18m			
spoke5	default.policy3-common-ptp-sub-policy	inform	NonCompliant

18m				
spoke5	default.policy4-common-sriov-sub-policy	inform	NonCompliant	
18m				
spoke6	default.policy3-common-ptp-sub-policy	inform	NonCompliant	
18m				
spoke6	default.policy4-common-sriov-sub-policy	inform	NonCompliant	
18m				
default	policy1-common-ptp-sub-policy	inform	Compliant	18m
default	policy2-common-sriov-sub-policy	inform	NonCompliant	18m
default	policy3-common-ptp-sub-policy	inform	NonCompliant	18m
default	policy4-common-sriov-sub-policy	inform	NonCompliant	18m

- The **spec.remediationAction** value changes to **enforce** for the child policies applied to the clusters from the current batch.
- The **spec.remediationAction** value remains **inform** for the child policies in the rest of the clusters.
- After the batch is complete, the **spec.remediationAction** value changes back to **inform** for the enforced child policies.

3. If the policies include Operator subscriptions, you can check the installation progress directly on the single-node cluster.

- Export the **KUBECONFIG** file of the single-node cluster you want to check the installation progress for by running the following command:

```
$ export KUBECONFIG=<cluster_kubeconfig_absolute_path>
```

- Check all the subscriptions present on the single-node cluster and look for the one in the policy you are trying to install through the **ClusterGroupUpgrade** CR by running the following command:

```
$ oc get subs -A | grep -i <subscription_name>
```

Example output for cluster-logging policy

NAMESPACE	NAME	PACKAGE	SOURCE
CHANNEL openshift-logging operators stable	cluster-logging	cluster-logging	redhat-

4. If one of the managed policies includes a **ClusterVersion** CR, check the status of platform updates in the current batch by running the following command against the spoke cluster:

```
$ oc get clusterversion
```

Example output

NAME	VERSION	AVAILABLE	PROGRESSING	SINCE	STATUS
version	4.4.18.5	True	True	43s	Working towards 4.4.18.7: 71 of 735 done (9% complete)

5. Check the Operator subscription by running the following command:

```
$ oc get subs -n <operator-namespace> <operator-subscription> -ojsonpath=".status"
```

- Check the install plans present on the single-node cluster that is associated with the desired subscription by running the following command:

```
$ oc get installplan -n <subscription_namespace>
```

Example output for cluster-logging Operator

NAMESPACE	NAME	CSV	APPROVAL
APPROVED openshift-logging	install-6khtw	cluster-logging.5.3.3-4	Manual true
1			

- The install plans have their **Approval** field set to **Manual** and their **Approved** field changes from **false** to **true** after TALM approves the install plan.



NOTE

When TALM is remediating a policy containing a subscription, it automatically approves any install plans attached to that subscription. Where multiple install plans are needed to get the operator to the latest known version, TALM might approve multiple install plans, upgrading through one or more intermediate versions to get to the final version.

- Check if the cluster service version for the Operator of the policy that the **ClusterGroupUpgrade** is installing reached the **Succeeded** phase by running the following command:

```
$ oc get csv -n <operator_namespace>
```

Example output for OpenShift Logging Operator

NAME	DISPLAY	VERSION	REPLACES	PHASE
cluster-logging.5.4.2	Red Hat OpenShift Logging	5.4.2		Succeeded

12.7. USING THE CONTAINER IMAGE PRE-CACHE FEATURE

Single-node OpenShift clusters might have limited bandwidth to access the container image registry, which can cause a timeout before the updates are completed.



NOTE

The time of the update is not set by TALM. You can apply the **ClusterGroupUpgrade** CR at the beginning of the update by manual application or by external automation.

The container image pre-caching starts when the **preCaching** field is set to **true** in the **ClusterGroupUpgrade** CR.

TALM uses the **PrecacheSpecValid** condition to report status information as follows:

- **true**
The pre-caching spec is valid and consistent.
- **false**
The pre-caching spec is incomplete.

TALM uses the **PrecachingSucceeded** condition to report status information as follows:

- **true**
TALM has concluded the pre-caching process. If pre-caching fails for any cluster, the update fails for that cluster but proceeds for all other clusters. A message informs you if pre-caching has failed for any clusters.
- **false**
Pre-caching is still in progress for one or more clusters or has failed for all clusters.

After a successful pre-caching process, you can start remediating policies. The remediation actions start when the **enable** field is set to **true**. If there is a pre-caching failure on a cluster, the upgrade fails for that cluster. The upgrade process continues for all other clusters that have a successful pre-cache.

The pre-caching process can be in the following statuses:

- **NotStarted**
This is the initial state all clusters are automatically assigned to on the first reconciliation pass of the **ClusterGroupUpgrade** CR. In this state, TALM deletes any pre-caching namespace and hub view resources of spoke clusters that remain from previous incomplete updates. TALM then creates a new **ManagedClusterView** resource for the spoke pre-caching namespace to verify its deletion in the **PrecachePreparing** state.
- **PreparingToStart**
Cleaning up any remaining resources from previous incomplete updates is in progress.
- **Starting**
Pre-caching job prerequisites and the job are created.
- **Active**
The job is in "Active" state.
- **Succeeded**
The pre-cache job succeeded.
- **PrecacheTimeout**
The artifact pre-caching is partially done.
- **UnrecoverableError**
The job ends with a non-zero exit code.

12.7.1. Using the container image pre-cache filter

The pre-cache feature typically downloads more images than a cluster needs for an update. You can control which pre-cache images are downloaded to a cluster. This decreases download time, and saves bandwidth and storage.

You can see a list of all images to be downloaded using the following command:

```
$ oc adm release info <ocp-version>
```

The following **ConfigMap** example shows how you can exclude images using the **excludePrecachePatterns** field.

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: cluster-group-upgrade-overrides
data:
  excludePrecachePatterns: |
    azure ①
    aws
    vsphere
    alibaba
```

- ① TALM excludes all images with names that include any of the patterns listed here.

12.7.2. Creating a ClusterGroupUpgrade CR with pre-caching

For single-node OpenShift, the pre-cache feature allows the required container images to be present on the spoke cluster before the update starts.



NOTE

For pre-caching, TALM uses the **spec.remediationStrategy.timeout** value from the **ClusterGroupUpgrade** CR. You must set a **timeout** value that allows sufficient time for the pre-caching job to complete. When you enable the **ClusterGroupUpgrade** CR after pre-caching has completed, you can change the **timeout** value to a duration that is appropriate for the update.

Prerequisites

- Install the Topology Aware Lifecycle Manager (TALM).
- Provision one or more managed clusters.
- Log in as a user with **cluster-admin** privileges.

Procedure

1. Save the contents of the **ClusterGroupUpgrade** CR with the **preCaching** field set to **true** in the **clustergroupupgrades-group-du.yaml** file:

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: du-upgrade-4918
  namespace: ztp-group-du-sno
spec:
  preCaching: true ①
  clusters:
    - cnfdb1
    - cnfdb2
```

```

enable: false
managedPolicies:
- du-upgrade-platform-upgrade
remediationStrategy:
  maxConcurrency: 2
  timeout: 240

```

- 1 The **preCaching** field is set to **true**, which enables TALM to pull the container images before starting the update.
- 2 When you want to start pre-caching, apply the **ClusterGroupUpgrade** CR by running the following command:

```
$ oc apply -f clustergroupupgrades-group-du.yaml
```

Verification

- 1 Check if the **ClusterGroupUpgrade** CR exists in the hub cluster by running the following command:

```
$ oc get cgu -A
```

Example output

NAMESPACE	NAME	AGE	STATE	DETAILS
ztp-group-du-sno	du-upgrade-4918	10s	InProgress	Precaching is required and not done

- 1 The CR is created.
- 2 Check the status of the pre-caching task by running the following command:

```
$ oc get cgu -n ztp-group-du-sno du-upgrade-4918 -o jsonpath='{.status}'
```

Example output

```
{
  "conditions": [
    {
      "lastTransitionTime": "2022-01-27T19:07:24Z",
      "message": "Precaching is required and not done",
      "reason": "InProgress",
      "status": "False",
      "type": "PrecachingSucceeded"
    },
    {
      "lastTransitionTime": "2022-01-27T19:07:34Z",
      "message": "Pre-caching spec is valid and consistent",
      "reason": "PrecacheSpecIsWellFormed",
      "status": "True",
      "type": "PrecacheSpecValid"
    }
}
```

```
],
"precaching": {
  "clusters": [
    "cnfdb1" ①
    "cnfdb2"
  ],
  "spec": {
    "platformImage": "image.example.io",
  "status": {
    "cnfdb1": "Active"
    "cnfdb2": "Succeeded"
  }
}
}
```

① Displays the list of identified clusters.

3. Check the status of the pre-caching job by running the following command on the spoke cluster:

```
$ oc get jobs,pods -n openshift-talo-pre-cache
```

Example output

NAME	COMPLETIONS	DURATION	AGE
job.batch/pre-cache	0/1	3m10s	3m10s

NAME	READY	STATUS	RESTARTS	AGE
pod/pre-cache--1-9bmlr	1/1	Running	0	3m10s

4. Check the status of the **ClusterGroupUpgrade** CR by running the following command:

```
$ oc get cgu -n ztp-group-du-sno du-upgrade-4918 -o jsonpath='{.status}'
```

Example output

```
"conditions": [
  {
    "lastTransitionTime": "2022-01-27T19:30:41Z",
    "message": "The ClusterGroupUpgrade CR has all clusters compliant with all the
               managed policies",
    "reason": "UpgradeCompleted",
    "status": "True",
    "type": "Ready"
  },
  {
    "lastTransitionTime": "2022-01-27T19:28:57Z",
    "message": "Precaching is completed",
    "reason": "PrecachingCompleted",
    "status": "True",
    "type": "PrecachingSucceeded" ①
  }
]
```

- 1 The pre-cache tasks are done.

12.8. TROUBLESHOOTING THE TOPOLOGY AWARE LIFECYCLE MANAGER

The Topology Aware Lifecycle Manager (TALM) is an OpenShift Container Platform Operator that remediates RHACM policies. When issues occur, use the **oc adm must-gather** command to gather details and logs and to take steps in debugging the issues.

For more information about related topics, see the following documentation:

- [Red Hat Advanced Cluster Management for Kubernetes 2.4 Support Matrix](#)
- [Red Hat Advanced Cluster Management Troubleshooting](#)
- The "Troubleshooting Operator issues" section

12.8.1. General troubleshooting

You can determine the cause of the problem by reviewing the following questions:

- Is the configuration that you are applying supported?
 - Are the RHACM and the OpenShift Container Platform versions compatible?
 - Are the TALM and RHACM versions compatible?
- Which of the following components is causing the problem?
 - [Section 12.8.3, "Managed policies"](#)
 - [Section 12.8.4, "Clusters"](#)
 - [Section 12.8.5, "Remediation Strategy"](#)
 - [Section 12.8.6, "Topology Aware Lifecycle Manager"](#)

To ensure that the **ClusterGroupUpgrade** configuration is functional, you can do the following:

1. Create the **ClusterGroupUpgrade** CR with the **spec.enable** field set to **false**.
2. Wait for the status to be updated and go through the troubleshooting questions.
3. If everything looks as expected, set the **spec.enable** field to **true** in the **ClusterGroupUpgrade** CR.



WARNING

After you set the **spec.enable** field to **true** in the **ClusterUpgradeGroup** CR, the update procedure starts and you cannot edit the CR's **spec** fields anymore.

12.8.2. Cannot modify the ClusterUpgradeGroup CR

Issue

You cannot edit the **ClusterUpgradeGroup** CR after enabling the update.

Resolution

Restart the procedure by performing the following steps:

1. Remove the old **ClusterGroupUpgrade** CR by running the following command:

```
$ oc delete cgu -n <ClusterGroupUpgradeCR_namespace>  
<ClusterGroupUpgradeCR_name>
```

2. Check and fix the existing issues with the managed clusters and policies.
 - a. Ensure that all the clusters are managed clusters and available.
 - b. Ensure that all the policies exist and have the **spec.remediationAction** field set to **inform**.
3. Create a new **ClusterGroupUpgrade** CR with the correct configurations.

```
$ oc apply -f <ClusterGroupUpgradeCR_YAML>
```

12.8.3. Managed policies

Checking managed policies on the system

Issue

You want to check if you have the correct managed policies on the system.

Resolution

Run the following command:

```
$ oc get cgu lab-upgrade -ojsonpath='{.spec.managedPolicies}'
```

Example output

```
["group-du-sno-validator-du-validator-policy", "policy2-common-nto-sub-policy", "policy3-common-ptp-sub-policy"]
```

Checking remediationAction mode

Issue

You want to check if the **remediationAction** field is set to **inform** in the **spec** of the managed policies.

Resolution

Run the following command:

```
$ oc get policies --all-namespaces
```

Example output

NAMESPACE	NAME	REMEDIATION ACTION	COMPLIANCE
STATE	AGE		
default	policy1-common-cluster-version-policy	inform	NonCompliant
5d21h			
default	policy2-common-nto-sub-policy	inform	Compliant
default	policy3-common-ptp-sub-policy	inform	NonCompliant
default	policy4-common-sriov-sub-policy	inform	NonCompliant
			5d21h
			5d21h
			5d21h

Checking policy compliance state

Issue

You want to check the compliance state of policies.

Resolution

Run the following command:

```
$ oc get policies --all-namespaces
```

Example output

NAMESPACE	NAME	REMEDIATION ACTION	COMPLIANCE
STATE	AGE		
default	policy1-common-cluster-version-policy	inform	NonCompliant
5d21h			
default	policy2-common-nto-sub-policy	inform	Compliant
default	policy3-common-ptp-sub-policy	inform	NonCompliant
default	policy4-common-sriov-sub-policy	inform	NonCompliant
			5d21h
			5d21h
			5d21h

12.8.4. Clusters

Checking if managed clusters are present

Issue

You want to check if the clusters in the **ClusterGroupUpgrade** CR are managed clusters.

Resolution

Run the following command:

```
$ oc get managedclusters
```

Example output

NAME	HUB ACCEPTED	MANAGED CLUSTER URLs	JOINED	AVAILABLE
AGE				
local-cluster	true	https://api.hub.example.com:6443	True	Unknown 13d
spoke1	true	https://api.spoke1.example.com:6443	True	True 13d
spoke3	true	https://api.spoke3.example.com:6443	True	True 27h

1. Alternatively, check the TALM manager logs:

- a. Get the name of the TALM manager by running the following command:

```
$ oc get pod -n openshift-operators
```

Example output

NAME	READY	STATUS	RESTARTS	AGE
cluster-group-upgrades-controller-manager-75bcc7484d-8k8xp	2/2	Running	0	45m

- b. Check the TALM manager logs by running the following command:

```
$ oc logs -n openshift-operators \
cluster-group-upgrades-controller-manager-75bcc7484d-8k8xp -c manager
```

Example output

```
ERROR controller-runtime.manager.controller.clustergroupupgrade Reconciler error
{"reconciler group": "ran.openshift.io", "reconciler kind": "ClusterGroupUpgrade",
"name": "lab-upgrade", "namespace": "default", "error": "Cluster spoke5555 is not a
ManagedCluster"} ①
sigs.k8s.io/controller-runtime/pkg/internal/controller.
(*Controller).processNextWorkItem
```

- ① The error message shows that the cluster is not a managed cluster.

Checking if managed clusters are available

Issue

You want to check if the managed clusters specified in the **ClusterGroupUpgrade** CR are available.

Resolution

Run the following command:

```
$ oc get managedclusters
```

Example output

NAME	HUB	ACCEPTED	MANAGED CLUSTER URLs	JOINED	AVAILABLE
AGE					
local-cluster	true		https://api.hub.testlab.com:6443	True	Unknown 13d
spoke1	true		https://api.spoke1.testlab.com:6443	True	True 13d ①
spoke3	true		https://api.spoke3.testlab.com:6443	True	True 27h ②

- ① ② The value of the **AVAILABLE** field is **True** for the managed clusters.

Checking clusterLabelSelector

Issue

You want to check if the **clusterLabelSelector** field specified in the **ClusterGroupUpgrade** CR matches at least one of the managed clusters.

Resolution

Run the following command:

```
$ oc get managedcluster --selector=upgrade=true ①
```

- 1 The label for the clusters you want to update is **upgrade:true**.

Example output

NAME	HUB ACCEPTED	MANAGED CLUSTER URLs	JOINED		
AVAILABLE	AGE				
spoke1	true	https://api.spoke1.testlab.com:6443	True	True	13d
spoke3	true	https://api.spoke3.testlab.com:6443	True	True	27h

Checking if canary clusters are present

Issue

You want to check if the canary clusters are present in the list of clusters.

Example ClusterGroupUpgrade CR

```
spec:
  remediationStrategy:
    canaries:
      - spoke3
    maxConcurrency: 2
    timeout: 240
  clusterLabelSelectors:
    - matchLabels:
        upgrade: true
```

Resolution

Run the following commands:

```
$ oc get cgu lab-upgrade -ojsonpath='{.spec.clusters}'
```

Example output

```
["spoke1", "spoke3"]
```

1. Check if the canary clusters are present in the list of clusters that match **clusterLabelSelector** labels by running the following command:

```
$ oc get managedcluster --selector=upgrade=true
```

Example output

NAME	HUB ACCEPTED	MANAGED CLUSTER URLs	JOINED	AVAILABLE
AGE				
spoke1	true	https://api.spoke1.testlab.com:6443	True	True
spoke3	true	https://api.spoke3.testlab.com:6443	True	True
				13d 27h



NOTE

A cluster can be present in **spec.clusters** and also be matched by the **spec.clusterLabelSelector** label.

Checking the pre-caching status on spoke clusters

1. Check the status of pre-caching by running the following command on the spoke cluster:

```
$ oc get jobs,pods -n openshift-talo-pre-cache
```

12.8.5. Remediation Strategy

Checking if remediationStrategy is present in the ClusterGroupUpgrade CR

Issue

You want to check if the **remediationStrategy** is present in the **ClusterGroupUpgrade** CR.

Resolution

Run the following command:

```
$ oc get cgu lab-upgrade -ojsonpath='{.spec.remediationStrategy}'
```

Example output

```
{"maxConcurrency":2, "timeout":240}
```

Checking if maxConcurrency is specified in the ClusterGroupUpgrade CR

Issue

You want to check if the **maxConcurrency** is specified in the **ClusterGroupUpgrade** CR.

Resolution

Run the following command:

```
$ oc get cgu lab-upgrade -ojsonpath='{.spec.remediationStrategy.maxConcurrency}'
```

Example output

```
2
```

12.8.6. Topology Aware Lifecycle Manager

Checking condition message and status in the ClusterGroupUpgrade CR

Issue

You want to check the value of the **status.conditions** field in the **ClusterGroupUpgrade** CR.

Resolution

Run the following command:

```
$ oc get cgu lab-upgrade -ojsonpath='{.status.conditions}'
```

Example output

```
{"lastTransitionTime": "2022-02-17T22:25:28Z", "message": "Missing managed policies:[policyList]", "reason": "NotAllManagedPoliciesExist", "status": "False", "type": "Validated"}
```

Checking if status.remediationPlan was computed**Issue**

You want to check if **status.remediationPlan** is computed.

Resolution

Run the following command:

```
$ oc get cgu lab-upgrade -ojsonpath='{.status.remediationPlan}'
```

Example output

```
["spoke2", "spoke3"]
```

Errors in the TALM manager container**Issue**

You want to check the logs of the manager container of TALM.

Resolution

Run the following command:

```
$ oc logs -n openshift-operators \
cluster-group-upgrades-controller-manager-75bcc7484d-8k8xp -c manager
```

Example output

```
ERROR controller-runtime.manager.controller.clustergroupupgrade Reconciler error {"reconciler group": "ran.openshift.io", "reconciler kind": "ClusterGroupUpgrade", "name": "lab-upgrade", "namespace": "default", "error": "Cluster spoke5555 is not a ManagedCluster"} ①
sigs.k8s.io/controller-runtime/pkg/internal/controller.(*Controller).processNextWorkItem
```

① Displays the error.

Clusters are not compliant to some policies after aClusterGroupUpgrade CR has completed

Issue

The policy compliance status that TALM uses to decide if remediation is needed has not yet fully updated for all clusters. This may be because:

- The CGU was run too soon after a policy was created or updated.
- The remediation of a policy affects the compliance of subsequent policies in the **ClusterGroupUpgrade** CR.

Resolution

Create and apply a new **ClusterGroupUpdate** CR with the same specification.

Auto-created ClusterGroupUpgrade CR in the GitOps ZTP workflow has no managed policies

Issue

If there are no policies for the managed cluster when the cluster becomes **Ready**, a **ClusterGroupUpgrade** CR with no policies is auto-created. Upon completion of the **ClusterGroupUpgrade** CR, the managed cluster is labeled as **ztp-done**. If the **PolicyGenerator** or **PolicyGenTemplate** CRs were not pushed to the Git repository within the required time after **SiteConfig** resources were pushed, this might result in no policies being available for the target cluster when the cluster became **Ready**.

Resolution

Verify that the policies you want to apply are available on the hub cluster, then create a **ClusterGroupUpgrade** CR with the required policies.

You can either manually create the **ClusterGroupUpgrade** CR or trigger auto-creation again. To trigger auto-creation of the **ClusterGroupUpgrade** CR, remove the **ztp-done** label from the cluster and delete the empty **ClusterGroupUpgrade** CR that was previously created in the **zip-install** namespace.

Pre-caching has failed

Issue

Pre-caching might fail for one of the following reasons:

- There is not enough free space on the node.
- For a disconnected environment, the pre-cache image has not been properly mirrored.
- There was an issue when creating the pod.

Resolution

1. To check if pre-caching has failed due to insufficient space, check the log of the pre-caching pod in the node.

a. Find the name of the pod using the following command:

```
$ oc get pods -n openshift-talo-pre-cache
```

b. Check the logs to see if the error is related to insufficient space using the following command:

```
$ oc logs -n openshift-talo-pre-cache <pod name>
```

2. If there is no log, check the pod status using the following command:

```
$ oc describe pod -n openshift-talo-pre-cache <pod name>
```

3. If the pod does not exist, check the job status to see why it could not create a pod using the following command:

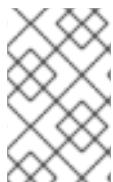
```
$ oc describe job -n openshift-talo-pre-cache pre-cache
```

Additional resources

- [OpenShift Container Platform Troubleshooting Operator Issues](#)
- [Updating managed policies with Topology Aware Lifecycle Manager](#)
- [About the PolicyGenerator CRD](#)

CHAPTER 13. EXPANDING SINGLE-NODE OPENSIFT CLUSTERS WITH GITOPS ZTP

You can expand single-node OpenShift clusters with GitOps Zero Touch Provisioning (ZTP). When you add worker nodes to single-node OpenShift clusters, the original single-node OpenShift cluster retains the control plane node role. Adding worker nodes does not require any downtime for the existing single-node OpenShift cluster.



NOTE

Although there is no specified limit on the number of worker nodes that you can add to a single-node OpenShift cluster, you must reevaluate the reserved CPU allocation on the control plane node for the additional worker nodes.

If you require workload partitioning on the worker node, you must deploy and remediate the managed cluster policies on the hub cluster before installing the node. This way, the workload partitioning **MachineConfig** objects are rendered and associated with the **worker** machine config pool before the GitOps ZTP workflow applies the **MachineConfig** ignition file to the worker node.

It is recommended that you first remediate the policies, and then install the worker node. If you create the workload partitioning manifests after installing the worker node, you must drain the node manually and delete all the pods managed by daemon sets. When the managing daemon sets create the new pods, the new pods undergo the workload partitioning process.



IMPORTANT

Adding worker nodes to single-node OpenShift clusters with GitOps ZTP 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](#).

Additional resources

- For more information about single-node OpenShift clusters tuned for vDU application deployments, see [Reference configuration for deploying vDUs on single-node OpenShift](#).
- For more information about worker nodes, see [Adding worker nodes to single-node OpenShift clusters](#).
- For information about removing a worker node from an expanded single-node OpenShift cluster, see [Removing managed cluster nodes by using the command line interface](#).

13.1. APPLYING PROFILES TO THE WORKER NODE WITH POLICYGENERATOR OR POLICYGENTEMPLATE RESOURCES

You can configure the additional worker node with a DU profile.

You can apply a RAN distributed unit (DU) profile to the worker node cluster using the GitOps Zero

Touch Provisioning (ZTP) common, group, and site-specific **PolicyGenerator** or **PolicyGenTemplate** resources. The GitOps ZTP pipeline that is linked to the ArgoCD **policies** application includes the following CRs that you can find in the relevant **out/argocd/example** folder when you extract the **ztp-site-generate** container:

/acmpolicygenerator resources

- **acm-common-ranGen.yaml**
- **acm-group-du-sno-ranGen.yaml**
- **acm-example-sno-site.yaml**
- **ns.yaml**
- **kustomization.yaml**

/policygentemplates resources

- **common-ranGen.yaml**
- **group-du-sno-ranGen.yaml**
- **example-sno-site.yaml**
- **ns.yaml**
- **kustomization.yaml**

Configuring the DU profile on the worker node is considered an upgrade. To initiate the upgrade flow, you must update the existing policies or create additional ones. Then, you must create a **ClusterGroupUpgrade** CR to reconcile the policies in the group of clusters.

13.2. ENSURING PTP AND SR-IOV DAEMON SELECTOR COMPATIBILITY

If the DU profile was deployed using the GitOps Zero Touch Provisioning (ZTP) plugin version 4.11 or earlier, the PTP and SR-IOV Operators might be configured to place the daemons only on nodes labeled as **master**. This configuration prevents the PTP and SR-IOV daemons from operating on the worker node. If the PTP and SR-IOV daemon node selectors are incorrectly configured on your system, you must change the daemons before proceeding with the worker DU profile configuration.

Procedure

1. Check the daemon node selector settings of the PTP Operator on one of the spoke clusters:

```
$ oc get ptoperatorconfig/default -n openshift-ptp -ojsonpath='{.spec}' | jq
```

Example output for PTP Operator

```
{"daemonNodeSelector":{"node-role.kubernetes.io/master":""}} ①
```

- ① If the node selector is set to **master**, the spoke was deployed with the version of the GitOps ZTP plugin that requires changes.

- Check the daemon node selector settings of the SR-IOV Operator on one of the spoke clusters:

```
$ oc get sriovoperatorconfig/default -n \
openshift-sriov-network-operator -ojsonpath='{.spec}' | jq
```

Example output for SR-IOV Operator

```
{"configDaemonNodeSelector":{"node-
role.kubernetes.io/worker":""}, "disableDrain":false,"enableInjector":true,"enableOperatorWebhook":true} ①
```

- If the node selector is set to **master**, the spoke was deployed with the version of the GitOps ZTP plugin that requires changes.

- In the group policy, add the following **complianceType** and **spec** entries:

```
spec:
- fileName: PtpOperatorConfig.yaml
  policyName: "config-policy"
  complianceType: mustonlyhave
  spec:
    daemonNodeSelector:
      node-role.kubernetes.io/worker: ""
- fileName: SriovOperatorConfig.yaml
  policyName: "config-policy"
  complianceType: mustonlyhave
  spec:
    configDaemonNodeSelector:
      node-role.kubernetes.io/worker: ""
```



IMPORTANT

Changing the **daemonNodeSelector** field causes temporary PTP synchronization loss and SR-IOV connectivity loss.

- Commit the changes in Git, and then push to the Git repository being monitored by the GitOps ZTP ArgoCD application.

13.3. PTP AND SR-IOV NODE SELECTOR COMPATIBILITY

The PTP configuration resources and SR-IOV network node policies use **node-role.kubernetes.io/master: ""** as the node selector. If the additional worker nodes have the same NIC configuration as the control plane node, the policies used to configure the control plane node can be reused for the worker nodes. However, the node selector must be changed to select both node types, for example with the "**node-role.kubernetes.io/worker**" label.

13.4. USING POLICYGENERATOR CRS TO APPLY WORKER NODE POLICIES TO WORKER NODES

You can create policies for worker nodes using **PolicyGenerator** CRs.

Procedure

1. Create the following **PolicyGenerator** CR:

```

apiVersion: policy.open-cluster-management.io/v1
kind: PolicyGenerator
metadata:
  name: example-sno-workers
placementBindingDefaults:
  name: example-sno-workers-placement-binding
policyDefaults:
  namespace: example-sno
  placement:
    labelSelector:
      matchExpressions:
        - key: sites
          operator: In
          values:
            - example-sno 1
  remediationAction: inform
  severity: low
  namespaceSelector:
    exclude:
      - kube-*
    include:
      - '*'
  evaluationInterval:
    compliant: 10m
    noncompliant: 10s
policies:
  - name: example-sno-workers-config-policy
    policyAnnotations:
      ran.openshift.io/ztp-deploy-wave: "10"
    manifests:
      - path: source-crs/MachineConfigGeneric.yaml 2
    patches:
      - metadata:
          labels:
            machineconfiguration.openshift.io/role: worker 3
      name: enable-workload-partitioning
    spec:
      config:
        storage:
          files:
            - contents:
                source: data:text/plain;charset=utf-
                8;base64,W2NyaW8ucnVudGltZS53b3JrbG9hZHMubWFuYWdlbWVudF0KYWN0aXZhdGvbl
                9hbm5vdGF0aW9uID0gInRhcmdldC53b3JrbG9hZC5vcGVuc2hpZnQuaW8vbWFuYWdlbWVu
                dCIKYW5ub3RhdGlvbl9wcmVmXggPSAicmVzb3VyY2VzLndvcmtsb2FkLm9wZW5zaGlmdC5
                pbyIKcmVzb3VyY2VzID0geyAiY3B1c2hhcmVzliA9IDAsICJjcHVzZXQiD0gljAtMyIgfQo=
                mode: 420
                overwrite: true
                path: /etc/crio/crio.conf.d/01-workload-partitioning
                user:
                  name: root
            - contents:

```

```

source: data:text/plain;charset=utf-
8;base64,ewogICJtYW5hZ2VtZW50IjogewogICAglmNwdXNldCI6IClwLTMiCiAgfQp9Cg==
mode: 420
overwrite: true
path: /etc/kubernetes/openshift-workload-pinning
user:
  name: root
- path: source-crs/PerformanceProfile-MCP-worker.yaml
  patches:
    - metadata:
        name: openshift-worker-node-performance-profile
      spec:
        cpu: ④
          isolated: 4-47
          reserved: 0-3
        hugepages:
          defaultHugepagesSize: 1G
          pages:
            - count: 32
              size: 1G
        realTimeKernel:
          enabled: true
    - path: source-crs/TunedPerformancePatch-MCP-worker.yaml
      patches:
        - metadata:
            name: performance-patch-worker
          spec:
            profile:
              - data: |
                  [main]
                  summary=Configuration changes profile inherited from performance created
tuned
profile
                  include=openshift-node-performance-openshift-worker-node-performance-
[bootloader]
cmdline_crash=nohz_full=4-47 ⑤
[sysctl]
kernel.timer_migration=1
[scheduler]
group.ice-ptp=0:f:10:*:ice-ptp.*
[service]
service.stalld=start,enable
service.chronyd=stop,disable
name: performance-patch-worker
recommend:
  - profile: performance-patch-worker

```

- 1 The policies are applied to all clusters with this label.
- 2 This generic **MachineConfig** CR is used to configure workload partitioning on the worker node.
- 3 The **MCP** field must be set to **worker**.
- 4 The **cpu.isolated** and **cpu.reserved** fields must be configured for each particular hardware platform.

- 5** The **cmdline_crash** CPU set must match the **cpu.isolated** set in the **PerformanceProfile** section.

A generic **MachineConfig** CR is used to configure workload partitioning on the worker node. You can generate the content of **crio** and **kubelet** configuration files.

2. Add the created policy template to the Git repository monitored by the ArgoCD **policies** application.
3. Add the policy in the **kustomization.yaml** file.
4. Commit the changes in Git, and then push to the Git repository being monitored by the GitOps ZTP ArgoCD application.
5. To remediate the new policies to your spoke cluster, create a TALM custom resource:

```
$ cat <<EOF | oc apply -f -
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: example-sno-worker-policies
  namespace: default
spec:
  backup: false
  clusters:
    - example-sno
  enable: true
  managedPolicies:
    - group-du-sno-config-policy
    - example-sno-workers-config-policy
    - example-sno-config-policy
  preCaching: false
  remediationStrategy:
    maxConcurrency: 1
EOF
```

13.5. USING POLICYGENTEMPLATE CRS TO APPLY WORKER NODE POLICIES TO WORKER NODES

You can create policies for worker nodes using **PolicyGenTemplate** CRs.

Procedure

1. Create the following **PolicyGenTemplate** CR:

```
apiVersion: ran.openshift.io/v1
kind: PolicyGenTemplate
metadata:
  name: "example-sno-workers"
  namespace: "example-sno"
spec:
  bindingRules:
    sites: "example-sno" 1
  mcp: "worker" 2
```

```

sourceFiles:
- fileName: MachineConfigGeneric.yaml 3
  policyName: "config-policy"
  metadata:
    labels:
      machineconfiguration.openshift.io/role: worker
      name: enable-workload-partitioning
  spec:
    config:
      storage:
        files:
          - contents:
              source: data:text/plain;charset=utf-
8;base64,W2NyaW8ucnVudGlzS53b3JrbG9hZHMubWFuYWdlbVVudF0KYWN0aXZhdGlvbl
9hbm5vdGF0aW9uID0gInRhcmdldC53b3JrbG9hZC5vcGVuc2hpZnQuaW8vbWFuYWdlbVVu
dCIKYW5ub3RhdGlvbl9wcmVmaXggPSAicmVzb3VyY2VzLndvcmtsb2FkLm9wZW5zaGlmdC5
pbyIKcmVzb3VyY2VzID0geyAiY3B1c2hhcmVzliA9IDAsICJjcHVzZXQiD0gljAtMyIgfQo=
            mode: 420
            overwrite: true
            path: /etc/crio/crio.conf.d/01-workload-partitioning
            user:
              name: root
          - contents:
              source: data:text/plain;charset=utf-
8;base64,ewogICJtYW5hZ2VtZW50ljogewogICAglmNwdXNldCl6IClwLTMiCiAgfQp9Cg==
            mode: 420
            overwrite: true
            path: /etc/kubernetes/openshift-workload-pinning
            user:
              name: root
    - fileName: PerformanceProfile.yaml
      policyName: "config-policy"
      metadata:
        name: openshift-worker-node-performance-profile
      spec:
        cpu: 4
        isolated: "4-47"
        reserved: "0-3"
        hugepages:
          defaultHugepagesSize: 1G
        pages:
          - size: 1G
            count: 32
        realTimeKernel:
          enabled: true
    - fileName: TunedPerformancePatch.yaml
      policyName: "config-policy"
      metadata:
        name: performance-patch-worker
      spec:
        profile:
          - name: performance-patch-worker
            data: |
              [main]
              summary=Configuration changes profile inherited from performance created tuned
              include=openshift-node-performance-openshift-worker-node-performance-profile

```

```
[bootloader]
cmdline_crash=nohz_full=4-47 ⑤
[sysctl]
kernel.timer_migration=1
[scheduler]
group.ice-ptp=0:f:10*:ice-ptp.*
[service]
service.stalld=start,enable
service.chronyd=stop,disable
recommend:
- profile: performance-patch-worker
```

- 1 The policies are applied to all clusters with this label.
- 2 The **MCP** field must be set to **worker**.
- 3 This generic **MachineConfig** CR is used to configure workload partitioning on the worker node.
- 4 The **cpu.isolated** and **cpu.reserved** fields must be configured for each particular hardware platform.
- 5 The **cmdline_crash** CPU set must match the **cpu.isolated** set in the **PerformanceProfile** section.

A generic **MachineConfig** CR is used to configure workload partitioning on the worker node. You can generate the content of **crio** and **kubelet** configuration files.

- 2 Add the created policy template to the Git repository monitored by the ArgoCD **policies** application.
- 3 Add the policy in the **kustomization.yaml** file.
- 4 Commit the changes in Git, and then push to the Git repository being monitored by the GitOps ZTP ArgoCD application.
- 5 To remediate the new policies to your spoke cluster, create a TALM custom resource:

```
$ cat <<EOF | oc apply -f -
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: example-sno-worker-policies
  namespace: default
spec:
  backup: false
  clusters:
    - example-sno
  enable: true
  managedPolicies:
    - group-du-sno-config-policy
    - example-sno-workers-config-policy
    - example-sno-config-policy
  preCaching: false
```

```

remediationStrategy:
  maxConcurrency: 1
EOF

```

13.6. ADDING WORKER NODES TO SINGLE-NODE OPENSHIFT CLUSTERS WITH GITOPS ZTP

You can add one or more worker nodes to existing single-node OpenShift clusters to increase available CPU resources in the cluster.

Prerequisites

- Install and configure RHACM 2.6 or later in an OpenShift Container Platform 4.11 or later bare-metal hub cluster
- Install Topology Aware Lifecycle Manager in the hub cluster
- Install Red Hat OpenShift GitOps in the hub cluster
- Use the GitOps ZTP **ztp-site-generate** container image version 4.12 or later
- Deploy a managed single-node OpenShift cluster with GitOps ZTP
- Configure the Central Infrastructure Management as described in the RHACM documentation
- Configure the DNS serving the cluster to resolve the internal API endpoint **api-int.<cluster_name>.<base_domain>**

Procedure

1. If you deployed your cluster by using the **example-sno.yaml SiteConfig** manifest, add your new worker node to the **spec.clusters['example-sno'].nodes** list:

```

nodes:
  - hostName: "example-node2.example.com"
    role: "worker"
    bmcAddress: "idrac-virtualmedia+https://[1111:2222:3333:4444::bbbb:1]/redfish/v1/Systems/System.Embedded.1"

    bmcCredentialsName:
      name: "example-node2-bmh-secret"
    bootMACAddress: "AA:BB:CC:DD:EE:11"
    bootMode: "UEFI"
    nodeNetwork:
      interfaces:
        - name: eno1
          macAddress: "AA:BB:CC:DD:EE:11"
    config:
      interfaces:
        - name: eno1
          type: ethernet
          state: up
          macAddress: "AA:BB:CC:DD:EE:11"
          ipv4:
            enabled: false

```

```

  ipv6:
    enabled: true
    address:
      - ip: 1111:2222:3333:4444::1
        prefix-length: 64
    dns-resolver:
      config:
        search:
          - example.com
        server:
          - 1111:2222:3333:4444::2
    routes:
      config:
        - destination: ::/0
          next-hop-interface: eno1
          next-hop-address: 1111:2222:3333:4444::1
          table-id: 254

```

2. Create a BMC authentication secret for the new host, as referenced by the **bmcCredentialsName** field in the **spec.nodes** section of your **SiteConfig** file:

```

apiVersion: v1
data:
  password: "password"
  username: "username"
kind: Secret
metadata:
  name: "example-node2-bmh-secret"
  namespace: example-sno
type: Opaque

```

3. Commit the changes in Git, and then push to the Git repository that is being monitored by the GitOps ZTP ArgoCD application.

When the ArgoCD **cluster** application synchronizes, two new manifests appear on the hub cluster generated by the GitOps ZTP plugin:

- **BareMetalHost**
- **NMStateConfig**



IMPORTANT

The **cpuset** field should not be configured for the worker node. Workload partitioning for worker nodes is added through management policies after the node installation is complete.

Verification

You can monitor the installation process in several ways.

- Check if the preprovisioning images are created by running the following command:

```
$ oc get ppimg -n example-sno
```

Example output

NAMESPACE	NAME	READY	REASON
example-sno	example-sno	True	ImageCreated
example-sno	example-node2	True	ImageCreated

- Check the state of the bare-metal hosts:

```
$ oc get bmh -n example-sno
```

Example output

NAME	STATE	CONSUMER	ONLINE	ERROR	AGE
example-sno	provisioned		true		69m
example-node2	provisioning		true		4m50s ①

- ① The **provisioning** state indicates that node booting from the installation media is in progress.

- Continuously monitor the installation process:

- Watch the agent install process by running the following command:

```
$ oc get agent -n example-sno --watch
```

Example output

NAME	CLUSTER	APPROVED	ROLE	STAGE
671bc05d-5358-8940-ec12-d9ad22804faa	example-sno	true		master Done
[...]				
14fd821b-a35d-9cba-7978-00ddf535ff37	example-sno	true		worker Starting
installation				
14fd821b-a35d-9cba-7978-00ddf535ff37	example-sno	true		worker Installing
14fd821b-a35d-9cba-7978-00ddf535ff37	example-sno	true		worker Writing image
to disk				
[...]				
14fd821b-a35d-9cba-7978-00ddf535ff37	example-sno	true		worker Waiting for
control plane				
[...]				
14fd821b-a35d-9cba-7978-00ddf535ff37	example-sno	true		worker Rebooting
14fd821b-a35d-9cba-7978-00ddf535ff37	example-sno	true		worker Done

- When the worker node installation is finished, the worker node certificates are approved automatically. At this point, the worker appears in the **ManagedClusterInfo** status. Run the following command to see the status:

```
$ oc get managedclusterinfo/example-sno -n example-sno -o \
jsonpath='{range .status.nodeList[*]}.{.name}{"\t"}{.conditions}{"\t"}{.labels}{"\n"}{end}'
```

Example output

```
example-sno [{"status":"True","type":"Ready"}] {"node-role.kubernetes.io/master":"","node-role.kubernetes.io/worker":""}
example-node2 [{"status":"True","type":"Ready"}] {"node-role.kubernetes.io/worker":""}
```

CHAPTER 14. PRE-CACHING IMAGES FOR SINGLE-NODE OPENSIFT DEPLOYMENTS

In environments with limited bandwidth where you use the GitOps Zero Touch Provisioning (ZTP) solution to deploy a large number of clusters, you want to avoid downloading all the images that are required for bootstrapping and installing OpenShift Container Platform. The limited bandwidth at remote single-node OpenShift sites can cause long deployment times. The factory-precaching-cli tool allows you to pre-stage servers before shipping them to the remote site for ZTP provisioning.

The factory-precaching-cli tool does the following:

- Downloads the RHCOS rootfs image that is required by the minimal ISO to boot.
- Creates a partition from the installation disk labelled as **data**.
- Formats the disk in xfs.
- Creates a GUID Partition Table (GPT) data partition at the end of the disk, where the size of the partition is configurable by the tool.
- Copies the container images required to install OpenShift Container Platform.
- Copies the container images required by ZTP to install OpenShift Container Platform.
- Optional: Copies Day-2 Operators to the partition.



IMPORTANT

The factory-precaching-cli tool 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](#).

14.1. GETTING THE FACTORY-PRECACHING-CLI TOOL

The factory-precaching-cli tool Go binary is publicly available in [the {rds-first} tools container image](#). The factory-precaching-cli tool Go binary in the container image is executed on the server running an RHCOS live image using **podman**. If you are working in a disconnected environment or have a private registry, you need to copy the image there so you can download the image to the server.

Procedure

- Pull the factory-precaching-cli tool image by running the following command:

```
# podman pull quay.io/openshift-kni/telco-ran-tools:latest
```

Verification

- To check that the tool is available, query the current version of the factory-precaching-cli tool Go binary:

```
# podman run quay.io/openshift-kni/telco-ran-tools:latest -- factory-precaching-cli -v
```

Example output

```
factory-precaching-cli version 20221018.120852+main.feecf17
```

14.2. BOOTING FROM A LIVE OPERATING SYSTEM IMAGE

You can use the factory-precaching-cli tool with to boot servers where only one disk is available and external disk drive cannot be attached to the server.



WARNING

RHCOS requires the disk to not be in use when the disk is about to be written with an RHCOS image.

Depending on the server hardware, you can mount the RHCOS live ISO on the blank server using one of the following methods:

- Using the Dell RACADM tool on a Dell server.
- Using the HPONCFG tool on a HP server.
- Using the Redfish BMC API.



NOTE

It is recommended to automate the mounting procedure. To automate the procedure, you need to pull the required images and host them on a local HTTP server.

Prerequisites

- You powered up the host.
- You have network connectivity to the host.



PROCEDURE

This example procedure uses the Redfish BMC API to mount the RHCOS live ISO.

1. Mount the RHCOS live ISO:

- a. Check virtual media status:

```
$ curl --globoff -H "Content-Type: application/json" -H \
"Accept: application/json" -k -X GET --user ${username_password} \
https://$BMC_ADDRESS/redfish/v1/Managers/Self/VirtualMedia/1 | python -m json.tool
```

- b. Mount the ISO file as a virtual media:

```
$ curl --globoff -L -w "%{http_code} %{url_effective}\n" -ku ${username_password} -H "Content-Type: application/json" -H "Accept: application/json" -d '{"Image": "http://[$HTTPD_IP]/RHCOS-live.iso"}' -X POST https://$BMC_ADDRESS/redfish/v1/Managers/Self/VirtualMedia/1/Actions/VirtualMedia.InsertMedia
```

- c. Set the boot order to boot from the virtual media once:

```
$ curl --globoff -L -w "%{http_code} %{url_effective}\n" -ku ${username_password} -H "Content-Type: application/json" -H "Accept: application/json" -d '{"Boot": {"BootSourceOverrideEnabled": "Once", "BootSourceOverrideTarget": "Cd", "BootSourceOverrideMode": "UEFI"}}' -X PATCH https://$BMC_ADDRESS/redfish/v1/Systems/Self
```

2. Reboot and ensure that the server is booting from virtual media.

Additional resources

- For more information about the **butane** utility, see [About Butane](#).
- For more information about creating a custom live RHCOS ISO, see [Creating a custom live RHCOS ISO for remote server access](#).
- For more information about using the Dell RACADM tool, see [Integrated Dell Remote Access Controller 9 RACADM CLI Guide](#).
- For more information about using the HP HPONCFG tool, see [Using HPONCFG](#).
- For more information about using the Redfish BMC API, see [Booting from an HTTP-hosted ISO image using the Redfish API](#).

14.3. PARTITIONING THE DISK

To run the full pre-caching process, you have to boot from a live ISO and use the factory-precaching-cli tool from a container image to partition and pre-cache all the artifacts required.

A live ISO or RHCOS live ISO is required because the disk must not be in use when the operating system (RHCOS) is written to the device during the provisioning. Single-disk servers can also be enabled with this procedure.

Prerequisites

- You have a disk that is not partitioned.
- You have access to the [quay.io/openshift-kni/telco-ran-tools:latest](#) image.
- You have enough storage to install OpenShift Container Platform and pre-cache the required images.

Procedure

1. Verify that the disk is cleared:

■

```
# lsblk
```

Example output

```
NAME  MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
loop0  7:0    0  93.8G  0 loop /run/ephemeral
loop1  7:1    0 897.3M  1 loop /sysroot
sr0   11:0   1  999M  0 rom  /run/media/iso
nvme0n1 259:1  0  1.5T  0 disk
```

- Erase any file system, RAID or partition table signatures from the device:

```
# wipefs -a /dev/nvme0n1
```

Example output

```
/dev/nvme0n1: 8 bytes were erased at offset 0x00000200 (gpt): 45 46 49 20 50 41 52 54
/dev/nvme0n1: 8 bytes were erased at offset 0x1749a955e00 (gpt): 45 46 49 20 50 41 52 54
/dev/nvme0n1: 2 bytes were erased at offset 0x000001fe (PMBR): 55 aa
```



IMPORTANT

The tool fails if the disk is not empty because it uses partition number 1 of the device for pre-caching the artifacts.

14.3.1. Creating the partition

Once the device is ready, you create a single partition and a GPT partition table. The partition is automatically labelled as **data** and created at the end of the device. Otherwise, the partition will be overridden by the **coreos-installer**.



IMPORTANT

The **coreos-installer** requires the partition to be created at the end of the device and to be labelled as **data**. Both requirements are necessary to save the partition when writing the RHCOS image to the disk.

Prerequisites

- The container must run as **privileged** due to formatting host devices.
- You have to mount the **/dev** folder so that the process can be executed inside the container.

Procedure

In the following example, the size of the partition is 250 GiB due to allow pre-caching the DU profile for Day 2 Operators.

- Run the container as **privileged** and partition the disk:

```
# podman run -v /dev:/dev --privileged \
--rm quay.io/openshift-kni/telco-ran-tools:latest -- \
factory-precaching-cli partition \ ①
```

```
-d /dev/nvme0n1 \ ②
-s 250 ③
```

- ① Specifies the partitioning function of the factory-precaching-cli tool.
- ② Defines the root directory on the disk.
- ③ Defines the size of the disk in GB.

2. Check the storage information:

```
# lsblk
```

Example output

NAME	MAJ:MIN	RM	SIZE	RO	TYPE	MOUNTPOINT
loop0	7:0	0	93.8G	0	loop	/run/ephemeral
loop1	7:1	0	897.3M	1	loop	/sysroot
sr0	11:0	1	999M	0	rom	/run/media/iso
nvme0n1	259:1	0	1.5T	0	disk	
					└─	nvme0n1p1 259:3 0 250G 0 part

Verification

You must verify that the following requirements are met:

- The device has a GPT partition table
- The partition uses the latest sectors of the device.
- The partition is correctly labeled as **data**.

Query the disk status to verify that the disk is partitioned as expected:

```
# gdisk -l /dev/nvme0n1
```

Example output

```
GPT fdisk (gdisk) version 1.0.3
```

Partition table scan:

 MBR: protective

 BSD: not present

 APM: not present

 GPT: present

Found valid GPT with protective MBR; using GPT.

Disk /dev/nvme0n1: 3125627568 sectors, 1.5 TiB

Model: Dell Express Flash PM1725b 1.6TB SFF

Sector size (logical/physical): 512/512 bytes

Disk identifier (GUID): CB5A9D44-9B3C-4174-A5C1-C64957910B61

Partition table holds up to 128 entries

Main partition table begins at sector 2 and ends at sector 33

First usable sector is 34, last usable sector is 3125627534

Partitions will be aligned on 2048-sector boundaries
Total free space is 2601338846 sectors (1.2 TiB)

Number	Start (sector)	End (sector)	Size	Code	Name
1	2601338880	3125627534	250.0 GiB	8300	data

14.3.2. Mounting the partition

After verifying that the disk is partitioned correctly, you can mount the device into **/mnt**.



IMPORTANT

It is recommended to mount the device into **/mnt** because that mounting point is used during GitOps ZTP preparation.

- Verify that the partition is formatted as **xfs**:

```
# lsblk -f /dev/nvme0n1
```

Example output

NAME	FSTYPE	LABEL	UUID	MOUNTPOINT
nvme0n1				
└─nvme0n1p1	xfs		1bee8ea4-d6cf-4339-b690-a76594794071	

- Mount the partition:

```
# mount /dev/nvme0n1p1 /mnt/
```

Verification

- Check that the partition is mounted:

```
# lsblk
```

Example output

NAME	MAJ:MIN	RM	SIZE	RO	TYPE	MOUNTPOINT
loop0	7:0	0	93.8G	0	loop	/run/ephemeral
loop1	7:1	0	897.3M	1	loop	/sysroot
sr0	11:0	1	999M	0	rom	/run/media/iso
nvme0n1	259:1	0	1.5T	0	disk	
└─nvme0n1p1	259:2	0	250G	0	part	1 /var/mnt

- 1** The mount point is **/var/mnt** because the **/mnt** folder in RHCOS is a link to **/var/mnt**.

14.4. DOWNLOADING THE IMAGES

The factory-precaching-cli tool allows you to download the following images to your partitioned server:

- OpenShift Container Platform images
- Operator images that are included in the distributed unit (DU) profile for 5G RAN sites
- Operator images from disconnected registries

**NOTE**

The list of available Operator images can vary in different OpenShift Container Platform releases.

14.4.1. Downloading with parallel workers

The factory-precaching-cli tool uses parallel workers to download multiple images simultaneously. You can configure the number of workers with the **--parallel** or **-p** option. The default number is set to 80% of the available CPUs to the server.

**NOTE**

Your login shell may be restricted to a subset of CPUs, which reduces the CPUs available to the container. To remove this restriction, you can precede your commands with **taskset 0xffffffff**, for example:

```
# taskset 0xffffffff podman run --rm quay.io/openshift-kni/telco-ran-tools:latest factory-precaching-cli download --help
```

14.4.2. Preparing to download the OpenShift Container Platform images

To download OpenShift Container Platform container images, you need to know the multicluster engine version. When you use the **--du-profile** flag, you also need to specify the Red Hat Advanced Cluster Management (RHACM) version running in the hub cluster that is going to provision the single-node OpenShift.

Prerequisites

- You have RHACM and the multicluster engine Operator installed.
- You partitioned the storage device.
- You have enough space for the images on the partitioned device.
- You connected the bare-metal server to the Internet.
- You have a valid pull secret.

Procedure

1. Check the RHACM version and the multicluster engine version by running the following commands in the hub cluster:

```
$ oc get csv -A | grep -i advanced-cluster-management
```

Example output

—

```
open-cluster-management           advanced-cluster-management.v2.6.3
Advanced Cluster Management for Kubernetes 2.6.3      advanced-cluster-
management.v2.6.3          Succeeded
```

```
$ oc get csv -A | grep -i multicloud-engine
```

Example output

multicloud-engine		cluster-group-upgrades-operator.v0.0.3	cluster-
group-upgrades-operator	0.0.3		Pending
multicloud-engine		multicloud-engine.v2.1.4	multicloud
engine for Kubernetes	2.1.4	multicloud-engine.v2.0.3	
Succeeded			
multicloud-engine		openshift-gitops-operator.v1.5.7	Red Hat
OpenShift GitOps	1.5.7	openshift-gitops-operator.v1.5.6-	
0.1664915551.p	Succeeded		
multicloud-engine		openshift-pipelines-operator-rh.v1.6.4	Red Hat
OpenShift Pipelines	1.6.4	openshift-pipelines-operator-rh.v1.6.3	
Succeeded			

- To access the container registry, copy a valid pull secret on the server to be installed:

- Create the **.docker** folder:

```
$ mkdir /root/.docker
```

- Copy the valid pull in the **config.json** file to the previously created **.docker/** folder:

```
$ cp config.json /root/.docker/config.json ①
```

- ① **/root/.docker/config.json** is the default path where **podman** checks for the login credentials for the registry.



NOTE

If you use a different registry to pull the required artifacts, you need to copy the proper pull secret. If the local registry uses TLS, you need to include the certificates from the registry as well.

14.4.3. Downloading the OpenShift Container Platform images

The factory-precaching-cli tool allows you to pre-cache all the container images required to provision a specific OpenShift Container Platform release.

Procedure

- Pre-cache the release by running the following command:

```
# podman run -v /mnt:/mnt -v /root/.docker:/root/.docker --privileged --rm quay.io/openshift-
kni/telco-ran-tools -- \
factory-precaching-cli download \ ①
-r 4.18.0 \ ②
```

```
--acm-version 2.6.3 \ ③
--mce-version 2.1.4 \ ④
-f /mnt \ ⑤
--img quay.io/custom/repository ⑥
```

- ① Specifies the downloading function of the factory-precaching-cli tool.
- ② Defines the OpenShift Container Platform release version.
- ③ Defines the RHACM version.
- ④ Defines the multicluster engine version.
- ⑤ Defines the folder where you want to download the images on the disk.
- ⑥ Optional. Defines the repository where you store your additional images. These images are downloaded and pre-cached on the disk.

Example output

```
Generated /mnt/imageset.yaml
Generating list of pre-cached artifacts...
Processing artifact [1/176]: ocp-v4.0-art-
dev@sha256_6ac2b96bf4899c01a87366fd0feae9f57b1b61878e3b5823da0c3f34f707fbf5
Processing artifact [2/176]: ocp-v4.0-art-
dev@sha256_f48b68d5960ba903a0d018a10544ae08db5802e21c2fa5615a14fc58b1c1657c
Processing artifact [3/176]: ocp-v4.0-art-
dev@sha256_a480390e91b1c07e10091c3da2257180654f6b2a735a4ad4c3b69dbdb77bbc06

Processing artifact [4/176]: ocp-v4.0-art-
dev@sha256_ecc5d8dbd77e326dba6594ff8c2d091eefbc4d90c963a9a85b0b2f0e6155f995
Processing artifact [5/176]: ocp-v4.0-art-
dev@sha256_274b6d561558a2f54db08ea96df9892315bb773fc203b1dbcea418d20f4c7ad1
Processing artifact [6/176]: ocp-v4.0-art-
dev@sha256_e142bf5020f5ca0d1bdda0026bf97f89b72d21a97c9cc2dc71bf85050e822bbf
...
Processing artifact [175/176]: ocp-v4.0-art-
dev@sha256_16cd7eda26f0fb0fc965a589e1e96ff8577e560fc当地14f06b5fda1643036ed6c8
Processing artifact [176/176]: ocp-v4.0-art-
dev@sha256_cf4d862b4a4170d4f611b39d06c31c97658e309724f9788e155999ae51e7188f
...
Summary:

Release: 4.18.0
Hub Version: 2.6.3
ACM Version: 2.6.3
MCE Version: 2.1.4
Include DU Profile: No
Workers: 83
```

Verification

- Check that all the images are compressed in the target folder of server:

```
$ ls -l /mnt ①
```

- 1 It is recommended that you pre-cache the images in the **/mnt** folder.

Example output

```
-rw-r--r--. 1 root root 136352323 Oct 31 15:19 ocp-v4.0-art-
dev@sha256_edec37e7cd8b1611d0031d45e7958361c65e2005f145b471a8108f1b54316c07.t
gz
-rw-r--r--. 1 root root 156092894 Oct 31 15:33 ocp-v4.0-art-
dev@sha256_ee51b062b9c3c9f4fe77bd5b3cc9a3b12355d040119a1434425a824f137c61a9.tg
z
-rw-r--r--. 1 root root 172297800 Oct 31 15:29 ocp-v4.0-art-
dev@sha256_ef23d9057c367a36e4a5c4877d23ee097a731e1186ed28a26c8d21501cd82718.t
gz
-rw-r--r--. 1 root root 171539614 Oct 31 15:23 ocp-v4.0-art-
dev@sha256_f0497bb63ef6834a619d4208be9da459510df697596b891c0c633da144dbb025.t
gz
-rw-r--r--. 1 root root 160399150 Oct 31 15:20 ocp-v4.0-art-
dev@sha256_f0c339da117cde44c9aae8d0bd054bceb6f19fdb191928f6912a703182330ac2.tgz

-rw-r--r--. 1 root root 175962005 Oct 31 15:17 ocp-v4.0-art-
dev@sha256_f19dd2e80fb41ef31d62bb8c08b339c50d193fdb10fc39cc15b353ccbfeb9b24.tgz

-rw-r--r--. 1 root root 174942008 Oct 31 15:33 ocp-v4.0-art-
dev@sha256_f1dbb81fa1aa724e96dd2b296b855ff52a565fbef003d08030d63590ae6454df.tgz

-rw-r--r--. 1 root root 246693315 Oct 31 15:31 ocp-v4.0-art-
dev@sha256_f44dcf2c94e4fd843cbbf9b11128df2ba856cd813786e42e3da1fdfb0f6ddd01.tgz
-rw-r--r--. 1 root root 170148293 Oct 31 15:00 ocp-v4.0-art-
dev@sha256_f48b68d5960ba903a0d018a10544ae08db5802e21c2fa5615a14fc58b1c1657c.tg
z
-rw-r--r--. 1 root root 168899617 Oct 31 15:16 ocp-v4.0-art-
dev@sha256_f5099b0989120a8d08a963601214b5c5cb23417a707a8624b7eb52ab788a7f75.t
gz
-rw-r--r--. 1 root root 176592362 Oct 31 15:05 ocp-v4.0-art-
dev@sha256_f68c0e6f5e17b0b0f7ab2d4c39559ea89f900751e64b97cb42311a478338d9c3.tg
z
-rw-r--r--. 1 root root 157937478 Oct 31 15:37 ocp-v4.0-art-
dev@sha256_f7ba33a6a9db9fcf4b0ab0f368569e19b9fa08f4c01a0d5f6a243d61ab781bd8.tgz

-rw-r--r--. 1 root root 145535253 Oct 31 15:26 ocp-v4.0-art-
dev@sha256_f8f098911d670287826e9499806553f7a1dd3e2b5332abbec740008c36e84de5.t
gz
-rw-r--r--. 1 root root 158048761 Oct 31 15:40 ocp-v4.0-art-
dev@sha256_f914228ddb99120986262168a705903a9f49724ffa958bb4bf12b2ec1d7fb47.tgz

-rw-r--r--. 1 root root 167914526 Oct 31 15:37 ocp-v4.0-art-
dev@sha256_fa3ca9401c7a9efda0502240aeb8d3ae2d239d38890454f17fe5158b62305010.tg
z
-rw-r--r--. 1 root root 164432422 Oct 31 15:24 ocp-v4.0-art-
dev@sha256_fc4783b446c70df30b3120685254b40ce13ba6a2b0bf8fb1645f116cf6a392f1.tgz
```

```
-rw-r--r--. 1 root root 306643814 Oct 31 15:11
troubleshoot@sha256_b86b8aea29a818a9c22944fd18243fa0347c7a2bf1ad8864113ff2bb2d8
e0726.tgz
```

14.4.4. Downloading the Operator images

You can also pre-cache Day-2 Operators used in the 5G Radio Access Network (RAN) Distributed Unit (DU) cluster configuration. The Day-2 Operators depend on the installed OpenShift Container Platform version.



IMPORTANT

You need to include the RHACM hub and multicluster engine Operator versions by using the **--acm-version** and **--mce-version** flags so the factory-precaching-cli tool can pre-cache the appropriate containers images for RHACM and the multicluster engine Operator.

Procedure

- Pre-cache the Operator images:

```
# podman run -v /mnt:/mnt -v /root/.docker:/root/.docker --privileged --rm quay.io/openshift-
kni/telco-ran-tools:latest -- factory-precaching-cli download \ ①
-r 4.18.0 \ ②
--acm-version 2.6.3 \ ③
--mce-version 2.1.4 \ ④
-f /mnt \ ⑤
--img quay.io/custom/repository ⑥
--du-profile -s ⑦
```

- Specifies the downloading function of the factory-precaching-cli tool.
- Defines the OpenShift Container Platform release version.
- Defines the RHACM version.
- Defines the multicluster engine version.
- Defines the folder where you want to download the images on the disk.
- Optional. Defines the repository where you store your additional images. These images are downloaded and pre-cached on the disk.
- Specifies pre-caching the Operators included in the DU configuration.

Example output

```
Generated /mnt/imageset.yaml
Generating list of pre-cached artifacts...
Processing artifact [1/379]: ocp-v4.0-art-
dev@sha256_7753a8d9dd5974be8c90649aadd7c914a3d8a1f1e016774c7ac7c9422e9f9958
Processing artifact [2/379]: ose-kube-rbac-
proxy@sha256_c27a7c01e5968aff16b6bb6670423f992d1a1de1a16e7e260d12908d3322431c
```

```

Processing artifact [3/379]: ocp-v4.0-art-
dev@sha256_370e47a14c798ca3f8707a38b28fcf28114f492bb35fe1112e55d1eb51022c99
...
Processing artifact [378/379]: ose-local-storage-
operator@sha256_0c81c2b79f79307305e51ce9d3837657cf9ba5866194e464b4d1b299f85034
d0
Processing artifact [379/379]: multicluster-operators-channel-
rhel8@sha256_c10f6bbb84fe36e05816e873a72188018856ad6aac6cc16271a1b3966f73ceb3

...
Summary:

Release: 4.18.0
Hub Version: 2.6.3
ACM Version: 2.6.3
MCE Version: 2.1.4
Include DU Profile: Yes
Workers: 83

```

14.4.5. Pre-caching custom images in disconnected environments

The **--generate-imageset** argument stops the factory-precaching-cli tool after the **ImageSetConfiguration** custom resource (CR) is generated. This allows you to customize the **ImageSetConfiguration** CR before downloading any images. After you customized the CR, you can use the **--skip-imageset** argument to download the images that you specified in the **ImageSetConfiguration** CR.

You can customize the **ImageSetConfiguration** CR in the following ways:

- Add Operators and additional images
- Remove Operators and additional images
- Change Operator and catalog sources to local or disconnected registries

Procedure

1. Pre-cache the images:

```

# podman run -v /mnt:/mnt -v /root/.docker:/root/.docker --privileged --rm quay.io/openshift-
kni/telco-ran-tools:latest -- factory-precaching-cli download \ ①
-r 4.18.0 \ ②
--acm-version 2.6.3 \ ③
--mce-version 2.1.4 \ ④
-f /mnt \ ⑤
--img quay.io/custom/repository \ ⑥
--du-profile -s \ ⑦
--generate-imageset \ ⑧

```

- ① Specifies the downloading function of the factory-precaching-cli tool.
- ② Defines the OpenShift Container Platform release version.

- 3 Defines the RHACM version.
- 4 Defines the multicluster engine version.
- 5 Defines the folder where you want to download the images on the disk.
- 6 Optional. Defines the repository where you store your additional images. These images are downloaded and pre-cached on the disk.
- 7 Specifies pre-caching the Operators included in the DU configuration.
- 8 The **--generate-imageset** argument generates the **ImageSetConfiguration** CR only, which allows you to customize the CR.

Example output

```
Generated /mnt/imageset.yaml
```

Example ImageSetConfiguration CR

```
apiVersion: mirror.openshift.io/v1alpha2
kind: ImageSetConfiguration
mirror:
  platform:
    channels:
      - name: stable-4.18
        minVersion: 4.18.0 1
        maxVersion: 4.18.0
    additionalImages:
      - name: quay.io/custom/repository
operators:
  - catalog: registry.redhat.io/redhat/redhat-operator-index:v4.18
    packages:
      - name: advanced-cluster-management 2
        channels:
          - name: 'release-2.6'
            minVersion: 2.6.3
            maxVersion: 2.6.3
      - name: multicluster-engine 3
        channels:
          - name: 'stable-2.1'
            minVersion: 2.1.4
            maxVersion: 2.1.4
      - name: local-storage-operator 4
        channels:
          - name: 'stable'
      - name: ptp-operator 5
        channels:
          - name: 'stable'
      - name: sriov-network-operator 6
        channels:
          - name: 'stable'
      - name: cluster-logging 7
        channels:
```

```

    - name: 'stable'
    - name: lvms-operator ⑧
      channels:
        - name: 'stable-4.18'
    - name: amq7-interconnect-operator ⑨
      channels:
        - name: '1.10.x'
    - name: bare-metal-event-relay ⑩
      channels:
        - name: 'stable'
    - catalog: registry.redhat.io/redhat/certified-operator-index:v4.18
      packages:
        - name: sriov-fec ⑪
          channels:
            - name: 'stable'

```

- ① The platform versions match the versions passed to the tool.
- ② ③ The versions of RHACM and the multicluster engine Operator match the versions passed to the tool.
- ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩ ⑪ The CR contains all the specified DU Operators.

2. Customize the catalog resource in the CR:

```

apiVersion: mirror.openshift.io/v1alpha2
kind: ImageSetConfiguration
mirror:
  platform:
  [...]
  operators:
    - catalog: eko4.cloud.lab.eng.bos.redhat.com:8443/redhat/certified-operator-index:v4.18
      packages:
        - name: sriov-fec
          channels:
            - name: 'stable'

```

When you download images by using a local or disconnected registry, you have to first add certificates for the registries that you want to pull the content from.

3. To avoid any errors, copy the registry certificate into your server:

```
# cp /tmp/eko4-ca.crt /etc/pki/ca-trust/source/anchors/.
```

4. Then, update the certificates trust store:

```
# update-ca-trust
```

5. Mount the host **/etc/pki** folder into the factory-cli image:

```
# podman run -v /mnt:/mnt -v /root/.docker:/root/.docker -v /etc/pki:/etc/pki --privileged --rm
quay.io/openshift-kni/telco-ran-tools:latest -- \
factory-precaching-cli download \ ①
```

```
-r 4.18.0 \ ②
--acm-version 2.6.3 \ ③
--mce-version 2.1.4 \ ④
-f /mnt \ ⑤
--img quay.io/custom/repository ⑥
--du-profile -s \ ⑦
--skip-imageset ⑧
```

- ① Specifies the downloading function of the factory-precaching-cli tool.
- ② Defines the OpenShift Container Platform release version.
- ③ Defines the RHACM version.
- ④ Defines the multicluster engine version.
- ⑤ Defines the folder where you want to download the images on the disk.
- ⑥ Optional. Defines the repository where you store your additional images. These images are downloaded and pre-cached on the disk.
- ⑦ Specifies pre-caching the Operators included in the DU configuration.
- ⑧ The **--skip-imageset** argument allows you to download the images that you specified in your customized **ImageSetConfiguration** CR.

6. Download the images without generating a new **imageSetConfiguration** CR:

```
# podman run -v /mnt:/mnt -v /root/.docker:/root/.docker --privileged --rm quay.io/openshift-
kni/telco-ran-tools:latest -- factory-precaching-cli download -r 4.18.0 \
--acm-version 2.6.3 --mce-version 2.1.4 -f /mnt \
--img quay.io/custom/repository \
--du-profile -s \
--skip-imageset
```

Additional resources

- To access the online Red Hat registries, see [OpenShift installation customization tools](#).
- For more information about using the multicluster engine, see [About cluster lifecycle with the multicluster engine operator](#).

14.5. PRE-CACHING IMAGES IN GITOPS ZTP

The **SiteConfig** manifest defines how an OpenShift cluster is to be installed and configured. In the GitOps Zero Touch Provisioning (ZTP) provisioning workflow, the factory-precaching-cli tool requires the following additional fields in the **SiteConfig** manifest:

- **clusters.ignitionConfigOverride**
- **nodes.installerArgs**
- **nodes.ignitionConfigOverride**



IMPORTANT

SiteConfig v1 is deprecated starting with OpenShift Container Platform version 4.18. Equivalent and improved functionality is now available through the SiteConfig Operator using the **ClusterInstance** custom resource. For more information, see [Procedure to transition from SiteConfig CRs to the ClusterInstance API](#).

For more information about the SiteConfig Operator, see [SiteConfig](#).

Example SiteConfig with additional fields

```

apiVersion: ran.openshift.io/v1
kind: SiteConfig
metadata:
  name: "example-5g-lab"
  namespace: "example-5g-lab"
spec:
  baseDomain: "example.domain.redhat.com"
  pullSecretRef:
    name: "assisted-deployment-pull-secret"
  clusterImageSetNameRef: "img4.9.10-x86-64-appsub" ①
  sshPublicKey: "ssh-rsa ..."
  clusters:
    - clusterName: "sno-worker-0"
      clusterImageSetNameRef: "eko4-img4.11.5-x86-64-appsub" ②
      clusterLabels:
        group-du-sno: ""
        common-411: true
        sites : "example-5g-lab"
        vendor: "OpenShift"
      clusterNetwork:
        - cidr: 10.128.0.0/14
          hostPrefix: 23
      machineNetwork:
        - cidr: 10.19.32.192/26
      serviceNetwork:
        - 172.30.0.0/16
    networkType: "OVNKubernetes"
    additionalNTPSources:
      - clock.corp.redhat.com
  ignitionConfigOverride:
    {
      "ignition": {
        "version": "3.1.0"
      },
      "systemd": {
        "units": [
          {
            "name": "var-mnt.mount",
            "enabled": true,
            "contents": "[Unit]\nDescription=Mount partition with artifacts\nBefore=precache-images.service\nBindsTo=precache-images.service\nStopWhenUnneeded=true\n[Mount]\nWhat=/dev/disk/by-partlabel/data\nWhere=/var/mnt\nType=xfs\nTimeoutSec=30\n[Install]\nRequiredBy=precache-images.service"
          }
        ]
      }
    }
  
```

```

    },
    {
      "name": "precache-images.service",
      "enabled": true,
      "contents": "[Unit]\nDescription=Extracts the precached images in discovery\nstage\nAfter=var-\nmnt.mount\nBefore=agent.service\n[Service]\nType=oneshot\nUser=root\nWorkingDirectory=/var/mnt\nExecStart=bash /usr/local/bin/extract-ai.sh\n#TimeoutStopSec=30\n[Install]\nWantedBy=multi-user.target default.target\nWantedBy=agent.service"
    }
  ],
},
"storage": {
  "files": [
    {
      "overwrite": true,
      "path": "/usr/local/bin/extract-ai.sh",
      "mode": 755,
      "user": {
        "name": "root"
      },
      "contents": {
        "source": "data:%23%21%2Fbin%2Fbash%0A%0AFOLDER%3D%22%24%7BFOLDER%3A-%\n%24%28pwd%29%7D%22%0AOCP_RELEASE_LIST%3D%22%24%7BOCP_RELEASE_LIST%3A-\nai-\nimages.txt%7D%22%0ABINARY_FOLDER%3D%2Fvar%2Fmnt%0A%0Apushd%20%24FOLDER%0\nA%0Atotal_copies%3D%24%28sort%20-\nu%20%24BINAY_FOLDER%2F%24OCP_RELEASE_LIST%20%7C%20wc%20-\n!%29%20%20%23%20Required%20to%20keep%20track%20of%20the%20pull%20task%20vs%20tot\nal%0Acurrent_copy%3D1%0A%0Awhile%20read%20-\nr%20line%3B%0Ado%0A%20%20uri%3D%24%28echo%20%22%24line%22%20%7C%20awk%20%\n27%7Bprint%241%7D%27%29%0A%20%20%23tar%3D%24%28echo%20%22%24line%22%20%7\nC%20awk%20%27%7Bprint%242%7D%27%29%0A%20%20podman%20image%20exists%20%24ur\ni%0A%20%20if%20%5B%5B%20%24%3F%20-\neq%200%20%5D%5D%3B%20then%0A%20%20%20%20%20echo%20%22Skipping%20existin\ng%20image%20%24tar%22%0A%20%20%20%20echo%20%22Copying%20%24%7Buri%7\nD%20%5B%24%7Bcurrent_copy%7D%2F%24%7Btotal_copies%7D%5D%22%0A%20%20%20%20\n%20%20current_copy%3D%24%28%28current_copy%20%2B%201%29%0A%20%20%20%20\n%20%20continue%0A%20%20fi%0A%20%20tar%3D%24%28echo%20%22%24uri%22%20%7C%2\n0%20rev%20%7C%20cut%20-d%20%22%2F%22%20-\nf1%20%7C%20rev%20%7C%20tr%20%22%3A%22%20%22_%22%29%0A%20%20tar%20xvf%20\n%24%7Btar%7D.tgz%0A%20%20if%20%5B%20%24%3F%20-\neq%200%20%5D%3B%20then%20rm%20-\nf%20%24%7Btar%7D.gz%3B%20fi%0A%20%20echo%20%22Copying%20%24%7Buri%7D%20%5B\n%24%7Bcurrent_copy%7D%2F%24%7Btotal_copies%7D%5D%22%0A%20%20skopeo%20copy%20\ndir%3A%2F%24%28pwd%29%2F%24%7Btar%7D%20containers-\nstorage%3A%24%7Buri%7D%0A%20%20if%20%5B%20%24%3F%20-\neq%200%20%5D%3B%20then%20rm%20-\nrf%20%24%7Btar%7D%3B%20current_copy%3D%24%28%28current_copy%20%2B%201%29%29\n%3B%20fi%0Adone%20%3C%20%24%7BBINAY_FOLDER%7D%2F%24%7BOCP_RELEASE_LIST%7D%0A%0A%23%20workaround%20while%20https%3A%2F%2Fgithub.com%2Fopenshift%2Fa\nssisted-service%2Fpull%2F3546%0A%23cp%20%2Fvar%2Fmnt%2Fmodified-rhcos-4.10.3-x86_64-\nmetal.x86_64.raw.gz%20%2Fvar%2Ftmp%2F.%0A%0Aexit%200"
      }
    },
  ],
}

```

```
{
  "overwrite": true,
  "path": "/usr/local/bin/agent-fix-bz1964591",
  "mode": 755,
  "user": {
    "name": "root"
  },
  "contents": {
    "source": "data; %23%21%2Fusr%2Fbin%2Fsh%0A%0A%23%20This%20script%20is%20a%20workaround%20for%20bugzilla%201964591%20where%20symlinks%20inside%20%2Fvar%2Flib%2Fcontainers%2F%20get%0A%23%20corrupted%20under%20some%20circumstances.%0A%23%0A%23%20In%20order%20to%20let%20agent.service%20start%20correctly%20we%20are%20checking%20here%20whether%20the%20requested%0A%23%20container%20image%20exists%20and%20in%20case%20%20%20podman%20images%22%20returns%20an%20error%20we%20try%20removing%20the%20faulty%0A%23%20image.%0A%23%0A%23%20In%20such%20a%20scenario%20agent.service%20will%20detect%20the%20image%20is%20not%20present%20and%20pull%20it%20again.%20In%20case%0A%23%20the%20image%20is%20present%20and%20can%20be%20detected%20correctly%2C%20no%20any%20action%20is%20required.%0A%0AIMAGE%3D%24%28echo%20%241%20%7C%20sed%20%27s%2F%3A.%2A%2F%2F%27%29%0Apodman%20image%20exists%20%24IMAGE%20%7C%20echo%20%22already%20loaded%22%20%7C%20echo%20%22need%20to%20be%20pulled%22%0A%23podman%20images%20%7C%20grep%20%24IMAGE%20%7C%20podman%20rmi%20--force%20%241%20%7C%20true"
  }
}
]
}
}
'
}

nodes:
- hostName: "snonode.sno-worker-0.example.domain.redhat.com"
  role: "master"
  bmcAddress: "idrac-virtualmedia+https://10.19.28.53/redfish/v1/Systems/System.Embedded.1"
  bmcCredentialsName:
    name: "worker0-bmh-secret"
  bootMACAddress: "e4:43:4b:bd:90:46"
  bootMode: "UEFI"
  rootDeviceHints:
    deviceName: /dev/disk/by-path/pci-0000:01:00.0-scsi-0:2:0:0
  installerArgs: ["--save-partlabel", "data"]
  ignitionConfigOverride: |
    {
      "ignition": {
        "version": "3.1.0"
      },
      "systemd": {
        "units": [
          {
            "name": "var-mnt.mount",
            "enabled": true,
            "contents": "[Unit]\nDescription=Mount partition with artifacts\nBefore=precache-ocp-images.service\nBindsTo=precache-ocp-images.service\nStopWhenUnneeded=true\n[Mount]\nWhat=/dev/disk/by-partlabel/data\nWhere=/var/mnt\nType=xfs\nTimeoutSec=30\n[Install]\nRequiredBy=precache-ocp-images.service"
          },
          {
            "

```

```

        "name": "precache-ocp-images.service",
        "enabled": true,
        "contents": "[Unit]\nDescription=Extracts the precached OCP images into containers\nstorage\nAfter=var-mnt.mount\nBefore=machine-config-daemon-pull.service nodeip-\nconfiguration.service\n\n[Service]\nType=oneshot\nUser=root\nWorkingDirectory=/var/mnt\nExecStart=k\nash /usr/local/bin/extract-ocp.sh\nTimeoutStopSec=60\n\n[Install]\nWantedBy=multi-user.target"
    }
]
},
"storage": {
  "files": [
    {
      "overwrite": true,
      "path": "/usr/local/bin/extract-ocp.sh",
      "mode": 755,
      "user": {
        "name": "root"
      },
      "contents": {
        "source": "data:,%23%21%2Fbin%2Fbash%0A%0AFOLDER%3D%22%24%7BFOLDER%3A-\n%24%28pwd%29%7D%22%0AOCP_RELEASE_LIST%3D%22%24%7BOCP_RELEASE_LIST%3A-\nocp-\nimages.txt%7D%22%0ABINARY_FOLDER%3D%2Fvar%2Fmnt%0A%0Apushd%20%24FOLDER%\nA%0Atotal_copies%3D%24%28sort%20-\nu%20%24BINAY_FOLDER%2F%24OCP_RELEASE_LIST%20%7C%20wc%20-\n!%29%20%20%23%20Required%20to%20keep%20track%20of%20the%20pull%20task%20vs%20tot\nal%0Acurrent_copy%3D1%0A%0Awhile%20read%20-\nr%20line%3B%0Ado%0A%20%20uri%3D%24%28echo%20%22%24line%22%20%7C%20awk%20%\n27%7Bprint%241%7D%27%29%0A%20%20%23tar%3D%24%28echo%20%22%24line%22%20%7\nC%20awk%20%27%7Bprint%242%7D%27%29%0A%20%20podman%20image%20exists%20%24ur\ni%0A%20%20if%20%5B%5B%20%24%3F%20-\neq%200%20%5D%5D%3B%20then%0A%20%20%20%20%20echo%20%22Skipping%20existin\ng%20image%20%24tar%22%0A%20%20%20%20echo%20%22Copying%20%24%7Buri%7\nD%20%5B%24%7Bcurrent_copy%7D%2F%24%7Btotal_copies%7D%5D%22%0A%20%20%20%20\n%20%20current_copy%3D%24%28%28current_copy%20%2B%201%29%29%0A%20%20%20%20\n%20%20continue%0A%20%20fi%0A%20%20tar%3D%24%28echo%20%22%24uri%22%20%7C%2\n0%20rev%20%7C%20cut%20-d%20%22%2F%22%20-\nf1%20%7C%20rev%20%7C%20tr%20%22%3A%22%20%22_%22%29%0A%20%20tar%20zvf%20\n%24%7Btar%7D.tgz%0A%20%20if%20%5B%20%24%3F%20-\neq%200%20%5D%3B%20then%20rm%20-\nf%20%24%7Btar%7D.gz%3B%20fi%0A%20%20echo%20%22Copying%20%24%7Buri%7D%20%5B\n%24%7Bcurrent_copy%7D%2F%24%7Btotal_copies%7D%5D%22%0A%20%20skopeo%20copy%20\ndir%3A%2F%2F%24%28pwd%29%2F%24%7Btar%7D%20containers-\nstorage%3A%24%7Buri%7D%0A%20%20if%20%5B%20%24%3F%20-\neq%200%20%5D%3B%20then%20rm%20-\nr%20%24%7Btar%7D%3B%20current_copy%3D%24%28%28current_copy%20%2B%201%29%29\n%3B%20fi%0Adone%20%3C%20%24%7BBINAY_FOLDER%7D%2F%24%7BOCP_RELEASE_LI\nST%7D%0A%0Aexit%20"
    }
  ]
}
nodeNetwork:
  config:

```

```

interfaces:
  - name: ens1f0
    type: ethernet
    state: up
    macAddress: "AA:BB:CC:11:22:33"
    ipv4:
      enabled: true
      dhcp: true
    ipv6:
      enabled: false
  interfaces:
    - name: "ens1f0"
      macAddress: "AA:BB:CC:11:22:33"

```

- 1 Specifies the cluster image set used for deployment, unless you specify a different image set in the **spec.clusters.clusterImageSetNameRef** field.
- 2 Specifies the cluster image set used to deploy an individual cluster. If defined, it overrides the **spec.clusterImageSetNameRef** at the site level.

14.5.1. Understanding the clusters.ignitionConfigOverride field

The **clusters.ignitionConfigOverride** field adds a configuration in Ignition format during the GitOps ZTP discovery stage. The configuration includes **systemd** services in the ISO mounted in virtual media. This way, the scripts are part of the discovery RHCOS live ISO and they can be used to load the Assisted Installer (AI) images.

systemd services

The **systemd** services are **var-mnt.mount** and **precache-images.services**. The **precache-images.service** depends on the disk partition to be mounted in **/var/mnt** by the **var-mnt.mount** unit. The service calls a script called **extract-ai.sh**.

extract-ai.sh

The **extract-ai.sh** script extracts and loads the required images from the disk partition to the local container storage. When the script finishes successfully, you can use the images locally.

agent-fix-bz1964591

The **agent-fix-bz1964591** script is a workaround for an AI issue. To prevent AI from removing the images, which can force the **agent.service** to pull the images again from the registry, the **agent-fix-bz1964591** script checks if the requested container images exist.

14.5.2. Understanding the nodes.installerArgs field

The **nodes.installerArgs** field allows you to configure how the **coreos-installer** utility writes the RHCOS live ISO to disk. You need to indicate to save the disk partition labeled as **data** because the artifacts saved in the **data** partition are needed during the OpenShift Container Platform installation stage.

The extra parameters are passed directly to the **coreos-installer** utility that writes the live RHCOS to disk. On the next reboot, the operating system starts from the disk.

You can pass several options to the **coreos-installer** utility:

OPTIONS:

```

...
-u, --image-url <URL>
  Manually specify the image URL

-f, --image-file <path>
  Manually specify a local image file

-i, --ignition-file <path>
  Embed an Ignition config from a file

-l, --ignition-url <URL>
  Embed an Ignition config from a URL

...
--save-partlabel <lx>...
  Save partitions with this label glob

--save-partindex <id>...
  Save partitions with this number or range

...
--insecure-ignition
  Allow Ignition URL without HTTPS or hash

```

14.5.3. Understanding the `nodes.ignitionConfigOverride` field

Similarly to `clusters.ignitionConfigOverride`, the `nodes.ignitionConfigOverride` field allows the addition of configurations in Ignition format to the `coreos-installer` utility, but at the OpenShift Container Platform installation stage. When the RHCOS is written to disk, the extra configuration included in the GitOps ZTP discovery ISO is no longer available. During the discovery stage, the extra configuration is stored in the memory of the live OS.



NOTE

At this stage, the number of container images extracted and loaded is bigger than in the discovery stage. Depending on the OpenShift Container Platform release and whether you install the Day-2 Operators, the installation time can vary.

At the installation stage, the `var-mnt.mount` and `precache-ocp.services systemd` services are used.

`precache-ocp.service`

The `precache-ocp.service` depends on the disk partition to be mounted in `/var/mnt` by the `var-mnt.mount` unit. The `precache-ocp.service` service calls a script called `extract-ocp.sh`.



IMPORTANT

To extract all the images before the OpenShift Container Platform installation, you must execute `precache-ocp.service` before executing the `machine-config-daemon-pull.service` and `nodeip-configuration.service` services.

`extract-ocp.sh`

The `extract-ocp.sh` script extracts and loads the required images from the disk partition to the local container storage.

When you commit the **SiteConfig** and optional **PolicyGenerator** or **PolicyGenTemplate** custom resources (CRs) to the Git repo that Argo CD is monitoring, you can start the GitOps ZTP workflow by syncing the CRs with the hub cluster.

14.6. TROUBLESHOOTING A "RENDERED CATALOG IS INVALID" ERROR

When you download images by using a local or disconnected registry, you might see the **The rendered catalog is invalid** error. This means that you are missing certificates of the new registry you want to pull content from.



NOTE

The factory-precaching-cli tool image is built on a UBI RHEL image. Certificate paths and locations are the same on RHCOS.

Example error

```
Generating list of pre-cached artifacts...
error: unable to run command oc-mirror -c /mnt/imageset.yaml file:///tmp/fp-cli-3218002584/mirror --ignore-history --dry-run: Creating directory: /tmp/fp-cli-3218002584/mirror/oc-mirror-workspace/src/publish
Creating directory: /tmp/fp-cli-3218002584/mirror/oc-mirror-workspace/src/v2
Creating directory: /tmp/fp-cli-3218002584/mirror/oc-mirror-workspace/src/charts
Creating directory: /tmp/fp-cli-3218002584/mirror/oc-mirror-workspace/src/release-signatures
backend is not configured in /mnt/imageset.yaml, using stateless mode
backend is not configured in /mnt/imageset.yaml, using stateless mode
No metadata detected, creating new workspace
level=info msg=trying next host error=failed to do request: Head
"https://eko4.cloud.lab.eng.bos.redhat.com:8443/v2/redhat/redhat-operator-index/manifests/v4.11": x509: certificate signed by unknown authority host=eko4.cloud.lab.eng.bos.redhat.com:8443
```

The rendered catalog is invalid.

Run "oc-mirror list operators --catalog CATALOG-NAME --package PACKAGE-NAME" for more information.

```
error: error rendering new refs: render reference
"eko4.cloud.lab.eng.bos.redhat.com:8443/redhat/redhat-operator-index:v4.11": error resolving name :
failed to do request: Head "https://eko4.cloud.lab.eng.bos.redhat.com:8443/v2/redhat/redhat-operator-index/manifests/v4.11": x509: certificate signed by unknown authority
```

Procedure

1. Copy the registry certificate into your server:

```
# cp /tmp/eko4-ca.crt /etc/pki/ca-trust/source/anchors/.
```

2. Update the certificates truststore:

```
# update-ca-trust
```

3. Mount the host **/etc/pki** folder into the factory-cli image:

```
# podman run -v /mnt:/mnt -v /root/.docker:/root/.docker -v /etc/pki:/etc/pki --privileged -it --rm  
quay.io/openshift-kni/telco-ran-tools:latest -- \  
factory-precaching-cli download -r 4.18.0 --acm-version 2.5.4 \  
--mce-version 2.0.4 -f /mnt \--img quay.io/custom/repository  
--du-profile -s --skip-imageset
```

CHAPTER 15. IMAGE-BASED UPGRADE FOR SINGLE-NODE OPENSHIFT CLUSTERS

15.1. UNDERSTANDING THE IMAGE-BASED UPGRADE FOR SINGLE-NODE OPENSHIFT CLUSTERS

From OpenShift Container Platform 4.14.13, the Lifecycle Agent provides you with an alternative way to upgrade the platform version of a single-node OpenShift cluster. The image-based upgrade is faster than the standard upgrade method and allows you to directly upgrade from OpenShift Container Platform <4.y> to <4.y+2>, and <4.y.z> to <4.y.z+n>.

This upgrade method utilizes a generated OCI image from a dedicated seed cluster that is installed on the target single-node OpenShift cluster as a new **ostree** stateroot. A seed cluster is a single-node OpenShift cluster deployed with the target OpenShift Container Platform version, Day 2 Operators, and configurations that are common to all target clusters.

You can use the seed image, which is generated from the seed cluster, to upgrade the platform version on any single-node OpenShift cluster that has the same combination of hardware, Day 2 Operators, and cluster configuration as the seed cluster.



IMPORTANT

The image-based upgrade uses custom images that are specific to the hardware platform that the clusters are running on. Each different hardware platform requires a separate seed image.

The Lifecycle Agent uses two custom resources (CRs) on the participating clusters to orchestrate the upgrade:

- On the seed cluster, the **SeedGenerator** CR allows for the seed image generation. This CR specifies the repository to push the seed image to.
- On the target cluster, the **ImageBasedUpgrade** CR specifies the seed image for the upgrade of the target cluster and the backup configurations for your workloads.

Example SeedGenerator CR

```
apiVersion: lca.openshift.io/v1
kind: SeedGenerator
metadata:
  name: seedimage
spec:
  seedImage: <seed_image>
```

Example ImageBasedUpgrade CR

```
apiVersion: lca.openshift.io/v1
kind: ImageBasedUpgrade
metadata:
  name: upgrade
spec:
  stage: Idle ①
```

```

seedImageRef: ②
  version: <target_version>
  image: <seed_container_image>
  pullSecretRef:
    name: <seed_pull_secret>
  autoRollbackOnFailure: {}
#  initMonitorTimeoutSeconds: 1800 ③
extraManifests: ④
- name: example-extra-manifests
  namespace: openshift-lifecycle-agent
oadpContent: ⑤
- name: oadp-cm-example
  namespace: openshift-адп

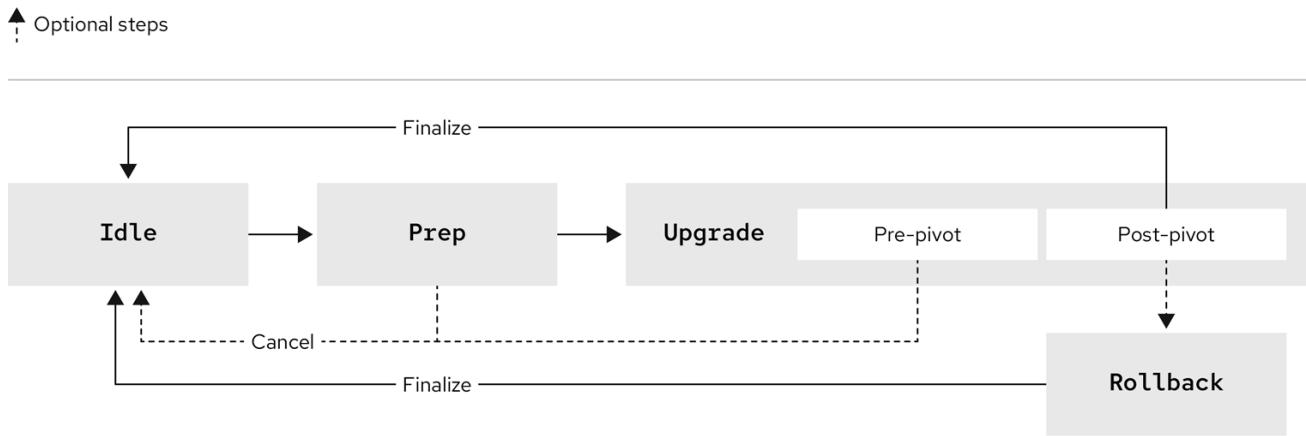
```

- ① Stage of the **ImageBasedUpgrade** CR. The value can be **Idle**, **Prep**, **Upgrade**, or **Rollback**.
- ② Target platform version, seed image to be used, and the secret required to access the image.
- ③ Optional: Time frame in seconds to roll back when the upgrade does not complete within that time frame after the first reboot. If not defined or set to **0**, the default value of **1800** seconds (30 minutes) is used.
- ④ Optional: List of **ConfigMap** resources that contain your custom catalog sources to retain after the upgrade, and your extra manifests to apply to the target cluster that are not part of the seed image.
- ⑤ List of **ConfigMap** resources that contain the OADP **Backup** and **Restore** CRs.

15.1.1. Stages of the image-based upgrade

After generating the seed image on the seed cluster, you can move through the stages on the target cluster by setting the **spec.stage** field to one of the following values in the **ImageBasedUpgrade** CR:

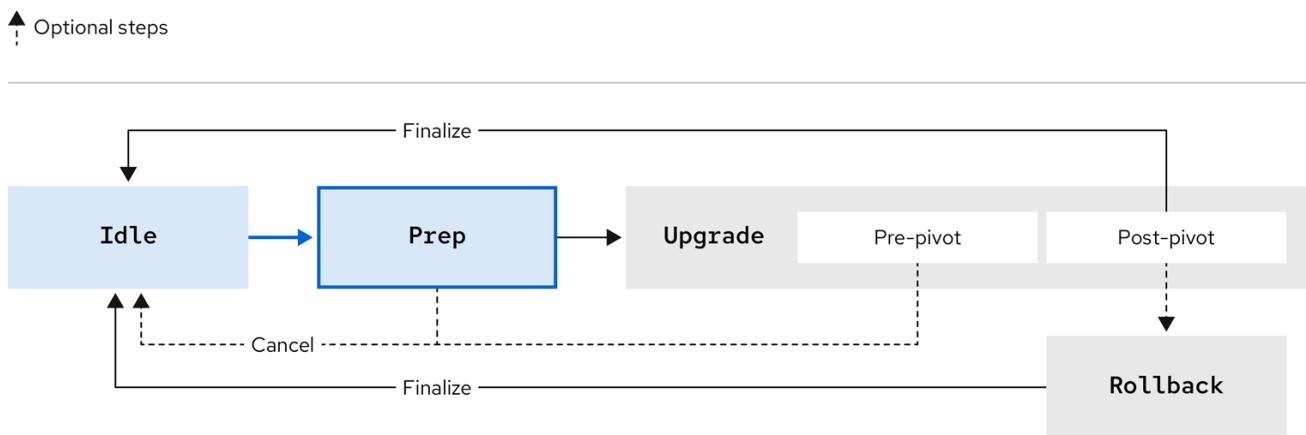
- **Idle**
- **Prep**
- **Upgrade**
- **Rollback** (Optional)

Figure 15.1. Stages of the image-based upgrade

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15.1.1.1. Idle stage

The Lifecycle Agent creates an **ImageBasedUpgrade** CR set to **stage: Idle** when the Operator is first deployed. This is the default stage. There is no ongoing upgrade and the cluster is ready to move to the **Prep** stage.

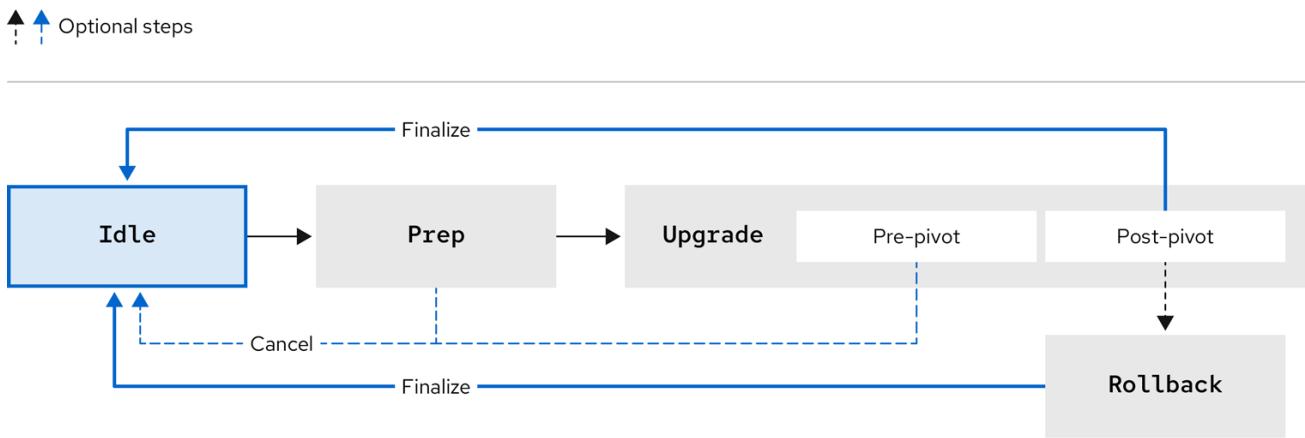
Figure 15.2. Transition from Idle stage

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You also move to the **Idle** stage to do one of the following steps:

- Finalize a successful upgrade
- Finalize a rollback
- Cancel an ongoing upgrade until the pre-pivot phase in the **Upgrade** stage

Moving to the **Idle** stage ensures that the Lifecycle Agent cleans up resources, so that the cluster is ready for upgrades again.

Figure 15.3. Transitions to Idle stage

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**IMPORTANT**

If using RHACM when you cancel an upgrade, you must remove the **import.open-cluster-management.io/disable-auto-import** annotation from the target managed cluster to re-enable the automatic import of the cluster.

15.1.1.2. Prep stage**NOTE**

You can complete this stage before a scheduled maintenance window.

For the **Prep** stage, you specify the following upgrade details in the **ImageBasedUpgrade** CR:

- seed image to use
- resources to back up
- extra manifests to apply and custom catalog sources to retain after the upgrade, if any

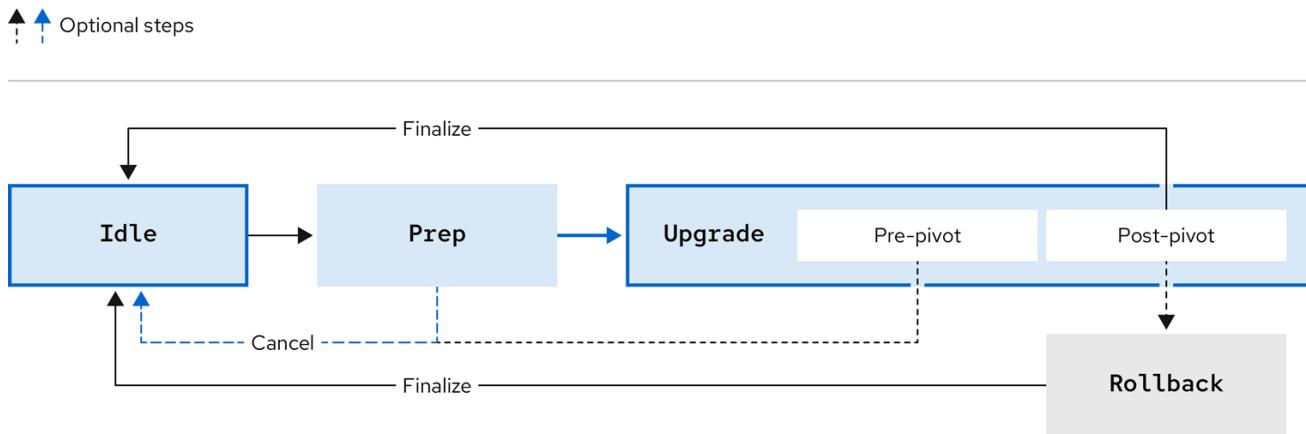
Then, based on what you specify, the Lifecycle Agent prepares for the upgrade without impacting the current running version. During this stage, the Lifecycle Agent ensures that the target cluster is ready to proceed to the **Upgrade** stage by checking if it meets certain conditions. The Operator pulls the seed image to the target cluster with additional container images specified in the seed image. The Lifecycle Agent checks if there is enough space on the container storage disk and if necessary, the Operator deletes unpinned images until the disk usage is below the specified threshold. For more information about how to configure or disable the cleaning up of the container storage disk, see "Configuring the automatic image cleanup of the container storage disk".

You also prepare backup resources with the OADP Operator's **Backup** and **Restore** CRs. These CRs are used in the **Upgrade** stage to reconfigure the cluster, register the cluster with RHACM, and restore application artifacts.

In addition to the OADP Operator, the Lifecycle Agent uses the **ostree** versioning system to create a backup, which allows complete cluster reconfiguration after both upgrade and rollback.

After the **Prep** stage finishes, you can cancel the upgrade process by moving to the **Idle** stage or you can start the upgrade by moving to the **Upgrade** stage in the **ImageBasedUpgrade** CR. If you cancel the upgrade, the Operator performs cleanup operations.

Figure 15.4. Transition from Prep stage



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15.1.1.3. Upgrade stage

The **Upgrade** stage consists of two phases:

pre-pivot

Just before pivoting to the new stateroot, the Lifecycle Agent collects the required cluster specific artifacts and stores them in the new stateroot. The backup of your cluster resources specified in the **Prep** stage are created on a compatible Object storage solution. The Lifecycle Agent exports CRs specified in the **extraManifests** field in the **ImageBasedUpgrade** CR or the CRs described in the ZTP policies that are bound to the target cluster. After pre-pivot phase has completed, the Lifecycle Agent sets the new stateroot deployment as the default boot entry and reboots the node.

post-pivot

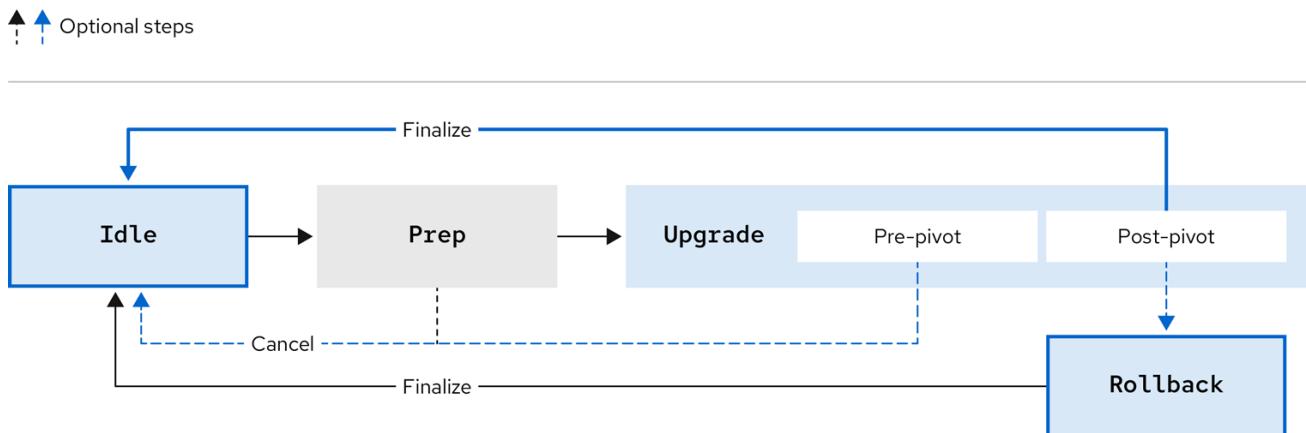
After booting from the new stateroot, the Lifecycle Agent also regenerates the seed image's cluster cryptography. This ensures that each single-node OpenShift cluster upgraded with the same seed image has unique and valid cryptographic objects. The Operator then reconfigures the cluster by applying cluster-specific artifacts that were collected in the pre-pivot phase. The Operator applies all saved CRs, and restores the backups.

After the upgrade has completed and you are satisfied with the changes, you can finalize the upgrade by moving to the **Idle** stage.



IMPORTANT

When you finalize the upgrade, you cannot roll back to the original release.

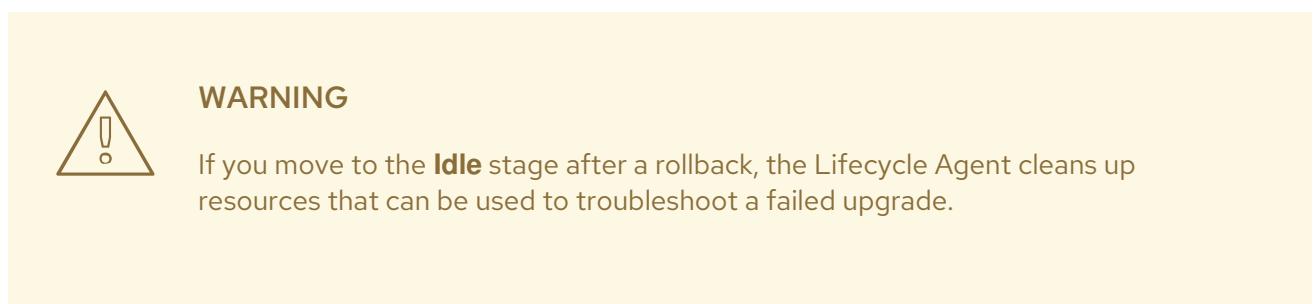
Figure 15.5. Transitions from Upgrade stage

696_OpenShift_0624

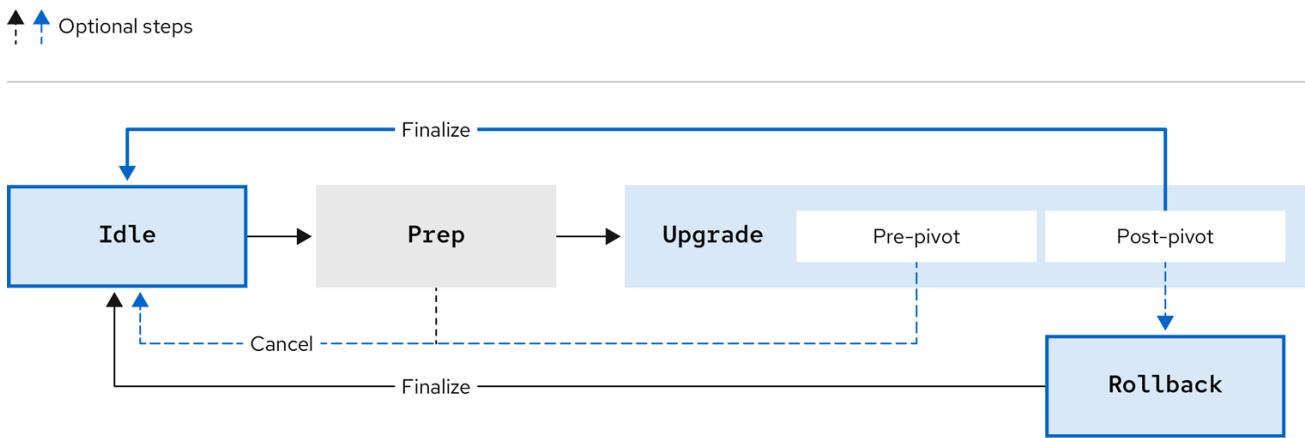
If you want to cancel the upgrade, you can do so until the pre-pivot phase of the **Upgrade** stage. If you encounter issues after the upgrade, you can move to the **Rollback** stage for a manual rollback.

15.1.1.4. Rollback stage

The **Rollback** stage can be initiated manually or automatically upon failure. During the **Rollback** stage, the Lifecycle Agent sets the original **ostree** stateroot deployment as default. Then, the node reboots with the previous release of OpenShift Container Platform and application configurations.



The Lifecycle Agent initiates an automatic rollback if the upgrade does not complete within a specified time limit. For more information about the automatic rollback, see the "Moving to the Rollback stage with Lifecycle Agent" or "Moving to the Rollback stage with Lifecycle Agent and GitOps ZTP" sections.

Figure 15.6. Transition from Rollback stage

696_OpenShift_0624

Additional resources

- Configuring the automatic image cleanup of the container storage disk
- Performing an image-based upgrade for single-node OpenShift clusters with Lifecycle Agent
- Performing an image-based upgrade for single-node OpenShift clusters using GitOps ZTP

15.1.2. Guidelines for the image-based upgrade

For a successful image-based upgrade, your deployments must meet certain requirements.

There are different deployment methods in which you can perform the image-based upgrade:

GitOps ZTP

You use the GitOps Zero Touch Provisioning (ZTP) to deploy and configure your clusters.

Non-GitOps

You manually deploy and configure your clusters.

You can perform an image-based upgrade in disconnected environments. For more information about how to mirror images for a disconnected environment, see "Mirroring images for a disconnected installation".

Additional resources

- Mirroring images for a disconnected installation

15.1.2.1. Minimum software version of components

Depending on your deployment method, the image-based upgrade requires the following minimum software versions.

Table 15.1. Minimum software version of components

Component	Software version	Required
Lifecycle Agent	4.16	Yes
OADP Operator	1.4.1	Yes
Managed cluster version	4.14.13	Yes
Hub cluster version	4.16	No
RHACM	2.10.2	No
GitOps ZTP plugin	4.16	Only for GitOps ZTP deployment method
Red Hat OpenShift GitOps	1.12	Only for GitOps ZTP deployment method
Topology Aware Lifecycle Manager (TALM)	4.16	Only for GitOps ZTP deployment method
Local Storage Operator [1]	4.14	Yes
Logical Volume Manager (LVM) Storage [1]	4.14.2	Yes

1. The persistent storage must be provided by either the LVM Storage or the Local Storage Operator, not both.

15.1.2.2. Hub cluster guidelines

If you are using Red Hat Advanced Cluster Management (RHACM), your hub cluster needs to meet the following conditions:

- To avoid including any RHACM resources in your seed image, you need to disable all optional RHACM add-ons before generating the seed image.
- Your hub cluster must be upgraded to at least the target version before performing an image-based upgrade on a target single-node OpenShift cluster.

15.1.2.3. Seed image guidelines

The seed image targets a set of single-node OpenShift clusters with the same hardware and similar configuration. This means that the seed cluster must match the configuration of the target clusters for the following items:

- CPU topology
 - Number of CPU cores

- Tuned performance configuration, such as number of reserved CPUs
- **MachineConfig** resources for the target cluster
- IP version

**NOTE**

Dual-stack networking is not supported in this release.

- Set of Day 2 Operators, including the Lifecycle Agent and the OADP Operator
- Disconnected registry
- FIPS configuration

The following configurations only have to partially match on the participating clusters:

- If the target cluster has a proxy configuration, the seed cluster must have a proxy configuration too but the configuration does not have to be the same.
- A dedicated partition on the primary disk for container storage is required on all participating clusters. However, the size and start of the partition does not have to be the same. Only the **spec.config.storage.disks.partitions.label: varlibcontainers** label in the **MachineConfig** CR must match on both the seed and target clusters. For more information about how to create the disk partition, see "Configuring a shared container partition between ostree stateroots" or "Configuring a shared container partition between ostree stateroots when using GitOps ZTP".

For more information about what to include in the seed image, see "Seed image configuration" and "Seed image configuration using the RAN DU profile".

Additional resources

- [Configuring a shared container partition between ostree stateroots](#)
- [Configuring a shared container partition between ostree stateroots when using GitOps ZTP](#)
- [Seed image configuration](#)

15.1.2.4. OADP backup and restore guidelines

With the OADP Operator, you can back up and restore your applications on your target clusters by using **Backup** and **Restore** CRs wrapped in **ConfigMap** objects. The application must work on the current and the target OpenShift Container Platform versions so that they can be restored after the upgrade. The backups must include resources that were initially created.

The following resources must be excluded from the backup:

- **pods**
- **endpoints**
- **controllerrevision**
- **podmetrics**

- **packagemanifest**
- **replicaset**
- **localvolume**, if using Local Storage Operator (LSO)

There are two local storage implementations for single-node OpenShift:

Local Storage Operator (LSO)

The Lifecycle Agent automatically backs up and restores the required artifacts, including **localvolume** resources and their associated **StorageClass** resources. You must exclude the **persistentvolumes** resource in the application **Backup** CR.

LVM Storage

You must create the **Backup** and **Restore** CRs for LVM Storage artifacts. You must include the **persistentVolumes** resource in the application **Backup** CR.

For the image-based upgrade, only one Operator is supported on a given target cluster.



IMPORTANT

For both Operators, you must not apply the Operator CRs as extra manifests through the **ImageBasedUpgrade** CR.

The persistent volume contents are preserved and used after the pivot. When you are configuring the **DataProtectionApplication** CR, you must ensure that the **.spec.configuration.restic.enable** is set to **false** for an image-based upgrade. This disables Container Storage Interface integration.

15.1.2.4.1. **Ica.openshift.io/apply-wave** guidelines

The **Ica.openshift.io/apply-wave** annotation determines the apply order of **Backup** or **Restore** CRs. The value of the annotation must be a string number. If you define the **Ica.openshift.io/apply-wave** annotation in the **Backup** or **Restore** CRs, they are applied in increasing order based on the annotation value. If you do not define the annotation, they are applied together.

The **Ica.openshift.io/apply-wave** annotation must be numerically lower in your platform **Restore** CRs, for example RHACM and LVM Storage artifacts, than that of the application. This way, the platform artifacts are restored before your applications.

If your application includes cluster-scoped resources, you must create separate **Backup** and **Restore** CRs to scope the backup to the specific cluster-scoped resources created by the application. The **Restore** CR for the cluster-scoped resources must be restored before the remaining application **Restore** CR(s).

15.1.2.4.2. **Ica.openshift.io/apply-label** guidelines

You can back up specific resources exclusively with the **Ica.openshift.io/apply-label** annotation. Based on which resources you define in the annotation, the Lifecycle Agent applies the **Ica.openshift.io/backup: <backup_name>** label and adds the **labelSelector.matchLabels.Ica.openshift.io/backup: <backup_name>** label selector to the specified resources when creating the **Backup** CRs.

To use the **Ica.openshift.io/apply-label** annotation for backing up specific resources, the resources listed in the annotation must also be included in the **spec** section. If the **Ica.openshift.io/apply-label** annotation is used in the **Backup** CR, only the resources listed in the annotation are backed up, even if

other resource types are specified in the **spec** section or not.

Example CR

```
apiVersion: velero.io/v1
kind: Backup
metadata:
  name: acm-klusterlet
  namespace: openshift-adp
  annotations:
    lca.openshift.io/apply-label:
    rbac.authorization.k8s.io/v1/clusterroles/klusterlet,apps/v1/deployments/open-cluster-management-agent/klusterlet ①
  labels:
    velero.io/storage-location: default
spec:
  includedNamespaces:
    - open-cluster-management-agent
  includedClusterScopedResources:
    - clusterroles
  includedNamespaceScopedResources:
    - deployments
```

- ① The value must be a list of comma-separated objects in **group/version/resource/name** format for cluster-scoped resources or **group/version/resource/namespace/name** format for namespace-scoped resources, and it must be attached to the related **Backup** CR.

15.1.2.5. Extra manifest guidelines

The Lifecycle Agent uses extra manifests to restore your target clusters after rebooting with the new stateroot deployment and before restoring application artifacts.

Different deployment methods require a different way to apply the extra manifests:

GitOps ZTP

You use the **lca.openshift.io/target-ocp-version: <target_ocp_version>** label to mark the extra manifests that the Lifecycle Agent must extract and apply after the pivot. You can specify the number of manifests labeled with **lca.openshift.io/target-ocp-version** by using the **lca.openshift.io/target-ocp-version-manifest-count** annotation in the **ImageBasedUpgrade** CR. If specified, the Lifecycle Agent verifies that the number of manifests extracted from policies matches the number provided in the annotation during the prep and upgrade stages.

Example for the **lca.openshift.io/target-ocp-version-manifest-count** annotation

```
apiVersion: lca.openshift.io/v1
kind: ImageBasedUpgrade
metadata:
  annotations:
    lca.openshift.io/target-ocp-version-manifest-count: "5"
  name: upgrade
```

Non-Gitops

You mark your extra manifests with the `lca.openshift.io/apply-wave` annotation to determine the apply order. The labeled extra manifests are wrapped in `ConfigMap` objects and referenced in the `ImageBasedUpgrade` CR that the Lifecycle Agent uses after the pivot.

If the target cluster uses custom catalog sources, you must include them as extra manifests that point to the correct release version.



IMPORTANT

You cannot apply the following items as extra manifests:

- `MachineConfig` objects
- OLM Operator subscriptions

Additional resources

- [Performing an image-based upgrade for single-node OpenShift clusters with Lifecycle Agent](#)
- [Preparing the hub cluster for ZTP](#)
- [Creating ConfigMap objects for the image-based upgrade with Lifecycle Agent](#)
- [Creating ConfigMap objects for the image-based upgrade with GitOps ZTP](#)
- [About installing OADP](#)

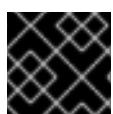
15.2. PREPARING FOR AN IMAGE-BASED UPGRADE FOR SINGLE-NODE OPENSIFT CLUSTERS

15.2.1. Configuring a shared container partition for the image-based upgrade

Your single-node OpenShift clusters need to have a shared `/var/lib/containers` partition for the image-based upgrade. You can do this at install time.

15.2.1.1. Configuring a shared container partition between ostree stateroots

Apply a `MachineConfig` to both the seed and the target clusters during installation time to create a separate partition and share the `/var/lib/containers` partition between the two `ostree` stateroots that will be used during the upgrade process.



IMPORTANT

You must complete this procedure at installation time.

Procedure

- Apply a `MachineConfig` to create a separate partition:

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: master
```

```

name: 98-var-lib-containers-partitioned
spec:
  config:
    ignition:
      version: 3.2.0
  storage:
    disks:
      - device: /dev/disk/by-path/pci-<root_disk> ①
        partitions:
          - label: var-lib-containers
            startMiB: <start_of_partition> ②
            sizeMiB: <partition_size> ③
    fileystems:
      - device: /dev/disk/by-partlabel/var-lib-containers
        format: xfs
        mountOptions:
          - defaults
          - prjquota
        path: /var/lib/containers
        wipeFilesystem: true
  systemd:
    units:
      - contents: |-
          # Generated by Butane
          [Unit]
          Before=local-fs.target
          Requires=systemd-fsck@dev-disk-by\x2dpartlabel-var\x2dlib\x2dcontainers.service
          After=systemd-fsck@dev-disk-by\x2dpartlabel-var\x2dlib\x2dcontainers.service

          [Mount]
          Where=/var/lib/containers
          What=/dev/disk/by-partlabel/var-lib-containers
          Type=xfs
          Options=defaults,prjquota

          [Install]
          RequiredBy=local-fs.target
          enabled: true
          name: var-lib-containers.mount

```

- ① Specify the root disk.
- ② Specify the start of the partition in MiB. If the value is too small, the installation will fail.
- ③ Specify a minimum size for the partition of 500 GB to ensure adequate disk space for precached images. If the value is too small, the deployments after installation will fail.

15.2.1.2. Configuring a shared container directory between ostree stateroots when using GitOps ZTP

When you are using the GitOps Zero Touch Provisioning (ZTP) workflow, you do the following procedure to create a separate disk partition on both the seed and target cluster and to share the **/var/lib/containers** partition.



IMPORTANT

You must complete this procedure at installation time.

Prerequisites

- You have installed Butane. For more information, see "Installing Butane".

Procedure

- 1 Create the **storage.bu** file:

```
variant: fcos
version: 1.3.0
storage:
disks:
- device: /dev/disk/by-path/pci-<root_disk> ①
  wipe_table: false
partitions:
- label: var-lib-containers
  start_mib: <start_of_partition> ②
  size_mib: <partition_size> ③
filesystems:
- path: /var/lib/containers
  device: /dev/disk/by-partlabel/var-lib-containers
  format: xfs
  wipe_filesystem: true
  with_mount_unit: true
  mount_options:
    - defaults
    - prjquota
```

- ① Specify the root disk.
- ② Specify the start of the partition in MiB. If the value is too small, the installation will fail.
- ③ Specify a minimum size for the partition of 500 GB to ensure adequate disk space for precached images. If the value is too small, the deployments after installation will fail.

- 2 Convert the **storage.bu** to an Ignition file by running the following command:

```
$ butane storage.bu
```

Example output

```
{"ignition":{"version":"3.2.0"},"storage":{"disks":[{"device":"/dev/disk/by-path/pci-0000:00:17.0-ata-1.0","partitions":[{"label":"var-lib-containers","sizeMiB":0,"startMiB":2500000,"wipeTable":false}],"filesystems":[{"device":"/dev/disk/by-partlabel/var-lib-containers","format":"xfs","mountOptions":["defaults","prjquota"],"path":"/var/lib/containers","wipeFilesystem":true}]}],"systemd":{"units":[{"contents": "# Generated by Butane\n[Unit]\nRequires=systemd-fsck@dev-disk-by\\x2dpartlabel-var\\x2dlib\\x2dcontainers.service\nAfter=systemd-fsck@dev-disk-by\\x2dpartlabel-\nvar\\x2dlib\\x2dcontainers.service\n[Mount]\nWhere=/var/lib/containers\nWhat=/dev/disk/by-"}]}
```

```
partlabel/var-lib-
containers\nType=xfs\nOptions=defaults,prjquota\n\n[Install]\nRequiredBy=local-
fs.target","enabled":true,"name":"var-lib-containers.mount"}]}
```

- Copy the output into the `.spec.clusters.nodes.ignitionConfigOverride` field in the `SiteConfig` CR:

```
[...]
spec:
clusters:
- nodes:
  - hostName: <name>
    ignitionConfigOverride: '{"ignition":{"version":"3.2.0"},"storage":{"disks":
[{"device":"/dev/disk/by-path/pci-0000:00:17.0-ata-1.0","partitions":[{"label":"var-lib-
containers","sizeMiB":0,"startMiB":2500000}],"wipeTable":false}],"filesystems":
[{"device":"/dev/disk/by-partlabel/var-lib-containers","format":"xfs","mountOptions":
["defaults","prjquota"],"path":"/var/lib/containers","wipeFilesystem":true}}],"systemd":{"units":
[{"contents": "# Generated by Butane\n[Unit]\nRequires=systemd-fsck@dev-disk-
by\\x2dpartlabel-var\\x2dlib\\x2dcontainers.service\nAfter=systemd-fsck@dev-disk-
by\\x2dpartlabel-
var\\x2dlib\\x2dcontainers.service\n\n[Mount]\nWhere=/var/lib/containers\nWhat=/dev/disk/by-
partlabel/var-lib-
containers\nType=xfs\nOptions=defaults,prjquota\n\n[Install]\nRequiredBy=local-
fs.target","enabled":true,"name":"var-lib-containers.mount"}]}}
[...]
```

Verification

- During or after installation, verify on the hub cluster that the `BareMetalHost` object shows the annotation by running the following command:

```
$ oc get bmh -n my-sno-ns my-sno -ojson | jq '.metadata.annotations["bmac.agent-
install.openshift.io/ignition-config-overrides"]'
```

Example output

```
{"ignition":{"version":"3.2.0"},"storage":{"disks":[{"device":"/dev/disk/by-path/pci-
0000:00:17.0-ata-1.0","partitions":[{"label":"var-lib-
containers","sizeMiB":0,"startMiB":2500000}],"wipeTable":false}],"filesystems":
[{"device":"/dev/disk/by-partlabel/var-lib-containers","format":"xfs","mountOptions":
["defaults","prjquota"],"path":"/var/lib/containers","wipeFilesystem":true}}],"systemd":
{"units": [{"contents": "# Generated by Butane\\n[Unit]\\nRequires=systemd-fsck@dev-disk-
by\\\\x2dpartlabel-var\\\\x2dlib\\\\x2dcontainers.service\\nAfter=systemd-fsck@dev-disk-
by\\\\x2dpartlabel-
var\\\\x2dlib\\\\x2dcontainers.service\\n\\n[Mount]\\nWhere=/var/lib/containers\\nWhat=/dev/disk/
by-partlabel/var-lib-
containers\\nType=xfs\\nOptions=defaults,prjquota\\n\\n[Install]\\nRequiredBy=local-
fs.target","enabled":true,"name":"var-lib-containers.mount"}]}}
```

- After installation, check the single-node OpenShift disk status by running the following commands:

```
# lsblk
```

Example output

```

NAME  MAJ:MIN RM  SIZE RO TYPE MOUNTPOINTS
sda   8:0    0 446.6G 0 disk
└─sda1 8:1    0   1M 0 part
└─sda2 8:2    0 127M 0 part
└─sda3 8:3    0 384M 0 part /boot
└─sda4 8:4    0 243.6G 0 part /var
      /sysroot/ostree/deploy/rhcos/var
      /usr
      /etc
      /
      /sysroot
└─sda5 8:5    0 202.5G 0 part /var/lib/containers

```

```
# df -h
```

Example output

Filesystem	Size	Used	Avail	Use%	Mounted on
devtmpfs	4.0M	0	4.0M	0%	/dev
tmpfs	126G	84K	126G	1%	/dev/shm
tmpfs	51G	93M	51G	1%	/run
/dev/sda4	244G	5.2G	239G	3%	/sysroot
tmpfs	126G	4.0K	126G	1%	/tmp
/dev/sda5	203G	119G	85G	59%	/var/lib/containers
/dev/sda3	350M	110M	218M	34%	/boot
tmpfs	26G	0	26G	0%	/run/user/1000

Additional resources

- [Installing Butane](#)

15.2.2. Installing Operators for the image-based upgrade

Prepare your clusters for the upgrade by installing the Lifecycle Agent and the OADP Operator.

To install the OADP Operator with the non-GitOps method, see "Installing the OADP Operator".

Additional resources

- [Installing the OADP Operator](#)
- [About backup and snapshot locations and their secrets](#)
- [Creating a Backup CR](#)
- [Creating a Restore CR](#)

15.2.2.1. Installing the Lifecycle Agent by using the CLI

You can use the OpenShift CLI (**oc**) to install the Lifecycle Agent.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in as a user with **cluster-admin** privileges.

Procedure

1. Create a **Namespace** object YAML file for the Lifecycle Agent:

```
apiVersion: v1
kind: Namespace
metadata:
  name: openshift-lifecycle-agent
  annotations:
    workload.openshift.io/allowed: management
```

- a. Create the **Namespace** CR by running the following command:

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

2. Create an **OperatorGroup** object YAML file for the Lifecycle Agent:

```
apiVersion: operators.coreos.com/v1
kind: OperatorGroup
metadata:
  name: openshift-lifecycle-agent
  namespace: openshift-lifecycle-agent
spec:
  targetNamespaces:
    - openshift-lifecycle-agent
```

- a. Create the **OperatorGroup** CR by running the following command:

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

3. Create a **Subscription** CR for the Lifecycle Agent:

```
apiVersion: operators.coreos.com/v1alpha1
kind: Subscription
metadata:
  name: openshift-lifecycle-agent-subscription
  namespace: openshift-lifecycle-agent
spec:
  channel: "stable"
  name: lifecycle-agent
  source: redhat-operators
  sourceNamespace: openshift-marketplace
```

- a. Create the **Subscription** CR by running the following command:

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

Verification

- To verify that the installation succeeded, inspect the CSV resource by running the following command:

```
$ oc get csv -n openshift-lifecycle-agent
```

Example output

NAME	DISPLAY	VERSION	REPLACES
PHASE			
lifecycle-agent.v4.18.0	Openshift Lifecycle Agent	4.18.0	Succeeded

- Verify that the Lifecycle Agent is up and running by running the following command:

```
$ oc get deploy -n openshift-lifecycle-agent
```

Example output

NAME	READY	UP-TO-DATE	AVAILABLE	AGE
lifecycle-agent-controller-manager	1/1	1	1	14s

15.2.2.2. Installing the Lifecycle Agent by using the web console

You can use the OpenShift Container Platform web console to install the Lifecycle Agent.

Prerequisites

- You have logged in as a user with **cluster-admin** privileges.

Procedure

- In the OpenShift Container Platform web console, navigate to **Operators** → **OperatorHub**.
- Search for the **Lifecycle Agent** from the list of available Operators, and then click **Install**.
- On the **Install Operator** page, under **A specific namespace on the cluster** select **openshift-lifecycle-agent**.
- Click **Install**.

Verification

- To confirm that the installation is successful:
 - Click **Operators** → **Installed Operators**.
 - Ensure that the Lifecycle Agent is listed in the **openshift-lifecycle-agent** project with a **Status** of **InstallSucceeded**.



NOTE

During installation an Operator might display a **Failed** status. If the installation later succeeds with an **InstallSucceeded** message, you can ignore the **Failed** message.

If the Operator is not installed successfully:

1. Click **Operators → Installed Operators**, and inspect the **Operator Subscriptions** and **Install Plans** tabs for any failure or errors under **Status**.
2. Click **Workloads → Pods**, and check the logs for pods in the `openshift-lifecycle-agent` project.

15.2.2.3. Installing the Lifecycle Agent with GitOps ZTP

Install the Lifecycle Agent with GitOps Zero Touch Provisioning (ZTP) to do an image-based upgrade.

Procedure

1. Extract the following CRs from the **ztp-site-generate** container image and push them to the **source-cr** directory:

Example LcaSubscriptionNS.yaml file

```
apiVersion: v1
kind: Namespace
metadata:
  name: openshift-lifecycle-agent
  annotations:
    workload.openshift.io/allowed: management
    ran.openshift.io/ztp-deploy-wave: "2"
  labels:
    kubernetes.io/metadata.name: openshift-lifecycle-agent
```

Example LcaSubscriptionOperGroup.yaml file

```
apiVersion: operators.coreos.com/v1
kind: OperatorGroup
metadata:
  name: lifecycle-agent-operatorgroup
  namespace: openshift-lifecycle-agent
  annotations:
    ran.openshift.io/ztp-deploy-wave: "2"
spec:
  targetNamespaces:
    - openshift-lifecycle-agent
```

Example LcaSubscription.yaml file

```
apiVersion: operators.coreos.com/v1alpha1
kind: Subscription
metadata:
  name: lifecycle-agent
  namespace: openshift-lifecycle-agent
  annotations:
    ran.openshift.io/ztp-deploy-wave: "2"
spec:
  channel: "stable"
  name: lifecycle-agent
  source: redhat-operators
```

```

sourceNamespace: openshift-marketplace
installPlanApproval: Manual
status:
  state: AtLatestKnown

```

Example directory structure

```

├── kustomization.yaml
└── sno
    ├── example-cnf.yaml
    ├── common-ranGen.yaml
    ├── group-du-sno-ranGen.yaml
    ├── group-du-sno-validator-ranGen.yaml
    └── ns.yaml
└── source-crs
    ├── LcaSubscriptionNS.yaml
    ├── LcaSubscriptionOperGroup.yaml
    └── LcaSubscription.yaml

```

2. Add the CRs to your common **PolicyGenTemplate**:

```

apiVersion: ran.openshift.io/v1
kind: PolicyGenTemplate
metadata:
  name: "example-common-latest"
  namespace: "ztp-common"
spec:
  bindingRules:
    common: "true"
    du-profile: "latest"
  sourceFiles:
    - fileName: LcaSubscriptionNS.yaml
      policyName: "subscriptions-policy"
    - fileName: LcaSubscriptionOperGroup.yaml
      policyName: "subscriptions-policy"
    - fileName: LcaSubscription.yaml
      policyName: "subscriptions-policy"
  [...]

```

15.2.2.4. Installing and configuring the OADP Operator with GitOps ZTP

Install and configure the OADP Operator with GitOps ZTP before starting the upgrade.

Procedure

1. Extract the following CRs from the **ztp-site-generate** container image and push them to the **source-cr** directory:

Example OadpSubscriptionNS.yaml file

```

apiVersion: v1
kind: Namespace
metadata:
  name: openshift-adp

```

```
annotations:  
  ran.openshift.io/ztp-deploy-wave: "2"  
labels:  
  kubernetes.io/metadata.name: openshift-adp
```

Example OadpSubscriptionOperGroup.yaml file

```
apiVersion: operators.coreos.com/v1  
kind: OperatorGroup  
metadata:  
  name: redhat-oadp-operator  
  namespace: openshift-adp  
  annotations:  
    ran.openshift.io/ztp-deploy-wave: "2"  
spec:  
  targetNamespaces:  
    - openshift-adp
```

Example OadpSubscription.yaml file

```
apiVersion: operators.coreos.com/v1alpha1  
kind: Subscription  
metadata:  
  name: redhat-oadp-operator  
  namespace: openshift-adp  
  annotations:  
    ran.openshift.io/ztp-deploy-wave: "2"  
spec:  
  channel: stable-1.4  
  name: redhat-oadp-operator  
  source: redhat-operators  
  sourceNamespace: openshift-marketplace  
  installPlanApproval: Manual  
status:  
  state: AtLatestKnown
```

Example OadpOperatorStatus.yaml file

```
apiVersion: operators.coreos.com/v1  
kind: Operator  
metadata:  
  name: redhat-oadp-operator.openshift-adp  
  annotations:  
    ran.openshift.io/ztp-deploy-wave: "2"  
status:  
  components:  
    refs:  
      - kind: Subscription  
        namespace: openshift-adp  
        conditions:  
          - type: CatalogSourcesUnhealthy  
            status: "False"  
          - kind: InstallPlan  
            namespace: openshift-adp
```

```

conditions:
- type: Installed
  status: "True"
- kind: ClusterServiceVersion
  namespace: openshift-adp
  conditions:
    - type: Succeeded
      status: "True"
  reason: InstallSucceeded

```

Example directory structure

```

kustomization.yaml
└── sno
    ├── example-cnf.yaml
    ├── common-ranGen.yaml
    ├── group-du-sno-ranGen.yaml
    ├── group-du-sno-validator-ranGen.yaml
    └── ns.yaml
└── source-crs
    ├── OadpSubscriptionNS.yaml
    ├── OadpSubscriptionOperGroup.yaml
    ├── OadpSubscription.yaml
    └── OadpOperatorStatus.yaml

```

2. Add the CRs to your common **PolicyGenTemplate**:

```

apiVersion: ran.openshift.io/v1
kind: PolicyGenTemplate
metadata:
  name: "example-common-latest"
  namespace: "ztp-common"
spec:
  bindingRules:
    common: "true"
    du-profile: "latest"
  sourceFiles:
    - fileName: OadpSubscriptionNS.yaml
      policyName: "subscriptions-policy"
    - fileName: OadpSubscriptionOperGroup.yaml
      policyName: "subscriptions-policy"
    - fileName: OadpSubscription.yaml
      policyName: "subscriptions-policy"
    - fileName: OadpOperatorStatus.yaml
      policyName: "subscriptions-policy"
  [...]

```

3. Create the **DataProtectionApplication** CR and the S3 secret only for the target cluster:

- a. Extract the following CRs from the **ztp-site-generate** container image and push them to the **source-cr** directory:

Example **OadpDataProtectionApplication.yaml** file

```

apiVersion: oadp.openshift.io/v1alpha1

```

```

kind: DataProtectionApplication
metadata:
  name: dataprotectionapplication
  namespace: openshift-adp
  annotations:
    ran.openshift.io/ztp-deploy-wave: "100"
spec:
  configuration:
    restic:
      enable: false 1
    velero:
      defaultPlugins:
        - aws
        - openshift
      resourceTimeout: 10m
  backupLocations:
    - velero:
        config:
          profile: "default"
          region: minio
          s3Url: $url
          insecureSkipTLSVerify: "true"
          s3ForcePathStyle: "true"
        provider: aws
        default: true
        credential:
          key: cloud
          name: cloud-credentials
        objectStorage:
          bucket: $bucketName 2
          prefix: $prefixName 3
  status:
    conditions:
      - reason: Complete
        status: "True"
        type: Reconciled

```

1 The **spec.configuration.restic.enable** field must be set to **false** for an image-based upgrade because persistent volume contents are retained and reused after the upgrade.

2 **3** The bucket defines the bucket name that is created in S3 backend. The prefix defines the name of the subdirectory that will be automatically created in the bucket. The combination of bucket and prefix must be unique for each target cluster to avoid interference between them. To ensure a unique storage directory for each target cluster, you can use the Red Hat Advanced Cluster Management hub template function, for example, **prefix: {{hub .ManagedClusterName hub}}**.

Example OadpSecret.yaml file

```

apiVersion: v1
kind: Secret
metadata:
  name: cloud-credentials

```

```

namespace: openshift-adp
annotations:
  ran.openshift.io/ztp-deploy-wave: "100"
type: Opaque

```

Example `OadpBackupStorageLocationStatus.yaml` file

```

apiVersion: velero.io/v1
kind: BackupStorageLocation
metadata:
  name: dataprotectionapplication-1 ①
  namespace: openshift-adp
  annotations:
    ran.openshift.io/ztp-deploy-wave: "100"
status:
  phase: Available

```

- ① The **name** value in the **BackupStorageLocation** resource must follow the **<DataProtectionApplication.metadata.name>-<index>** pattern. The **<index>** represents the position of the corresponding **backupLocations** entry in the **spec.backupLocations** field in the **DataProtectionApplication** resource. The position starts from **1**. If the **metadata.name** value of the **DataProtectionApplication** resource is changed in the **OadpDataProtectionApplication.yaml** file, update the **metadata.name** field in the **BackupStorageLocation** resource accordingly.

The **OadpBackupStorageLocationStatus.yaml** CR verifies the availability of backup storage locations created by OADP.

- Add the CRs to your site **PolicyGenTemplate** with overrides:

```

apiVersion: ran.openshift.io/v1
kind: PolicyGenTemplate
metadata:
  name: "example-cnf"
  namespace: "ztp-site"
spec:
  bindingRules:
    sites: "example-cnf"
    du-profile: "latest"
    mcp: "master"
  sourceFiles:
    ...
    - fileName: OadpSecret.yaml
      policyName: "config-policy"
      data:
        cloud: <your_credentials> ①
    - fileName: OadpDataProtectionApplication.yaml ②
      policyName: "config-policy"
      spec:
        backupLocations:
          - velero:
              config:
                region: minio
                s3Url: <your_S3_URL> ③

```

```

profile: "default"
insecureSkipTLSVerify: "true"
s3ForcePathStyle: "true"
provider: aws
default: true
credential:
  key: cloud
  name: cloud-credentials
objectStorage:
  bucket: <your_bucket_name> ④
  prefix: <cluster_name> ⑤
- fileName: OadpBackupStorageLocationStatus.yaml
  policyName: "config-policy"

```

- ① Specify your credentials for your S3 storage backend.
- ② If more than one **backupLocations** entries are defined in the **OadpDataProtectionApplication** CR, ensure that each location has a corresponding **OadpBackupStorageLocation** CR added for status tracking. Ensure that the name of each additional **OadpBackupStorageLocation** CR is overridden with the correct index as described in the example **OadpBackupStorageLocationStatus.yaml** file.
- ③ Specify the URL for your S3-compatible bucket.
- ④ ⑤ The **bucket** defines the bucket name that is created in S3 backend. The **prefix** defines the name of the subdirectory that will be automatically created in the **bucket**. The combination of **bucket** and **prefix** must be unique for each target cluster to avoid interference between them. To ensure a unique storage directory for each target cluster, you can use the Red Hat Advanced Cluster Management hub template function, for example, **prefix: {{hub .ManagedClusterName hub}}**.

15.2.3. Generating a seed image for the image-based upgrade with the Lifecycle Agent

Use the Lifecycle Agent to generate the seed image with the **SeedGenerator** custom resource (CR).

15.2.3.1. Seed image configuration

The seed image targets a set of single-node OpenShift clusters with the same hardware and similar configuration. This means that the seed image must have all of the components and configuration that the seed cluster shares with the target clusters. Therefore, the seed image generated from the seed cluster cannot contain any cluster-specific configuration.

The following table lists the components, resources, and configurations that you must and must not include in your seed image:

Table 15.2. Seed image configuration

Cluster configuration	Include in seed image
Performance profile	Yes
MachineConfig resources for the target cluster	Yes

Cluster configuration	Include in seed image
IP version [1]	Yes
Set of Day 2 Operators, including the Lifecycle Agent and the OADP Operator	Yes
Disconnected registry configuration [2]	Yes
Valid proxy configuration [3]	Yes
FIPS configuration	Yes
Dedicated partition on the primary disk for container storage that matches the size of the target clusters	Yes
Local volumes <ul style="list-style-type: none"> ● StorageClass used in LocalVolume for LSO ● LocalVolume for LSO ● LVMCluster CR for LVMS 	No
OADP DataProtectionApplication CR	No

1. Dual-stack networking is not supported in this release.
2. If the seed cluster is installed in a disconnected environment, the target clusters must also be installed in a disconnected environment.
3. The proxy configuration must be either enabled or disabled in both the seed and target clusters. However, the proxy servers configured on the clusters does not have to match.

15.2.3.1.1. Seed image configuration using the RAN DU profile

The following table lists the components, resources, and configurations that you must and must not include in the seed image when using the RAN DU profile:

Table 15.3. Seed image configuration with RAN DU profile

Resource	Include in seed image
All extra manifests that are applied as part of Day 0 installation	Yes
All Day 2 Operator subscriptions	Yes

Resource	Include in seed image
DisableOLMPprof.yaml	Yes
TunedPerformancePatch.yaml	Yes
PerformanceProfile.yaml	Yes
SriovOperatorConfig.yaml	Yes
DisableSnoNetworkDiag.yaml	Yes
StorageClass.yaml	No, if it is used in StorageLV.yaml
StorageLV.yaml	No
StorageLVMCluster.yaml	No

Table 15.4. Seed image configuration with RAN DU profile for extra manifests

Resource	Apply as extra manifest
ClusterLogForwarder.yaml	<p>Yes</p>  <p>NOTE</p> <p>The DU profile includes the Cluster Logging Operator, but the profile does not configure or apply any Cluster Logging Operator CRs. To enable log forwarding, include the ClusterLogForwarder.yaml CR as an extra manifest. The extra manifest is applied to the target single-node OpenShift cluster during the image-based upgrade process.</p>
ReduceMonitoringFootprint.yaml	Yes
SriovFecClusterConfig.yaml	Yes
PtpOperatorConfigForEvent.yaml	Yes
DefaultCatsrc.yaml	Yes
PtpConfig.yaml	If the interfaces of the target cluster are common with the seed cluster, you can include them in the seed image. Otherwise, apply it as extra manifests.

Resource	Apply as extra manifest
SriovNetwork.yaml SriovNetworkNodePolicy.yaml	If the configuration, including namespaces, is exactly the same on both the seed and target cluster, you can include them in the seed image. Otherwise, apply them as extra manifests.

15.2.3.2. Generating a seed image with the Lifecycle Agent

Use the Lifecycle Agent to generate a seed image from a managed cluster. The Operator checks for required system configurations, performs any necessary system cleanup before generating the seed image, and launches the image generation. The seed image generation includes the following tasks:

- Stopping cluster Operators
- Preparing the seed image configuration
- Generating and pushing the seed image to the image repository specified in the **SeedGenerator** CR
- Restoring cluster Operators
- Expiring seed cluster certificates
- Generating new certificates for the seed cluster
- Restoring and updating the **SeedGenerator** CR on the seed cluster

Prerequisites

- RHACM and multicluster engine for Kubernetes Operator are not installed on the seed cluster.
- You have configured a shared container directory on the seed cluster.
- You have installed the minimum version of the OADP Operator and the Lifecycle Agent on the seed cluster.
- Ensure that persistent volumes are not configured on the seed cluster.
- Ensure that the **LocalVolume** CR does not exist on the seed cluster if the Local Storage Operator is used.
- Ensure that the **LVMCluster** CR does not exist on the seed cluster if LVM Storage is used.
- Ensure that the **DataProtectionApplication** CR does not exist on the seed cluster if OADP is used.

Procedure

1. Detach the managed cluster from the hub to delete any RHACM-specific resources from the seed cluster that must not be in the seed image:
 - a. Manually detach the seed cluster by running the following command:

```
$ oc delete managedcluster sno-worker-example
```

- i. Wait until the managed cluster is removed. After the cluster is removed, create the proper **SeedGenerator** CR. The Lifecycle Agent cleans up the RHACM artifacts.
- b. If you are using GitOps ZTP, detach your cluster by removing the seed cluster's **SiteConfig** CR from the **kustomization.yaml**.
 - i. If you have a **kustomization.yaml** file that references multiple **SiteConfig** CRs, remove your seed cluster's **SiteConfig** CR from the **kustomization.yaml**:

```
apiVersion: kustomize.config.k8s.io/v1beta1
kind: Kustomization

generators:
#- example-seed-sno1.yaml
- example-target-sno2.yaml
- example-target-sno3.yaml
```

- ii. If you have a **kustomization.yaml** that references one **SiteConfig** CR, remove your seed cluster's **SiteConfig** CR from the **kustomization.yaml** and add the **generators: {}** line:

```
apiVersion: kustomize.config.k8s.io/v1beta1
kind: Kustomization

generators: {}
```

- iii. Commit the **kustomization.yaml** changes in your Git repository and push the changes to your repository.

The ArgoCD pipeline detects the changes and removes the managed cluster.

2. Create the **Secret** object so that you can push the seed image to your registry.

- a. Create the authentication file by running the following commands:

```
$ MY_USER=myuserid
$ AUTHFILE=/tmp/my-auth.json
$ podman login --authfile ${AUTHFILE} -u ${MY_USER} quay.io/${MY_USER}

$ base64 -w 0 ${AUTHFILE} ; echo
```

- b. Copy the output into the **seedAuth** field in the **Secret** YAML file named **seedgen** in the **openshift-lifecycle-agent** namespace:

```
apiVersion: v1
kind: Secret
metadata:
  name: seedgen 1
  namespace: openshift-lifecycle-agent
  type: Opaque
data:
  seedAuth: <encoded_AUTHFILE> 2
```

- 1 The **Secret** resource must have the **name: seedgen** and **namespace: openshift-lifecycle-agent** fields.
- 2 Specifies a base64-encoded authfile for write-access to the registry for pushing the generated seed images.

c. Apply the **Secret** by running the following command:

```
$ oc apply -f secretseedgenerator.yaml
```

3. Create the **SeedGenerator** CR:

```
apiVersion: lca.openshift.io/v1
kind: SeedGenerator
metadata:
  name: seedimage ①
spec:
  seedImage: <seed_container_image> ②
```

- 1 The **SeedGenerator** CR must be named **seedimage**.
- 2 Specify the container image URL, for example, **quay.io/example/seed-container-image:<tag>**. It is recommended to use the **<seed_cluster_name>:<ocp_version>** format.

4. Generate the seed image by running the following command:

```
$ oc apply -f seedgenerator.yaml
```



IMPORTANT

The cluster reboots and loses API capabilities while the Lifecycle Agent generates the seed image. Applying the **SeedGenerator** CR stops the **kubelet** and the CRI-O operations, then it starts the image generation.

If you want to generate more seed images, you must provision a new seed cluster with the version that you want to generate a seed image from.

Verification

- After the cluster recovers and it is available, you can check the status of the **SeedGenerator** CR by running the following command:

```
$ oc get seedgenerator -o yaml
```

Example output

```
status:
conditions:
- lastTransitionTime: "2024-02-13T21:24:26Z"
  message: Seed Generation completed
  observedGeneration: 1
```

```

reason: Completed
status: "False"
type: SeedGenInProgress
- lastTransitionTime: "2024-02-13T21:24:26Z"
  message: Seed Generation completed
  observedGeneration: 1
  reason: Completed
  status: "True"
  type: SeedGenCompleted ①
observedGeneration: 1

```

- ① The seed image generation is complete.

Additional resources

- [Configuring a shared container partition between ostree stateroots](#)
- [Configuring a shared container partition between ostree stateroots when using GitOps ZTP](#)

15.2.4. Creating ConfigMap objects for the image-based upgrade with the Lifecycle Agent

The Lifecycle Agent needs all your OADP resources, extra manifests, and custom catalog sources wrapped in a **ConfigMap** object to process them for the image-based upgrade.

15.2.4.1. Creating OADP ConfigMap objects for the image-based upgrade with Lifecycle Agent

Create your OADP resources that are used to back up and restore your resources during the upgrade.

Prerequisites

- You have generated a seed image from a compatible seed cluster.
- You have created OADP backup and restore resources.
- You have created a separate partition on the target cluster for the container images that is shared between stateroots. For more information, see "Configuring a shared container partition for the image-based upgrade".
- You have deployed a version of Lifecycle Agent that is compatible with the version used with the seed image.
- You have installed the OADP Operator, the **DataProtectionApplication** CR, and its secret on the target cluster.
- You have created an S3-compatible storage solution and a ready-to-use bucket with proper credentials configured. For more information, see "About installing OADP".

Procedure

1. Create the OADP **Backup** and **Restore** CRs for platform artifacts in the same namespace where the OADP Operator is installed, which is **openshift-adp**.

~ If the target cluster is managed by DHACM, add the following YAML file for backing up and

- d. If the target cluster is managed by RHACM, add the following YAML file for backing up and restoring RHACM artifacts:

PlatformBackupRestore.yaml for RHACM

```

apiVersion: velero.io/v1
kind: Backup
metadata:
  name: acm-klusterlet
  annotations:
    lca.openshift.io/apply-label: "apps/v1/deployments/open-cluster-management-
      agent/klusterlet,v1/secrets/open-cluster-management-agent/bootstrap-hub-
      kubeconfig,rbac.authorization.k8s.io/v1/clusterroles/klusterlet,v1/serviceaccounts/open-
      cluster-management-agent/klusterlet,scheduling.k8s.io/v1/priorityclasses/klusterlet-
      critical,rbac.authorization.k8s.io/v1/clusterroles/open-cluster-management:klusterlet-
      admin-aggregate-
      clusterrole,rbac.authorization.k8s.io/v1/clusterrolebindings/klusterlet,operator.open-
      cluster-
      management.io/v1/klusterlets/klusterlet,apiextensions.k8s.io/v1/customresourcedefinitions/k
      usterlets.operator.open-cluster-management.io,v1/secrets/open-cluster-management-
      agent/open-cluster-management-image-pull-credentials" ①
  labels:
    velero.io/storage-location: default
  namespace: openshift-adp
spec:
  includedNamespaces:
  - open-cluster-management-agent
  includedClusterScopedResources:
  - klusterlets.operator.open-cluster-management.io
  - clusterroles.rbac.authorization.k8s.io
  - clusterrolebindings.rbac.authorization.k8s.io
  - priorityclasses.scheduling.k8s.io
  includedNamespaceScopedResources:
  - deployments
  - serviceaccounts
  - secrets
  excludedNamespaceScopedResources: []
---
apiVersion: velero.io/v1
kind: Restore
metadata:
  name: acm-klusterlet
  namespace: openshift-adp
  labels:
    velero.io/storage-location: default
  annotations:
    lca.openshift.io/apply-wave: "1"
spec:
  backupName:
    acm-klusterlet

```

- ① If your **multiclusterHub** CR does not have **.spec.imagePullSecret** defined and the secret does not exist on the **open-cluster-management-agent** namespace in your hub cluster, remove **v1/secrets/open-cluster-management-agent/open-cluster-
management-image-pull-credentials**.

- b. If you created persistent volumes on your cluster through LVM Storage, add the following YAML file for LVM Storage artifacts:

PlatformBackupRestoreLvms.yaml for LVM Storage

```
apiVersion: velero.io/v1
kind: Backup
metadata:
  labels:
    velero.io/storage-location: default
  name: lvmcluster
  namespace: openshift-adp
spec:
  includedNamespaces:
    - openshift-storage
  includedNamespaceScopedResources:
    - lvmclusters
    - lvmvolumegroups
    - lvmvolumegroupnodestatuses
---
apiVersion: velero.io/v1
kind: Restore
metadata:
  name: lvmcluster
  namespace: openshift-adp
  labels:
    velero.io/storage-location: default
  annotations:
    lca.openshift.io/apply-wave: "2" 1
spec:
  backupName:
    lvmcluster
```

1 The **lca.openshift.io/apply-wave** value must be lower than the values specified in the application **Restore** CRs.

2. If you need to restore applications after the upgrade, create the OADP **Backup** and **Restore** CRs for your application in the **openshift-adp** namespace.

- a. Create the OADP CRs for cluster-scoped application artifacts in the **openshift-adp** namespace.

Example OADP CRs for cluster-scoped application artifacts for LSO and LVM Storage

```
apiVersion: velero.io/v1
kind: Backup
metadata:
  annotations:
    lca.openshift.io/apply-label:
      "apiextensions.k8s.io/v1/customresourcedefinitions/test.example.com,security.openshift.io/v1/securitycontextconstraints/test,rbac.authorization.k8s.io/v1/clusterroles/test-role,rbac.authorization.k8s.io/v1/clusterrolebindings/system:openshift:scc:test" 1
  name: backup-app-cluster-resources
```

```

labels:
  velero.io/storage-location: default
namespace: openshift-adp
spec:
  includedClusterScopedResources:
    - customresourcedefinitions
    - securitycontextconstraints
    - clusterrolebindings
    - clusterroles
  excludedClusterScopedResources:
    - Namespace
---
apiVersion: velero.io/v1
kind: Restore
metadata:
  name: test-app-cluster-resources
  namespace: openshift-adp
  labels:
    velero.io/storage-location: default
  annotations:
    lca.openshift.io/apply-wave: "3" 2
spec:
  backupName:
    backup-app-cluster-resources

```

- 1 Replace the example resource name with your actual resources.
- 2 The **lca.openshift.io/apply-wave** value must be higher than the value in the platform **Restore** CRs and lower than the value in the application namespace-scoped **Restore** CR.

b. Create the OADP CRs for your namespace-scoped application artifacts.

Example OADP CRs namespace-scoped application artifacts when LSO is used

```

apiVersion: velero.io/v1
kind: Backup
metadata:
  labels:
    velero.io/storage-location: default
  name: backup-app
  namespace: openshift-adp
spec:
  includedNamespaces:
    - test
  includedNamespaceScopedResources:
    - secrets
    - persistentvolumeclaims
    - deployments
    - statefulsets
    - configmaps
    - cronjobs
    - services
    - job
    - poddisruptionbudgets

```

```

- <application_custom_resources> 1
excludedClusterScopedResources:
- persistentVolumes
---
apiVersion: velero.io/v1
kind: Restore
metadata:
  name: test-app
  namespace: openshift-adp
  labels:
    velero.io/storage-location: default
  annotations:
    lca.openshift.io/apply-wave: "4"
spec:
  backupName:
    backup-app

```

- 1 Define custom resources for your application.

Example OADP CRs namespace-scoped application artifacts when LVM Storage is used

```

apiVersion: velero.io/v1
kind: Backup
metadata:
  labels:
    velero.io/storage-location: default
  name: backup-app
  namespace: openshift-adp
spec:
  includedNamespaces:
  - test
  includedNamespaceScopedResources:
  - secrets
  - persistentvolumeclaims
  - deployments
  - statefulsets
  - configmaps
  - cronjobs
  - services
  - job
  - poddisruptionbudgets
  - <application_custom_resources> 1
  includedClusterScopedResources:
  - persistentVolumes 2
  - logicalvolumes.topolvm.io 3
  - volumesnapshotcontents 4
---
apiVersion: velero.io/v1
kind: Restore
metadata:
  name: test-app
  namespace: openshift-adp
  labels:

```

```

velero.io/storage-location: default
annotations:
  lca.openshift.io/apply-wave: "4"
spec:
  backupName:
    backup-app
  restorePVs: true
  restoreStatus:
    includedResources:
      - logicalvolumes 5

```

- 1 Define custom resources for your application.
- 2 Required field.
- 3 Required field
- 4 Optional if you use LVM Storage volume snapshots.
- 5 Required field.



IMPORTANT

The same version of the applications must function on both the current and the target release of OpenShift Container Platform.

3. Create the **ConfigMap** object for your OADP CRs by running the following command:

```
$ oc create configmap oadp-cm-example --from-file=example-oadp-resources.yaml=
<path_to_oadp_crs> -n openshift-adp
```

4. Patch the **ImageBasedUpgrade** CR by running the following command:

```
$ oc patch imagebasedupgrades.lca.openshift.io upgrade \
-p='{"spec": {"oadpContent": [{"name": "oadp-cm-example", "namespace": "openshift-
adp"}]}'}' \
--type=merge -n openshift-lifecycle-agent
```

Additional resources

- [Configuring a shared container partition between ostree stateroots](#)
- [About installing OADP](#)

15.2.4.2. Creating ConfigMap objects of extra manifests for the image-based upgrade with Lifecycle Agent

Create additional manifests that you want to apply to the target cluster.



NOTE

If you add more than one extra manifest, and the manifests must be applied in a specific order, you must prefix the filenames of the manifests with numbers that represent the required order. For example, **00-namespace.yaml**, **01-sriov-extra-manifest.yaml**, and so on.

Procedure

1. Create a YAML file that contains your extra manifests, such as SR-IOV.

Example SR-IOV resources

```
apiVersion: sriovnetwork.openshift.io/v1
kind: SriovNetworkNodePolicy
metadata:
  name: "example-sriov-node-policy"
  namespace: openshift-sriov-network-operator
spec:
  deviceType: vfio-pci
  isRdma: false
  nicSelector:
    pfNames: [ens1f0]
  nodeSelector:
    node-role.kubernetes.io/master: ""
  mtu: 1500
  numVfs: 8
  priority: 99
  resourceName: example-sriov-node-policy
---
apiVersion: sriovnetwork.openshift.io/v1
kind: SriovNetwork
metadata:
  name: "example-sriov-network"
  namespace: openshift-sriov-network-operator
spec:
  ipam: |- 
    {
    }
  linkState: auto
  networkNamespace: sriov-namespace
  resourceName: example-sriov-node-policy
  spoofChk: "on"
  trust: "off"
```

2. Create the **ConfigMap** object by running the following command:

```
$ oc create configmap example-extra-manifests-cm --from-file=example-extra-manifests.yaml=<path_to_extramanifest> -n openshift-lifecycle-agent
```

3. Patch the **ImageBasedUpgrade** CR by running the following command:

```
$ oc patch imagebasedupgrades.lca.openshift.io upgrade \
-p='{"spec": {"extraManifests": [{"name": "example-extra-manifests-cm", "namespace": "openshift-lifecycle-agent"}]}}' \
```

```
--type=merge -n openshift-lifecycle-agent
```

15.2.4.3. Creating ConfigMap objects of custom catalog sources for the image-based upgrade with Lifecycle Agent

You can keep your custom catalog sources after the upgrade by generating a **ConfigMap** object for your catalog sources and adding them to the **spec.extraManifest** field in the **ImageBasedUpgrade** CR. For more information about catalog sources, see "Catalog source".

Procedure

1. Create a YAML file that contains the **CatalogSource** CR:

```
apiVersion: operators.coreos.com/v1
kind: CatalogSource
metadata:
  name: example-catalogsources
  namespace: openshift-marketplace
spec:
  sourceType: grpc
  displayName: disconnected-redhat-operators
  image: quay.io/example-org/example-catalog:v1
```

2. Create the **ConfigMap** object by running the following command:

```
$ oc create configmap example-catalogsources-cm --from-file=example-catalogsources.yaml=<path_to_catalogsource_cr> -n openshift-lifecycle-agent
```

3. Patch the **ImageBasedUpgrade** CR by running the following command:

```
$ oc patch imagebasedupgrades.lca.openshift.io upgrade \
-p='{"spec": {"extraManifests": [{"name": "example-catalogsources-cm", "namespace": "openshift-lifecycle-agent"}]}' \
--type=merge -n openshift-lifecycle-agent
```

Additional resources

- [Catalog source](#)
- [Performing an image-based upgrade for single-node OpenShift with Lifecycle Agent](#)

15.2.5. Creating ConfigMap objects for the image-based upgrade with the Lifecycle Agent using GitOps ZTP

Create your OADP resources, extra manifests, and custom catalog sources wrapped in a **ConfigMap** object to prepare for the image-based upgrade.

15.2.5.1. Creating OADP resources for the image-based upgrade with GitOps ZTP

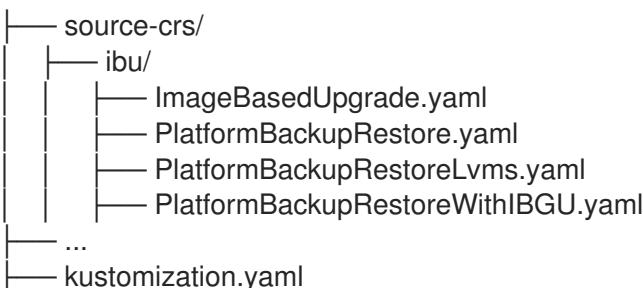
Prepare your OADP resources to restore your application after an upgrade.

Prerequisites

- You have provisioned one or more managed clusters with GitOps ZTP.
- You have logged in as a user with **cluster-admin** privileges.
- You have generated a seed image from a compatible seed cluster.
- You have created a separate partition on the target cluster for the container images that is shared between stateroots. For more information, see "Configuring a shared container partition between ostree stateroots when using GitOps ZTP".
- You have deployed a version of Lifecycle Agent that is compatible with the version used with the seed image.
- You have installed the OADP Operator, the **DataProtectionApplication** CR, and its secret on the target cluster.
- You have created an S3-compatible storage solution and a ready-to-use bucket with proper credentials configured. For more information, see "Installing and configuring the OADP Operator with GitOps ZTP".
- The **openshift-adp** namespace for the OADP **ConfigMap** object must exist on all managed clusters and the hub for the OADP **ConfigMap** to be generated and copied to the clusters.

Procedure

1. Ensure that your Git repository that you use with the ArgoCD policies application contains the following directory structure:



The **source-crs/ibu/PlatformBackupRestoreWithIBGU.yaml** file is provided in the ZTP container image.

PlatformBackupRestoreWithIBGU.yaml

```

apiVersion: velero.io/v1
kind: Backup
metadata:
  name: acm-klusterlet
  annotations:
    lca.openshift.io/apply-label: "apps/v1/deployments/open-cluster-management-agent/klusterlet,v1/secrets/open-cluster-management-agent/bootstrap-hub-kubeconfig,rbac.authorization.k8s.io/v1/clusterroles/klusterlet,v1/serviceaccounts/open-cluster-management-agent/klusterlet,scheduling.k8s.io/v1/priorityclasses/klusterlet-critical,rbac.authorization.k8s.io/v1/clusterroles/open-cluster-management:klusterlet-work:ibu-role,rbac.authorization.k8s.io/v1/clusterroles/open-cluster-management:klusterlet-admin-aggregate-clusterrole,rbac.authorization.k8s.io/v1/clusterrolebindings/klusterlet,operator.open-cluster-management.io/v1/klusterlets/klusterlet,apiextensions.k8s.io/v1/customresourcedefinitions/klusterlet"
  
```

```

rlets.operator.open-cluster-management.io,v1/secrets/open-cluster-management-
agent/open-cluster-management-image-pull-credentials" ①
  labels:
    velero.io/storage-location: default
  namespace: openshift-adp
spec:
  includedNamespaces:
    - open-cluster-management-agent
  includedClusterScopedResources:
    - klusterlets.operator.open-cluster-management.io
    - clusterroles.rbac.authorization.k8s.io
    - clusterrolebindings.rbac.authorization.k8s.io
    - priorityclasses.scheduling.k8s.io
  includedNamespaceScopedResources:
    - deployments
    - serviceaccounts
    - secrets
  excludedNamespaceScopedResources: []
---
apiVersion: velero.io/v1
kind: Restore
metadata:
  name: acm-klusterlet
  namespace: openshift-adp
  labels:
    velero.io/storage-location: default
  annotations:
    lca.openshift.io/apply-wave: "1"
spec:
  backupName:
    acm-klusterlet

```

- ①** If your **multicloudHub** CR does not have **.spec.imagePullSecret** defined and the secret does not exist on the **open-cluster-management-agent** namespace in your hub cluster, remove **v1/secrets/open-cluster-management-agent/open-cluster-management-image-pull-credentials**.



NOTE

If you perform the image-based upgrade directly on managed clusters, use the **PlatformBackupRestore.yaml** file.

If you use LVM Storage to create persistent volumes, you can use the **source-crs/ibu/PlatformBackupRestoreLvms.yaml** provided in the ZTP container image to back up your LVM Storage resources.

PlatformBackupRestoreLvms.yaml

```

apiVersion: velero.io/v1
kind: Backup
metadata:
  labels:
    velero.io/storage-location: default
  name: lvmcluster

```

```

namespace: openshift-adp
spec:
  includedNamespaces:
    - openshift-storage
  includedNamespaceScopedResources:
    - lvmclusters
    - lvmvolumegroups
    - lvmvolumegroupnodestatuses
---
apiVersion: velero.io/v1
kind: Restore
metadata:
  name: lvmcluster
  namespace: openshift-adp
  labels:
    velero.io/storage-location: default
  annotations:
    lca.openshift.io/apply-wave: "2" ①
spec:
  backupName:
    lvmcluster

```

- ① The **lca.openshift.io/apply-wave** value must be lower than the values specified in the application **Restore** CRs.

2. If you need to restore applications after the upgrade, create the OADP **Backup** and **Restore** CRs for your application in the **openshift-adp** namespace:

- a. Create the OADP CRs for cluster-scoped application artifacts in the **openshift-adp** namespace:

Example OADP CRs for cluster-scoped application artifacts for LSO and LVM Storage

```

apiVersion: velero.io/v1
kind: Backup
metadata:
  annotations:
    lca.openshift.io/apply-label:
      "apiextensions.k8s.io/v1/customresourcedefinitions/test.example.com,security.openshift.io/v1/securitycontextconstraints/test,rbac.authorization.k8s.io/v1/clusterroles/test-role,rbac.authorization.k8s.io/v1/clusterrolebindings/system:openshift:scc:test" ①
  name: backup-app-cluster-resources
  labels:
    velero.io/storage-location: default
    namespace: openshift-adp
spec:
  includedClusterScopedResources:
    - customresourcedefinitions
    - securitycontextconstraints
    - clusterrolebindings
    - clusterroles
  excludedClusterScopedResources:
    - Namespace
---

```

```

apiVersion: velero.io/v1
kind: Restore
metadata:
  name: test-app-cluster-resources
  namespace: openshift-adp
  labels:
    velero.io/storage-location: default
  annotations:
    lca.openshift.io/apply-wave: "3" 2
spec:
  backupName:
    backup-app-cluster-resources

```

- 1** Replace the example resource name with your actual resources.
- 2** The **lca.openshift.io/apply-wave** value must be higher than the value in the platform **Restore** CRs and lower than the value in the application namespace-scoped **Restore** CR.

- b. Create the OADP CRs for your namespace-scoped application artifacts in the **source-crs/custom-crs** directory:

Example OADP CRs namespace-scoped application artifacts when LSO is used

```

apiVersion: velero.io/v1
kind: Backup
metadata:
  labels:
    velero.io/storage-location: default
  name: backup-app
  namespace: openshift-adp
spec:
  includedNamespaces:
  - test
  includedNamespaceScopedResources:
  - secrets
  - persistentvolumeclaims
  - deployments
  - statefulsets
  - configmaps
  - cronjobs
  - services
  - job
  - poddisruptionbudgets
  - <application_custom_resources> 1
  excludedClusterScopedResources:
  - persistentVolumes
---
apiVersion: velero.io/v1
kind: Restore
metadata:
  name: test-app
  namespace: openshift-adp
  labels:
    velero.io/storage-location: default

```

```

annotations:
  lca.openshift.io/apply-wave: "4"
spec:
  backupName:
    backup-app

```

- 1 Define custom resources for your application.

Example OADP CRs namespace-scoped application artifacts when LVM Storage is used

```

apiVersion: velero.io/v1
kind: Backup
metadata:
  labels:
    velero.io/storage-location: default
  name: backup-app
  namespace: openshift-adp
spec:
  includedNamespaces:
    - test
  includedNamespaceScopedResources:
    - secrets
    - persistentvolumeclaims
    - deployments
    - statefulsets
    - configmaps
    - cronjobs
    - services
    - job
    - poddisruptionbudgets
    - <application_custom_resources> 1
  includedClusterScopedResources:
    - persistentVolumes 2
    - logicalvolumes.topolvm.io 3
    - volumesnapshotcontents 4
---
apiVersion: velero.io/v1
kind: Restore
metadata:
  name: test-app
  namespace: openshift-adp
  labels:
    velero.io/storage-location: default
  annotations:
    lca.openshift.io/apply-wave: "4"
spec:
  backupName:
    backup-app
  restorePVs: true
  restoreStatus:
    includedResources:
      - logicalvolumes 5

```

- ① Define custom resources for your application.
- ② Required field.
- ③ Required field
- ④ Optional if you use LVM Storage volume snapshots.
- ⑤ Required field.



IMPORTANT

The same version of the applications must function on both the current and the target release of OpenShift Container Platform.

3. Create a **kustomization.yaml** with the following content:

```
apiVersion: kustomize.config.k8s.io/v1beta1
kind: Kustomization

configMapGenerator: ①
- files:
  - source-crs/ibu/PlatformBackupRestoreWithIBGU.yaml
  #- source-crs/custom-crs/ApplicationClusterScopedBackupRestore.yaml
  #- source-crs/custom-crs/ApplicationApplicationBackupRestoreLso.yaml
  name: oadp-cm
  namespace: openshift-адр ②
generatorOptions:
  disableNameSuffixHash: true
```

- ① Creates the **oadp-cm ConfigMap** object on the hub cluster with **Backup** and **Restore** CRs.
- ② The namespace must exist on all managed clusters and the hub for the OADP **ConfigMap** to be generated and copied to the clusters.

4. Push the changes to your Git repository.

Additional resources

- [Configuring a shared container partition between ostree stateroots when using GitOps ZTP](#)
- [Installing and configuring the OADP Operator with GitOps ZTP](#)

15.2.5.2. Labeling extra manifests for the image-based upgrade with GitOps ZTP

Label your extra manifests so that the Lifecycle Agent can extract resources that are labeled with the `lca.openshift.io/target-ocp-version: <target_version>` label.

Prerequisites

- You have provisioned one or more managed clusters with GitOps ZTP.

- You have logged in as a user with **cluster-admin** privileges.
- You have generated a seed image from a compatible seed cluster.
- You have created a separate partition on the target cluster for the container images that is shared between stateroots. For more information, see "Configuring a shared container directory between ostree stateroots when using GitOps ZTP".
- You have deployed a version of Lifecycle Agent that is compatible with the version used with the seed image.

Procedure

1. Label your required extra manifests with the **Ica.openshift.io/target-ocp-version: <target_version>** label in your existing site **PolicyGenTemplate** CR:

```

apiVersion: ran.openshift.io/v1
kind: PolicyGenTemplate
metadata:
  name: example-sno
spec:
  bindingRules:
    sites: "example-sno"
    du-profile: "4.15"
    mcp: "master"
  sourceFiles:
    - fileName: SriovNetwork.yaml
      policyName: "config-policy"
      metadata:
        name: "sriov-nw-du-fh"
        labels:
          Ica.openshift.io/target-ocp-version: "4.15" ①
      spec:
        resourceName: du_fh
        vlan: 140
    - fileName: SriovNetworkNodePolicy.yaml
      policyName: "config-policy"
      metadata:
        name: "sriov-nnp-du-fh"
        labels:
          Ica.openshift.io/target-ocp-version: "4.15"
      spec:
        deviceType: netdevice
        isRdma: false
        nicSelector:
          pfNames: ["ens5f0"]
        numVfs: 8
        priority: 10
        resourceName: du_fh
    - fileName: SriovNetwork.yaml
      policyName: "config-policy"
      metadata:
        name: "sriov-nw-du-mh"
        labels:
          Ica.openshift.io/target-ocp-version: "4.15"
      spec:

```

```

resourceName: du_mh
vlan: 150
- fileName: SriovNetworkNodePolicy.yaml
  policyName: "config-policy"
  metadata:
    name: "sriov-nnp-du-mh"
    labels:
      lca.openshift.io/target-ocp-version: "4.15"
  spec:
    deviceType: vfio-pci
    isRdma: false
    nicSelector:
      pfNames: ["ens7f0"]
      numVfs: 8
      priority: 10
    resourceName: du_mh
- fileName: DefaultCatsrc.yaml ②
  policyName: "config-policy"
  metadata:
    name: default-cat-source
    namespace: openshift-marketplace
    labels:
      lca.openshift.io/target-ocp-version: "4.15"
  spec:
    displayName: default-cat-source
    image: quay.io/example-org/example-catalog:v1

```

- ① Ensure that the **lca.openshift.io/target-ocp-version** label matches either the y-stream or the z-stream of the target OpenShift Container Platform version that is specified in the **spec.seedImageRef.version** field of the **ImageBasedUpgrade** CR. The Lifecycle Agent only applies the CRs that match the specified version.
- ② If you do not want to use custom catalog sources, remove this entry.

2. Push the changes to your Git repository.

Additional resources

- [Configuring a shared container partition between ostree stateroots when using GitOps ZTP](#)
- [Performing an image-based upgrade for single-node OpenShift clusters using GitOps ZTP](#)

15.2.6. Configuring the automatic image cleanup of the container storage disk

Configure when the Lifecycle Agent cleans up unpinned images in the **Prep** stage by setting a minimum threshold for available storage space through annotations. The default container storage disk usage threshold is 50%.

The Lifecycle Agent does not delete images that are pinned in CRI-O or are currently used. The Operator selects the images for deletion by starting with dangling images and then sorting the images from oldest to newest that is determined by the image **Created** timestamp.

15.2.6.1. Configuring the automatic image cleanup of the container storage disk

Configure the minimum threshold for available storage space through annotations.

Prerequisites

- You have created an **ImageBasedUpgrade** CR.

Procedure

1. Increase the threshold to 65% by running the following command:

```
$ oc -n openshift-lifecycle-agent annotate ibu upgrade image-cleanup.lca.openshift.io/disk-usage-threshold-percent='65'
```

2. (Optional) Remove the threshold override by running the following command:

```
$ oc -n openshift-lifecycle-agent annotate ibu upgrade image-cleanup.lca.openshift.io/disk-usage-threshold-percent-
```

15.2.6.2. Disable the automatic image cleanup of the container storage disk

Disable the automatic image cleanup threshold.

Procedure

1. Disable the automatic image cleanup by running the following command:

```
$ oc -n openshift-lifecycle-agent annotate ibu upgrade image-cleanup.lca.openshift.io/on-prep='Disabled'
```

2. (Optional) Enable automatic image cleanup again by running the following command:

```
$ oc -n openshift-lifecycle-agent annotate ibu upgrade image-cleanup.lca.openshift.io/on-prep-
```

15.3. PERFORMING AN IMAGE-BASED UPGRADE FOR SINGLE-NODE OPENSHIFT CLUSTERS WITH THE LIFECYCLE AGENT

You can use the Lifecycle Agent to do a manual image-based upgrade of a single-node OpenShift cluster.

When you deploy the Lifecycle Agent on a cluster, an **ImageBasedUpgrade** CR is automatically created. You update this CR to specify the image repository of the seed image and to move through the different stages.

15.3.1. Moving to the Prep stage of the image-based upgrade with Lifecycle Agent

When you deploy the Lifecycle Agent on a cluster, an **ImageBasedUpgrade** custom resource (CR) is automatically created.

After you created all the resources that you need during the upgrade, you can move on to the **Prep** stage. For more information, see the "Creating ConfigMap objects for the image-based upgrade with Lifecycle Agent" section.



NOTE

In a disconnected environment, if the seed cluster's release image registry is different from the target cluster's release image registry, you must create an **ImageDigestMirrorSet** (IDMS) resource to configure alternative mirrored repository locations. For more information, see "Configuring image registry repository mirroring".

You can retrieve the release registry used in the seed image by running the following command:

```
$ skopeo inspect docker://<imagename> | jq -r '.Labels."com.openshift.lifecycle-agent.seed_cluster_info" | fromjson | .release_registry'
```

Prerequisites

- You have created resources to back up and restore your clusters.

Procedure

- 1 Check that you have patched your **ImageBasedUpgrade** CR:

```
apiVersion: lca.openshift.io/v1
kind: ImageBasedUpgrade
metadata:
  name: upgrade
spec:
  stage: Idle
  seedImageRef:
    version: 4.15.2 ①
    image: <seed_container_image> ②
    pullSecretRef: <seed_pull_secret> ③
    autoRollbackOnFailure: {}
  # initMonitorTimeoutSeconds: 1800 ④
  extraManifests: ⑤
    - name: example-extra-manifests-cm
      namespace: openshift-lifecycle-agent
    - name: example-catalogsources-cm
      namespace: openshift-lifecycle-agent
  oadpContent: ⑥
    - name: oadp-cm-example
      namespace: openshift-adp
```

- 1 Target platform version. The value must match the version of the seed image.
- 2 Repository where the target cluster can pull the seed image from.
- 3 Reference to a secret with credentials to pull container images if the images are in a private registry.
- 4 Optional: Time frame in seconds to roll back if the upgrade does not complete within that time frame after the first reboot. If not defined or set to **0**, the default value of **1800** seconds (30 minutes) is used.
- 5 Optional: List of **ConfigMap** resources that contain your custom catalog sources to retain

6

- List of **ConfigMap** resources that contain the OADP **Backup** and **Restore** CRs.

- To start the **Prep** stage, change the value of the **stage** field to **Prep** in the **ImageBasedUpgrade** CR by running the following command:

```
$ oc patch imagebasedupgrades.lca.openshift.io upgrade -p='{"spec": {"stage": "Prep"}}' --type=merge -n openshift-lifecycle-agent
```

If you provide **ConfigMap** objects for OADP resources and extra manifests, Lifecycle Agent validates the specified **ConfigMap** objects during the **Prep** stage. You might encounter the following issues:

- Validation warnings or errors if the Lifecycle Agent detects any issues with the **extraManifests** parameters.
- Validation errors if the Lifecycle Agent detects any issues with the **oadpContent** parameters.

Validation warnings do not block the **Upgrade** stage but you must decide if it is safe to proceed with the upgrade. These warnings, for example missing CRDs, namespaces, or dry run failures, update the **status.conditions** for the **Prep** stage and **annotation** fields in the **ImageBasedUpgrade** CR with details about the warning.

Example validation warning

```
# ...
metadata:
annotations:
  extra-manifest.lca.openshift.io/validation-warning: '...'
# ...
```

However, validation errors, such as adding **MachineConfig** or Operator manifests to extra manifests, cause the **Prep** stage to fail and block the **Upgrade** stage.

When the validations pass, the cluster creates a new **ostree** stateroot, which involves pulling and unpacking the seed image, and running host-level commands. Finally, all the required images are precached on the target cluster.

Verification

- Check the status of the **ImageBasedUpgrade** CR by running the following command:

```
$ oc get ibu -o yaml
```

Example output

```
conditions:
- lastTransitionTime: "2024-01-01T09:00:00Z"
  message: In progress
  observedGeneration: 13
  reason: InProgress
  status: "False"
  type: Idle
- lastTransitionTime: "2024-01-01T09:00:00Z"
```

```

message: Prep completed
observedGeneration: 13
reason: Completed
status: "False"
type: PreInProgress
- lastTransitionTime: "2024-01-01T09:00:00Z"
  message: Prep stage completed successfully
  observedGeneration: 13
  reason: Completed
  status: "True"
  type: PrepCompleted
  observedGeneration: 13
validNextStages:
- Idle
- Upgrade

```

Additional resources

- [Creating ConfigMap objects for the image-based upgrade with Lifecycle Agent](#)
- [Configuring image registry repository mirroring](#)

15.3.2. Moving to the Upgrade stage of the image-based upgrade with Lifecycle Agent

After you generate the seed image and complete the **Prep** stage, you can upgrade the target cluster. During the upgrade process, the OADP Operator creates a backup of the artifacts specified in the OADP custom resources (CRs), then the Lifecycle Agent upgrades the cluster.

If the upgrade fails or stops, an automatic rollback is initiated. If you have an issue after the upgrade, you can initiate a manual rollback. For more information about manual rollback, see "Moving to the Rollback stage of the image-based upgrade with Lifecycle Agent".

Prerequisites

- You have completed the **Prep** stage.

Procedure

1. To move to the **Upgrade** stage, change the value of the **stage** field to **Upgrade** in the **ImageBasedUpgrade** CR by running the following command:

```
$ oc patch imagebasedupgrades.lca.openshift.io upgrade -p='{"spec": {"stage": "Upgrade"}}' -type=merge
```

2. Check the status of the **ImageBasedUpgrade** CR by running the following command:

```
$ oc get ibu -o yaml
```

Example output

```

status:
conditions:
- lastTransitionTime: "2024-01-01T09:00:00Z"

```

```

message: In progress
observedGeneration: 5
reason: InProgress
status: "False"
type: Idle
- lastTransitionTime: "2024-01-01T09:00:00Z"
  message: Prep completed
  observedGeneration: 5
  reason: Completed
  status: "False"
  type: PrepInProgress
- lastTransitionTime: "2024-01-01T09:00:00Z"
  message: Prep completed successfully
  observedGeneration: 5
  reason: Completed
  status: "True"
  type: PrepCompleted
- lastTransitionTime: "2024-01-01T09:00:00Z"
  message: |-|
    Waiting for system to stabilize: one or more health checks failed
    - one or more ClusterOperators not yet ready: authentication
    - one or more MachineConfigPools not yet ready: master
    - one or more ClusterServiceVersions not yet ready: sriov-fec.v2.8.0
  observedGeneration: 1
  reason: InProgress
  status: "True"
  type: UpgradeInProgress
  observedGeneration: 1
  rollbackAvailabilityExpiration: "2024-05-19T14:01:52Z"
  validNextStages:
  - Rollback

```

The OADP Operator creates a backup of the data specified in the OADP **Backup** and **Restore** CRs and the target cluster reboots.

3. Monitor the status of the CR by running the following command:

```
$ oc get ibu -o yaml
```

4. If you are satisfied with the upgrade, finalize the changes by patching the value of the **stage** field to **Idle** in the **ImageBasedUpgrade** CR by running the following command:

```
$ oc patch imagebasedupgrades.lca.openshift.io upgrade -p='{"spec": {"stage": "Idle"}}' --type=merge
```



IMPORTANT

You cannot roll back the changes once you move to the **Idle** stage after an upgrade.

The Lifecycle Agent deletes all resources created during the upgrade process.

5. You can remove the OADP Operator and its configuration files after a successful upgrade. For more information, see "Deleting Operators from a cluster".

Verification

- Check the status of the **ImageBasedUpgrade** CR by running the following command:

```
$ oc get ibu -o yaml
```

Example output

```
status:
conditions:
- lastTransitionTime: "2024-01-01T09:00:00Z"
  message: In progress
  observedGeneration: 5
  reason: InProgress
  status: "False"
  type: Idle
- lastTransitionTime: "2024-01-01T09:00:00Z"
  message: Prep completed
  observedGeneration: 5
  reason: Completed
  status: "False"
  type: PreInProgress
- lastTransitionTime: "2024-01-01T09:00:00Z"
  message: Prep completed successfully
  observedGeneration: 5
  reason: Completed
  status: "True"
  type: PrepCompleted
- lastTransitionTime: "2024-01-01T09:00:00Z"
  message: Upgrade completed
  observedGeneration: 1
  reason: Completed
  status: "False"
  type: UpgradeInProgress
- lastTransitionTime: "2024-01-01T09:00:00Z"
  message: Upgrade completed
  observedGeneration: 1
  reason: Completed
  status: "True"
  type: UpgradeCompleted
  observedGeneration: 1
  rollbackAvailabilityExpiration: "2024-01-01T09:00:00Z"
  validNextStages:
  - Idle
  - Rollback
```

- Check the status of the cluster restoration by running the following command:

```
$ oc get restores -n openshift-adp -o custom-
columns=NAME:.metadata.name,Status:.status.phase,Reason:.status.failureReason
```

Example output

NAME	Status	Reason
------	--------	--------

```
acm-klusterlet  Completed  <none>  1
apache-app      Completed  <none>
localvolume     Completed  <none>
```

- 1 The **acm-klusterlet** is specific to RHACM environments only.

Additional resources

- [Moving to the Rollback stage of the image-based upgrade with Lifecycle Agent](#)
- [Deleting Operators from a cluster](#)

15.3.3. Moving to the Rollback stage of the image-based upgrade with Lifecycle Agent

An automatic rollback is initiated if the upgrade does not complete within the time frame specified in the **initMonitorTimeoutSeconds** field after rebooting.

Example ImageBasedUpgrade CR

```
apiVersion: lca.openshift.io/v1
kind: ImageBasedUpgrade
metadata:
  name: upgrade
spec:
  stage: Idle
  seedImageRef:
    version: 4.15.2
    image: <seed_container_image>
  autoRollbackOnFailure: {}
#  initMonitorTimeoutSeconds: 1800  1
# ...
```

- 1 Optional: The time frame in seconds to roll back if the upgrade does not complete within that time frame after the first reboot. If not defined or set to **0**, the default value of **1800** seconds (30 minutes) is used.

You can manually roll back the changes if you encounter unresolvable issues after an upgrade.

Prerequisites

- You have logged into the hub cluster as a user with **cluster-admin** privileges.
- You ensured that the control plane certificates on the original stateroot are valid. If the certificates expired, see "Recovering from expired control plane certificates".

Procedure

1. To move to the rollback stage, patch the value of the **stage** field to **Rollback** in the **ImageBasedUpgrade** CR by running the following command:

```
$ oc patch imagebasedupgrades.lca.openshift.io upgrade -p='{"spec": {"stage": "Rollback"}}' --type=merge
```

The Lifecycle Agent reboots the cluster with the previously installed version of OpenShift Container Platform and restores the applications.

- If you are satisfied with the changes, finalize the rollback by patching the value of the **stage** field to **Idle** in the **ImageBasedUpgrade** CR by running the following command:

```
$ oc patch imagebasedupgrades.lca.openshift.io upgrade -p='{"spec": {"stage": "Idle"}}' --type=merge -n openshift-lifecycle-agent
```



WARNING

If you move to the **Idle** stage after a rollback, the Lifecycle Agent cleans up resources that can be used to troubleshoot a failed upgrade.

Additional resources

- [Recovering from expired control plane certificates](#)

15.3.4. Troubleshooting image-based upgrades with Lifecycle Agent

Perform troubleshooting steps on the managed clusters that are affected by an issue.



IMPORTANT

If you are using the **ImageBasedGroupUpgrade** CR to upgrade your clusters, ensure that the **lcm.openshift.io/ibgu-<stage>-completed** or **lcm.openshift.io/ibgu-<stage>-failed** cluster labels are updated properly after performing troubleshooting or recovery steps on the managed clusters. This ensures that the TALM continues to manage the image-based upgrade for the cluster.

15.3.4.1. Collecting logs

You can use the **oc adm must-gather** CLI to collect information for debugging and troubleshooting.

Procedure

- Collect data about the Operators by running the following command:

```
$ oc adm must-gather \
--dest-dir=must-gather/tmp \
--image=$(oc -n openshift-lifecycle-agent get deployment.apps/lifecycle-agent-controller-manager -o jsonpath='{.spec.template.spec.containers[?(@.name == "manager")].image}') \
--image=quay.io/konveyor/oadp-must-gather:latest // 1 \
--image=quay.io/openshift/origin-must-gather:latest 2
```

- 1 Optional: Add this option if you need to gather more information from the OADP Operator.
- 2 Optional: Add this option if you need to gather more information from the SR-IOV Operator.

15.3.4.2. AbortFailed or FinalizeFailed error

Issue

During the finalize stage or when you stop the process at the **Prep** stage, Lifecycle Agent cleans up the following resources:

- Stateroot that is no longer required
- Precaching resources
- OADP CRs
- **ImageBasedUpgrade** CR

If the Lifecycle Agent fails to perform the above steps, it transitions to the **AbortFailed** or **FinalizeFailed** states. The condition message and log show which steps failed.

Example error message

```
message: failed to delete all the backup CRs. Perform cleanup manually then add
'lca.openshift.io/manual-cleanup-done' annotation to ibu CR to transition back to Idle
observedGeneration: 5
reason: AbortFailed
status: "False"
type: Idle
```

Resolution

1. Inspect the logs to determine why the failure occurred.
2. To prompt Lifecycle Agent to retry the cleanup, add the **lca.openshift.io/manual-cleanup-done** annotation to the **ImageBasedUpgrade** CR.
After observing this annotation, Lifecycle Agent retries the cleanup and, if it is successful, the **ImageBasedUpgrade** stage transitions to **Idle**.

If the cleanup fails again, you can manually clean up the resources.

15.3.4.2.1. Cleaning up stateroot manually

Issue

Stopping at the **Prep** stage, Lifecycle Agent cleans up the new stateroot. When finalizing after a successful upgrade or a rollback, Lifecycle Agent cleans up the old stateroot. If this step fails, it is recommended that you inspect the logs to determine why the failure occurred.

Resolution

1. Check if there are any existing deployments in the stateroot by running the following command:

```
$ ostree admin status
```

2. If there are any, clean up the existing deployment by running the following command:

```
$ ostree admin undeploy <index_of_deployment>
```

3. After cleaning up all the deployments of the stateroot, wipe the stateroot directory by running the following commands:



WARNING

Ensure that the booted deployment is not in this stateroot.

```
$ stateroot=<stateroot_to_delete>"
```

```
$ unshare -m /bin/sh -c "mount -o remount,rw /sysroot && rm -rf /sysroot/ostree/deploy/${stateroot}"
```

15.3.4.2.2. Cleaning up OADP resources manually

Issue

Automatic cleanup of OADP resources can fail due to connection issues between Lifecycle Agent and the S3 backend. By restoring the connection and adding the **Ica.openshift.io/manual-cleanup-done** annotation, the Lifecycle Agent can successfully cleanup backup resources.

Resolution

1. Check the backend connectivity by running the following command:

```
$ oc get backupstoragelocations.velero.io -n openshift-adp
```

Example output

NAME	PHASE	LAST VALIDATED	AGE	DEFAULT
dataprotectionapplication-1	Available	33s	8d	true

2. Remove all backup resources and then add the **Ica.openshift.io/manual-cleanup-done** annotation to the **ImageBasedUpgrade** CR.

15.3.4.3. LVM Storage volume contents not restored

When LVM Storage is used to provide dynamic persistent volume storage, LVM Storage might not restore the persistent volume contents if it is configured incorrectly.

15.3.4.3.1. Missing LVM Storage-related fields in Backup CR

Issue

Your **Backup** CRs might be missing fields that are needed to restore your persistent volumes. You can check for events in your application pod to determine if you have this issue by running the following:

```
$ oc describe pod <your_app_name>
```

Example output showing missing LVM Storage-related fields in Backup CR

Events:

Type	Reason	Age	From	Message
Warning	FailedScheduling	58s (x2 over 66s)	default-scheduler	0/1 nodes are available: pod has unbound immediate PersistentVolumeClaims. preemption: 0/1 nodes are available: 1 Preemption is not helpful for scheduling..
Normal	Scheduled	56s	default-scheduler	Successfully assigned default/db-1234 to sno1.example.lab
Warning	FailedMount	24s (x7 over 55s)	kubelet	MountVolume.SetUp failed for volume "pvc-1234" : rpc error: code = Unknown desc = VolumeID is not found

Resolution

You must include **logicalvolumes.topolvm.io** in the application **Backup** CR. Without this resource, the application restores its persistent volume claims and persistent volume manifests correctly, however, the **logicalvolume** associated with this persistent volume is not restored properly after pivot.

Example Backup CR

```
apiVersion: velero.io/v1
kind: Backup
metadata:
  labels:
    velero.io/storage-location: default
  name: small-app
  namespace: openshift-adp
spec:
  includedNamespaces:
  - test
  includedNamespaceScopedResources:
  - secrets
  - persistentvolumeclaims
  - deployments
  - statefulsets
  includedClusterScopedResources: ①
  - persistentVolumes
  - volumesnapshotcontents
  - logicalvolumes.topolvm.io
```

- ① To restore the persistent volumes for your application, you must configure this section as shown.

15.3.4.3.2. Missing LVM Storage-related fields in Restore CR

Issue

The expected resources for the applications are restored but the persistent volume contents are not preserved after upgrading.

1. List the persistent volumes for your applications by running the following command before pivot:

```
$ oc get pv,pvc,logicalvolumes.topolvm.io -A
```

Example output before pivot

NAME	CAPACITY	ACCESS MODES	RECLAIM POLICY	STATUS
CLAIM	STORAGECLASS	REASON	AGE	
persistentvolume/pvc-1234	1Gi	RWO	Retain	Bound default/pvc-db
lvms-vg1			4h45m	

NAMESPACE	NAME	STATUS	VOLUME	CAPACITY	ACCESS MODES	STORAGECLASS	AGE
default	persistentvolumeclaim/pvc-db	Bound	pvc-1234	1Gi	RWO	lvms-vg1	4h45m

NAMESPACE	NAME	AGE
	logicalvolume.topolvm.io/pvc-1234	4h45m

2. List the persistent volumes for your applications by running the following command after pivot:

```
$ oc get pv,pvc,logicalvolumes.topolvm.io -A
```

Example output after pivot

NAME	CAPACITY	ACCESS MODES	RECLAIM POLICY	STATUS
CLAIM	STORAGECLASS	REASON	AGE	
persistentvolume/pvc-1234	1Gi	RWO	Delete	Bound default/pvc-db
lvms-vg1			19s	

NAMESPACE	NAME	STATUS	VOLUME	CAPACITY	ACCESS MODES	STORAGECLASS	AGE
default	persistentvolumeclaim/pvc-db	Bound	pvc-1234	1Gi	RWO	lvms-vg1	19s

NAMESPACE	NAME	AGE
	logicalvolume.topolvm.io/pvc-1234	18s

Resolution

The reason for this issue is that the **logicalvolume** status is not preserved in the **Restore** CR. This status is important because it is required for Velero to reference the volumes that must be preserved after pivoting. You must include the following fields in the application **Restore** CR:

Example Restore CR

```

apiVersion: velero.io/v1
kind: Restore
metadata:
  name: sample-vote-app
  namespace: openshift-adp
  labels:
    velero.io/storage-location: default
  annotations:
    lca.openshift.io/apply-wave: "3"
spec:
  backupName:
    sample-vote-app
  restorePVs: true 1
  restoreStatus: 2
  includedResources:
    - logicalvolumes

```

- 1** To preserve the persistent volumes for your application, you must set **restorePVs** to **true**.
- 2** To preserve the persistent volumes for your application, you must configure this section as shown.

15.3.4.4. Debugging failed Backup and Restore CRs

Issue

The backup or restoration of artifacts failed.

Resolution

You can debug **Backup** and **Restore** CRs and retrieve logs with the Velero CLI tool. The Velero CLI tool provides more detailed information than the OpenShift CLI tool.

1. Describe the **Backup** CR that contains errors by running the following command:

```
$ oc exec -n openshift-adp velero-7c87d58c7b-sw6fc -c velero -- ./velero describe backup
-n openshift-adp backup-acm-klusterlet --details
```

2. Describe the **Restore** CR that contains errors by running the following command:

```
$ oc exec -n openshift-adp velero-7c87d58c7b-sw6fc -c velero -- ./velero describe restore
-n openshift-adp restore-acm-klusterlet --details
```

3. Download the backed up resources to a local directory by running the following command:

```
$ oc exec -n openshift-adp velero-7c87d58c7b-sw6fc -c velero -- ./velero backup
download -n openshift-adp backup-acm-klusterlet -o ~/backup-acm-klusterlet.tar.gz
```

15.4. PERFORMING AN IMAGE-BASED UPGRADE FOR SINGLE-NODE OPENSHIFT CLUSTERS USING GITOPS ZTP

You can use a single resource on the hub cluster, the **ImageBasedGroupUpgrade** custom resource

(CR), to manage an image-based upgrade on a selected group of managed clusters through all stages. Topology Aware Lifecycle Manager (TALM) reconciles the **ImageBasedGroupUpgrade** CR and creates the underlying resources to complete the defined stage transitions, either in a manually controlled or a fully automated upgrade flow.

For more information about the image-based upgrade, see "Understanding the image-based upgrade for single-node OpenShift clusters".

Additional resources

- Understanding the image-based upgrade for single-node OpenShift clusters

15.4.1. Managing the image-based upgrade at scale using the **ImageBasedGroupUpgrade** CR on the hub

The **ImageBasedGroupUpgrade** CR combines the **ImageBasedUpgrade** and **ClusterGroupUpgrade** APIs. For example, you can define the cluster selection and rollout strategy with the **ImageBasedGroupUpgrade** API in the same way as the **ClusterGroupUpgrade** API. The stage transitions are different from the **ImageBasedUpgrade** API. The **ImageBasedGroupUpgrade** API allows you to combine several stage transitions, also called actions, into one step that share one rollout strategy.

Example `ImageBasedGroupUpgrade.yaml`

```
apiVersion: lcm.openshift.io/v1alpha1
kind: ImageBasedGroupUpgrade
metadata:
  name: <filename>
  namespace: default
spec:
  clusterLabelSelectors: 1
    - matchExpressions:
        - key: name
          operator: In
          values:
            - spoke1
            - spoke4
            - spoke6
  ibuSpec:
    seedImageRef: 2
      image: quay.io/seed/image:4.18.0-rc.1
      version: 4.18.0-rc.1
    pullSecretRef:
      name: "<seed_pull_secret>"
    extraManifests: 3
      - name: example-extra-manifests
        namespace: openshift-lifecycle-agent
    oadpContent: 4
      - name: oadp-cm
        namespace: openshift-adp
  plan: 5
    - actions: ["Prep", "Upgrade", "FinalizeUpgrade"]
```

```
rolloutStrategy:
  maxConcurrency: 200 6
  timeout: 2400 7
```

- 1** Clusters to upgrade.
- 2** Target platform version, the seed image to be used, and the secret required to access the image.

**NOTE**

If you add the seed image pull secret in the hub cluster, in the same namespace as the **ImageBasedGroupUpgrade** resource, the secret is added to the manifest list for the **Prep** stage. The secret is recreated in each spoke cluster in the **openshift-lifecycle-agent** namespace.

- 3** Optional: Applies additional manifests, which are not in the seed image, to the target cluster. Also applies **ConfigMap** objects for custom catalog sources.
- 4** **ConfigMap** resources that contain the OADP **Backup** and **Restore** CRs.
- 5** Upgrade plan details.
- 6** Number of clusters to update in a batch.
- 7** Timeout limit to complete the action in minutes.

15.4.1.1. Supported action combinations

Actions are the list of stage transitions that TALM completes in the steps of an upgrade plan for the selected group of clusters. Each **action** entry in the **ImageBasedGroupUpgrade** CR is a separate step and a step contains one or several actions that share the same rollout strategy. You can achieve more control over the rollout strategy for each action by separating actions into steps.

These actions can be combined differently in your upgrade plan and you can add subsequent steps later. Wait until the previous steps either complete or fail before adding a step to your plan. The first action of an added step for clusters that failed a previous steps must be either **Abort** or **Rollback**.

**IMPORTANT**

You cannot remove actions or steps from an ongoing plan.

The following table shows example plans for different levels of control over the rollout strategy:

Table 15.5. Example upgrade plans

Example plan	Description
<pre data-bbox="198 258 563 460"> plan: - actions: ["Prep", "Upgrade", "FinalizeUpgrade"] rolloutStrategy: maxConcurrency: 200 timeout: 60 </pre>	All actions share the same strategy
<pre data-bbox="198 640 563 965"> plan: - actions: ["Prep", "Upgrade"] rolloutStrategy: maxConcurrency: 200 timeout: 60 - actions: ["FinalizeUpgrade"] rolloutStrategy: maxConcurrency: 500 timeout: 10 </pre>	Some actions share the same strategy
<pre data-bbox="198 1066 563 1516"> plan: - actions: ["Prep"] rolloutStrategy: maxConcurrency: 200 timeout: 60 - actions: ["Upgrade"] rolloutStrategy: maxConcurrency: 200 timeout: 20 - actions: ["FinalizeUpgrade"] rolloutStrategy: maxConcurrency: 500 timeout: 10 </pre>	All actions have different strategies



IMPORTANT

Clusters that fail one of the actions will skip the remaining actions in the same step.

The **ImageBasedGroupUpgrade** API accepts the following actions:

Prep

Start preparing the upgrade resources by moving to the **Prep** stage.

Upgrade

Start the upgrade by moving to the **Upgrade** stage.

FinalizeUpgrade

Finalize the upgrade on selected clusters that completed the **Upgrade** action by moving to the **Idle** stage.

Rollback

Start a rollback only on successfully upgraded clusters by moving to the **Rollback** stage.

FinalizeRollback

Finalize the rollback by moving to the **Idle** stage.

AbortOnFailure

Cancel the upgrade on selected clusters that failed the **Prep** or **Upgrade** actions by moving to the **Idle** stage.

Abort

Cancel an ongoing upgrade only on clusters that are not yet upgraded by moving to the **Idle** stage.

The following action combinations are supported. A pair of brackets signifies one step in the **plan** section:

- **["Prep"], ["Abort"]**
- **["Prep", "Upgrade", "FinalizeUpgrade"]**
- **["Prep"], ["AbortOnFailure"], ["Upgrade"], ["AbortOnFailure"], ["FinalizeUpgrade"]**
- **["Rollback", "FinalizeRollback"]**

Use one of the following combinations when you need to resume or cancel an ongoing upgrade from a completely new **ImageBasedGroupUpgrade** CR:

- **["Upgrade", "FinalizeUpgrade"]**
- **["FinalizeUpgrade"]**
- **["FinalizeRollback"]**
- **["Abort"]**
- **["AbortOnFailure"]**

15.4.1.2. Labeling for cluster selection

Use the **spec.clusterLabelSelectors** field for initial cluster selection. In addition, TALM labels the managed clusters according to the results of their last stage transition.

When a stage completes or fails, TALM marks the relevant clusters with the following labels:

- **lcm.openshift.io/ibgu-<stage>-completed**
- **lcm.openshift.io/ibgu-<stage>-failed**

Use these cluster labels to cancel or roll back an upgrade on a group of clusters after troubleshooting issues that you might encounter.



IMPORTANT

If you are using the **ImageBasedGroupUpgrade** CR to upgrade your clusters, ensure that the **`lcm.openshift.io/ibgu-<stage>-completed`** or **`lcm.openshift.io/ibgu-<stage>-failed`** cluster labels are updated properly after performing troubleshooting or recovery steps on the managed clusters. This ensures that the TALM continues to manage the image-based upgrade for the cluster.

For example, if you want to cancel the upgrade for all managed clusters except for clusters that successfully completed the upgrade, you can add an **Abort** action to your plan. The **Abort** action moves back the **ImageBasedUpgrade** CR to the **Idle** stage, which cancels the upgrade on clusters that are not yet upgraded. Adding a separate **Abort** action ensures that the TALM does not perform the **Abort** action on clusters that have the **`lcm.openshift.io/ibgu-upgrade-completed`** label.

The cluster labels are removed after successfully canceling or finalizing the upgrade.

15.4.1.3. Status monitoring

The **ImageBasedGroupUpgrade** CR ensures a better monitoring experience with a comprehensive status reporting for all clusters that is aggregated in one place. You can monitor the following actions:

status.clusters.completedActions

Shows all completed actions defined in the **plan** section.

status.clusters.currentAction

Shows all actions that are currently in progress.

status.clusters.failedActions

Shows all failed actions along with a detailed error message.

15.4.2. Performing an image-based upgrade on managed clusters at scale in several steps

For use cases when you need better control of when the upgrade interrupts your service, you can upgrade a set of your managed clusters by using the **ImageBasedGroupUpgrade** CR with adding actions after the previous step is complete. After evaluating the results of the previous steps, you can move to the next upgrade stage or troubleshoot any failed steps throughout the procedure.



IMPORTANT

Only certain action combinations are supported and listed in *Supported action combinations*.

Prerequisites

- You have logged in to the hub cluster as a user with **cluster-admin** privileges.
- You have created policies and **ConfigMap** objects for resources used in the image-based upgrade.
- You have installed the Lifecycle Agent and OADP Operators on all managed clusters through the hub cluster.

Procedure

1. Create a YAML file on the hub cluster that contains the **ImageBasedGroupUpgrade** CR:

```

apiVersion: lcm.openshift.io/v1alpha1
kind: ImageBasedGroupUpgrade
metadata:
  name: <filename>
  namespace: default
spec:
  clusterLabelSelectors: ①
    - matchExpressions:
      - key: name
        operator: In
      values:
        - spoke1
        - spoke4
        - spoke6
  ibuSpec:
    seedImageRef: ②
      image: quay.io/seed/image:4.16.0-rc.1
      version: 4.16.0-rc.1
    pullSecretRef:
      name: "<seed_pull_secret>"
    extraManifests: ③
      - name: example-extra-manifests
        namespace: openshift-lifecycle-agent
    oadpContent: ④
      - name: oadp-cm
        namespace: openshift-adp
  plan: ⑤
    - actions: ["Prep"]
      rolloutStrategy:
        maxConcurrency: 2
        timeout: 2400

```

- ① Clusters to upgrade.
- ② Target platform version, the seed image to be used, and the secret required to access the image.



NOTE

If you add the seed image pull secret in the hub cluster, in the same namespace as the **ImageBasedGroupUpgrade** resource, the secret is added to the manifest list for the **Prep** stage. The secret is recreated in each spoke cluster in the **openshift-lifecycle-agent** namespace.

- ③ Optional: Applies additional manifests, which are not in the seed image, to the target cluster. Also applies **ConfigMap** objects for custom catalog sources.
- ④ List of **ConfigMap** resources that contain the OADP **Backup** and **Restore** CRs.
- ⑤ Upgrade plan details.

2. Apply the created file by running the following command on the hub cluster:

```
$ oc apply -f <filename>.yaml
```

3. Monitor the status updates by running the following command on the hub cluster:

```
$ oc get ibgu -o yaml
```

Example output

```
# ...
status:
clusters:
- completedActions:
  - action: Prep
  name: spoke1
- completedActions:
  - action: Prep
  name: spoke4
- failedActions:
  - action: Prep
  name: spoke6
# ...
```

The previous output of an example plan starts with the **Prep** stage only and you add actions to the plan based on the results of the previous step. TALM adds a label to the clusters to mark if the upgrade succeeded or failed. For example, the **lcm.openshift.io/ibgu-prep-failed** is applied to clusters that failed the **Prep** stage.

After investigating the failure, you can add the **AbortOnFailure** step to your upgrade plan. It moves the clusters labeled with **lcm.openshift.io/ibgu-<action>-failed** back to the **Idle** stage. Any resources that are related to the upgrade on the selected clusters are deleted.

4. Optional: Add the **AbortOnFailure** action to your existing **ImageBasedGroupUpgrade** CR by running the following command:

```
$ oc patch ibgu <filename> --type=json -p \
'[{"op": "add", "path": "/spec/plan/-", "value": {"actions": ["AbortOnFailure"], "rolloutStrategy": {"maxConcurrency": 5, "timeout": 10}}}]'
```

- a. Continue monitoring the status updates by running the following command:

```
$ oc get ibgu -o yaml
```

5. Add the action to your existing **ImageBasedGroupUpgrade** CR by running the following command:

```
$ oc patch ibgu <filename> --type=json -p \
'[{"op": "add", "path": "/spec/plan/-", "value": {"actions": ["Upgrade"], "rolloutStrategy": {"maxConcurrency": 2, "timeout": 30}}}]'
```

6. Optional: Add the **AbortOnFailure** action to your existing **ImageBasedGroupUpgrade** CR by running the following command:

```
$ oc patch ibgu <filename> --type=json -p \
'[{"op": "add", "path": "/spec/plan/-", "value": {"actions": ["AbortOnFailure"], "rolloutStrategy": {"maxConcurrency": 5, "timeout": 10}}}]'
```

- a. Continue monitoring the status updates by running the following command:

```
$ oc get ibgu -o yaml
```

7. Add the action to your existing **ImageBasedGroupUpgrade** CR by running the following command:

```
$ oc patch ibgu <filename> --type=json -p \
'[{"op": "add", "path": "/spec/plan/-", "value": {"actions": ["FinalizeUpgrade"], "rolloutStrategy": {"maxConcurrency": 10, "timeout": 3}}}]'
```

Verification

- Monitor the status updates by running the following command:

```
$ oc get ibgu -o yaml
```

Example output

```
# ...
status:
clusters:
- completedActions:
  - action: Prep
  - action: AbortOnFailure
failedActions:
- action: Upgrade
name: spoke1
- completedActions:
  - action: Prep
  - action: Upgrade
  - action: FinalizeUpgrade
name: spoke4
- completedActions:
  - action: AbortOnFailure
failedActions:
- action: Prep
name: spoke6
# ...
```

Additional resources

- [Configuring a shared container partition between ostree stateroots when using GitOps ZTP](#)
- [Creating ConfigMap objects for the image-based upgrade with Lifecycle Agent using GitOps ZTP](#)
- [About backup and snapshot locations and their secrets](#)

- [Creating a Backup CR](#)
- [Creating a Restore CR](#)
- [Supported action combinations](#)

15.4.3. Performing an image-based upgrade on managed clusters at scale in one step

For use cases when service interruption is not a concern, you can upgrade a set of your managed clusters by using the **ImageBasedGroupUpgrade** CR with several actions combined in one step with one rollout strategy. With one rollout strategy, the upgrade time can be reduced but you can only troubleshoot failed clusters after the upgrade plan is complete.

Prerequisites

- You have logged in to the hub cluster as a user with **cluster-admin** privileges.
- You have created policies and **ConfigMap** objects for resources used in the image-based upgrade.
- You have installed the Lifecycle Agent and OADP Operators on all managed clusters through the hub cluster.

Procedure

1. Create a YAML file on the hub cluster that contains the **ImageBasedGroupUpgrade** CR:

```
apiVersion: lcm.openshift.io/v1alpha1
kind: ImageBasedGroupUpgrade
metadata:
  name: <filename>
  namespace: default
spec:
  clusterLabelSelectors: ①
    - matchExpressions:
        - key: name
          operator: In
        values:
          - spoke1
          - spoke4
          - spoke6
  ibuSpec:
    seedImageRef: ②
      image: quay.io/seed/image:4.18.0-rc.1
      version: 4.18.0-rc.1
    pullSecretRef:
      name: "<seed_pull_secret>"
    extraManifests: ③
      - name: example-extra-manifests
        namespace: openshift-lifecycle-agent
    oadpContent: ④
      - name: oadp-cm
        namespace: openshift-adp
  plan: ⑤
```

```

    - actions: ["Prep", "Upgrade", "FinalizeUpgrade"]
      rolloutStrategy:
        maxConcurrency: 200 6
        timeout: 2400 7
  
```

- 1** Clusters to upgrade.
- 2** Target platform version, the seed image to be used, and the secret required to access the image.



NOTE

If you add the seed image pull secret in the hub cluster, in the same namespace as the **ImageBasedGroupUpgrade** resource, the secret is added to the manifest list for the **Prep** stage. The secret is recreated in each spoke cluster in the **openshift-lifecycle-agent** namespace.

- 3** Optional: Applies additional manifests, which are not in the seed image, to the target cluster. Also applies **ConfigMap** objects for custom catalog sources.
- 4** **ConfigMap** resources that contain the OADP **Backup** and **Restore** CRs.
- 5** Upgrade plan details.
- 6** Number of clusters to update in a batch.
- 7** Timeout limit to complete the action in minutes.

2. Apply the created file by running the following command on the hub cluster:

```
$ oc apply -f <filename>.yaml
```

Verification

- Monitor the status updates by running the following command:

```
$ oc get ibgu -o yaml
```

Example output

```

# ...
status:
clusters:
- completedActions:
  - action: Prep
  failedActions:
  - action: Upgrade
  name: spoke1
- completedActions:
  - action: Prep
  - action: Upgrade
  - action: FinalizeUpgrade
  name: spoke4
  
```

```

- failedActions:
  - action: Prep
    name: spoke6
# ...

```

15.4.4. Canceling an image-based upgrade on managed clusters at scale

You can cancel the upgrade on a set of managed clusters that completed the **Prep** stage.



IMPORTANT

Only certain action combinations are supported and listed in *Supported action combinations*.

Prerequisites

- You have logged in to the hub cluster as a user with **cluster-admin** privileges.

Procedure

1. Create a separate YAML file on the hub cluster that contains the **ImageBasedGroupUpgrade** CR:

```

apiVersion: lcm.openshift.io/v1alpha1
kind: ImageBasedGroupUpgrade
metadata:
  name: <filename>
  namespace: default
spec:
  clusterLabelSelectors:
    - matchExpressions:
        - key: name
          operator: In
          values:
            - spoke4
  ibuSpec:
    seedImageRef:
      image: quay.io/seed/image:4.16.0-rc.1
      version: 4.16.0-rc.1
    pullSecretRef:
      name: "<seed_pull_secret>"
    extraManifests:
      - name: example-extra-manifests
        namespace: openshift-lifecycle-agent
    oadpContent:
      - name: oadp-cm
        namespace: openshift-adp
  plan:
    - actions: ["Abort"]
  rolloutStrategy:
    maxConcurrency: 5
    timeout: 10

```

All managed clusters that completed the **Prep** stage are moved back to the **Idle** stage.

2. Apply the created file by running the following command on the hub cluster:

```
$ oc apply -f <filename>.yaml
```

Verification

- Monitor the status updates by running the following command:

```
$ oc get ibgu -o yaml
```

Example output

```
# ...
status:
clusters:
- completedActions:
  - action: Prep
currentActions:
- action: Abort
name: spoke4
# ...
```

Additional resources

- [Supported action combinations](#)

15.4.5. Rolling back an image-based upgrade on managed clusters at scale

Roll back the changes on a set of managed clusters if you encounter unresolvable issues after a successful upgrade. You need to create a separate **ImageBasedGroupUpgrade** CR and define the set of managed clusters that you want to roll back.



IMPORTANT

Only certain action combinations are supported and listed in *Supported action combinations*.

Prerequisites

- You have logged in to the hub cluster as a user with **cluster-admin** privileges.

Procedure

1. Create a separate YAML file on the hub cluster that contains the **ImageBasedGroupUpgrade** CR:

```
apiVersion: lcm.openshift.io/v1alpha1
kind: ImageBasedGroupUpgrade
metadata:
  name: <filename>
  namespace: default
spec:
  clusterLabelSelectors:
```

```

- matchExpressions:
  - key: name
    operator: In
    values:
    - spoke4
  ibuSpec:
    seedImageRef:
      image: quay.io/seed/image:4.18.0-rc.1
      version: 4.18.0-rc.1
    pullSecretRef:
      name: "<seed_pull_secret>"
  extraManifests:
    - name: example-extra-manifests
      namespace: openshift-lifecycle-agent
  oadpContent:
    - name: oadp-cm
      namespace: openshift-adp
  plan:
    - actions: ["Rollback", "FinalizeRollback"]
  rolloutStrategy:
    maxConcurrency: 200
    timeout: 2400

```

2. Apply the created file by running the following command on the hub cluster:

```
$ oc apply -f <filename>.yaml
```

All managed clusters that match the defined labels are moved back to the **Rollback** and then the **Idle** stages to finalize the rollback.

Verification

- Monitor the status updates by running the following command:

```
$ oc get ibgu -o yaml
```

Example output

```

# ...
status:
clusters:
- completedActions:
  - action: Rollback
  - action: FinalizeRollback
  name: spoke4
# ...

```

Additional resources

- [Supported action combinations](#)
- [Recovering from expired control plane certificates](#)

15.4.6. Troubleshooting image-based upgrades with Lifecycle Agent

Perform troubleshooting steps on the managed clusters that are affected by an issue.



IMPORTANT

If you are using the **ImageBasedGroupUpgrade** CR to upgrade your clusters, ensure that the **lcm.openshift.io/ibgu-<stage>-completed** or **lcm.openshift.io/ibgu-<stage>-failed** cluster labels are updated properly after performing troubleshooting or recovery steps on the managed clusters. This ensures that the TALM continues to manage the image-based upgrade for the cluster.

15.4.6.1. Collecting logs

You can use the **oc adm must-gather** CLI to collect information for debugging and troubleshooting.

Procedure

- Collect data about the Operators by running the following command:

```
$ oc adm must-gather \
--dest-dir=must-gather/tmp \
--image=$(oc -n openshift-lifecycle-agent get deployment.apps/lifecycle-agent-controller-
manager -o jsonpath='{.spec.template.spec.containers[?(@.name == "manager")].image}') \
--image=quay.io/konveyor/oadp-must-gather:latest / ①
--image=quay.io/openshift/origin-must-gather:latest ②
```

- ① Optional: Add this option if you need to gather more information from the OADP Operator.
- ② Optional: Add this option if you need to gather more information from the SR-IOV Operator.

15.4.6.2. AbortFailed or FinalizeFailed error

Issue

During the finalize stage or when you stop the process at the **Prep** stage, Lifecycle Agent cleans up the following resources:

- Stateroot that is no longer required
- Precaching resources
- OADP CRs
- **ImageBasedUpgrade** CR

If the Lifecycle Agent fails to perform the above steps, it transitions to the **AbortFailed** or **FinalizeFailed** states. The condition message and log show which steps failed.

Example error message

```
message: failed to delete all the backup CRs. Perform cleanup manually then add
'lca.openshift.io/manual-cleanup-done' annotation to ibu CR to transition back to Idle
observedGeneration: 5
```

```
reason: AbortFailed
status: "False"
type: Idle
```

Resolution

1. Inspect the logs to determine why the failure occurred.
2. To prompt Lifecycle Agent to retry the cleanup, add the **lca.openshift.io/manual-cleanup-done** annotation to the **ImageBasedUpgrade** CR.
After observing this annotation, Lifecycle Agent retries the cleanup and, if it is successful, the **ImageBasedUpgrade** stage transitions to **Idle**.

If the cleanup fails again, you can manually clean up the resources.

15.4.6.2.1. Cleaning up stateroot manually

Issue

Stopping at the **Prep** stage, Lifecycle Agent cleans up the new stateroot. When finalizing after a successful upgrade or a rollback, Lifecycle Agent cleans up the old stateroot. If this step fails, it is recommended that you inspect the logs to determine why the failure occurred.

Resolution

1. Check if there are any existing deployments in the stateroot by running the following command:

```
$ ostree admin status
```

2. If there are any, clean up the existing deployment by running the following command:

```
$ ostree admin undeploy <index_of_deployment>
```

3. After cleaning up all the deployments of the stateroot, wipe the stateroot directory by running the following commands:



WARNING

Ensure that the booted deployment is not in this stateroot.

```
$ stateroot=<stateroot_to_delete>
```

```
$ unshare -m /bin/sh -c "mount -o remount,rw /sysroot && rm -rf /sysroot/ostree/deploy/${stateroot}"
```

15.4.6.2.2. Cleaning up OADP resources manually

Issue

Automatic cleanup of OADP resources can fail due to connection issues between Lifecycle Agent and the S3 backend. By restoring the connection and adding the **lca.openshift.io/manual-cleanup-done** annotation, the Lifecycle Agent can successfully cleanup backup resources.

Resolution

1. Check the backend connectivity by running the following command:

```
$ oc get backupstoragelocations.velero.io -n openshift-adp
```

Example output

NAME	PHASE	LAST VALIDATED	AGE	DEFAULT
dataprotectionapplication-1	Available	33s	8d	true

2. Remove all backup resources and then add the **lca.openshift.io/manual-cleanup-done** annotation to the **ImageBasedUpgrade** CR.

15.4.6.3. LVM Storage volume contents not restored

When LVM Storage is used to provide dynamic persistent volume storage, LVM Storage might not restore the persistent volume contents if it is configured incorrectly.

15.4.6.3.1. Missing LVM Storage-related fields in Backup CR**Issue**

Your **Backup** CRs might be missing fields that are needed to restore your persistent volumes. You can check for events in your application pod to determine if you have this issue by running the following:

```
$ oc describe pod <your_app_name>
```

Example output showing missing LVM Storage-related fields in Backup CR

Events:

Type	Reason	Age	From	Message
Warning	FailedScheduling	58s (x2 over 66s)	default-scheduler	0/1 nodes are available: pod has unbound immediate PersistentVolumeClaims. preemption: 0/1 nodes are available: 1 Preemption is not helpful for scheduling..
Normal	Scheduled	56s	default-scheduler	Successfully assigned default/db-1234 to sno1.example.lab
Warning	FailedMount	24s (x7 over 55s)	kubelet	MountVolume.SetUp failed for volume "pvc-1234" : rpc error: code = Unknown desc = VolumeID is not found

Resolution

You must include **logicalvolumes.topolvm.io** in the application **Backup** CR. Without this resource, the application restores its persistent volume claims and persistent volume manifests correctly, however, the **logicalvolume** associated with this persistent volume is not restored properly after pivot.

Example Backup CR

```

apiVersion: velero.io/v1
kind: Backup
metadata:
  labels:
    velero.io/storage-location: default
  name: small-app
  namespace: openshift-adp
spec:
  includedNamespaces:
    - test
  includedNamespaceScopedResources:
    - secrets
    - persistentvolumeclaims
    - deployments
    - statefulsets
  includedClusterScopedResources: ①
    - persistentVolumes
    - volumesnapshotcontents
    - logicalvolumes.topolvm.io

```

- ① To restore the persistent volumes for your application, you must configure this section as shown.

15.4.6.3.2. Missing LVM Storage-related fields in Restore CR

Issue

The expected resources for the applications are restored but the persistent volume contents are not preserved after upgrading.

1. List the persistent volumes for your applications by running the following command before pivot:

```
$ oc get pv,pvc,logicalvolumes.topolvm.io -A
```

Example output before pivot

NAME CLAIM	CAPACITY STORAGECLASS	ACCESS MODES REASON	RECLAIM POLICY	STATUS	
persistentvolume/pvc-1234 lvms-vg1	1Gi 4h45m	RWO	Retain	Bound	default/pvc-db

NAMESPACE MODES	NAME STORAGECLASS	AGE	STATUS	VOLUME	CAPACITY	ACCESS
default vg1	persistentvolumeclaim/pvc-db	4h45m	Bound	pvc-1234	1Gi	RWO

NAMESPACE	NAME	AGE
logicalvolume.topolvm.io	pvc-1234	4h45m

2. List the persistent volumes for your applications by running the following command after pivot:

```
$ oc get pv,pvc,logicalvolumes.topolvm.io -A
```

Example output after pivot

NAME	CAPACITY	ACCESS MODES	RECLAIM POLICY	STATUS
CLAIM	STORAGECLASS	REASON	AGE	
persistentvolume/pvc-1234	1Gi	RWO	Delete	Bound default/pvc-db
lvms-vg1	19s			
NAMESPACE	NAME	STATUS	VOLUME	CAPACITY
MODES	STORAGECLASS	AGE		
default	persistentvolumeclaim/pvc-db	Bound	pvc-1234	1Gi
vg1	19s			RWO lvms-
NAMESPACE	NAME	AGE		
	logicalvolume.topolvm.io/pvc-1234	18s		

Resolution

The reason for this issue is that the **logicalvolume** status is not preserved in the **Restore** CR. This status is important because it is required for Velero to reference the volumes that must be preserved after pivoting. You must include the following fields in the application **Restore** CR:

Example Restore CR

```
apiVersion: velero.io/v1
kind: Restore
metadata:
  name: sample-vote-app
  namespace: openshift-adp
  labels:
    velero.io/storage-location: default
  annotations:
    lca.openshift.io/apply-wave: "3"
spec:
  backupName:
    sample-vote-app
  restorePVs: true ①
  restoreStatus: ②
  includedResources:
    - logicalvolumes
```

- ① To preserve the persistent volumes for your application, you must set **restorePVs** to **true**.
- ② To preserve the persistent volumes for your application, you must configure this section as shown.

15.4.6.4. Debugging failed Backup and Restore CRs

Issue

The backup or restoration of artifacts failed.

Resolution

You can debug **Backup** and **Restore** CRs and retrieve logs with the Velero CLI tool. The Velero CLI tool provides more detailed information than the OpenShift CLI tool.

1. Describe the **Backup** CR that contains errors by running the following command:

```
$ oc exec -n openshift-adp velero-7c87d58c7b-sw6fc -c velero -- ./velero describe backup  
-n openshift-adp backup-acm-klusterlet --details
```

2. Describe the **Restore** CR that contains errors by running the following command:

```
$ oc exec -n openshift-adp velero-7c87d58c7b-sw6fc -c velero -- ./velero describe restore  
-n openshift-adp restore-acm-klusterlet --details
```

3. Download the backed up resources to a local directory by running the following command:

```
$ oc exec -n openshift-adp velero-7c87d58c7b-sw6fc -c velero -- ./velero backup  
download -n openshift-adp backup-acm-klusterlet -o ~/backup-acm-klusterlet.tar.gz
```

CHAPTER 16. IMAGE-BASED INSTALLATION FOR SINGLE-NODE OPENSIFT

16.1. UNDERSTANDING IMAGE-BASED INSTALLATION AND DEPLOYMENT FOR SINGLE-NODE OPENSIFT

Image-based installations significantly reduce the deployment time of single-node OpenShift clusters by streamlining the installation process.

This approach enables the preinstallation of configured and validated instances of single-node OpenShift on target hosts. These preinstalled hosts can be rapidly reconfigured and deployed at the far edge of the network, including in disconnected environments, with minimal intervention.



NOTE

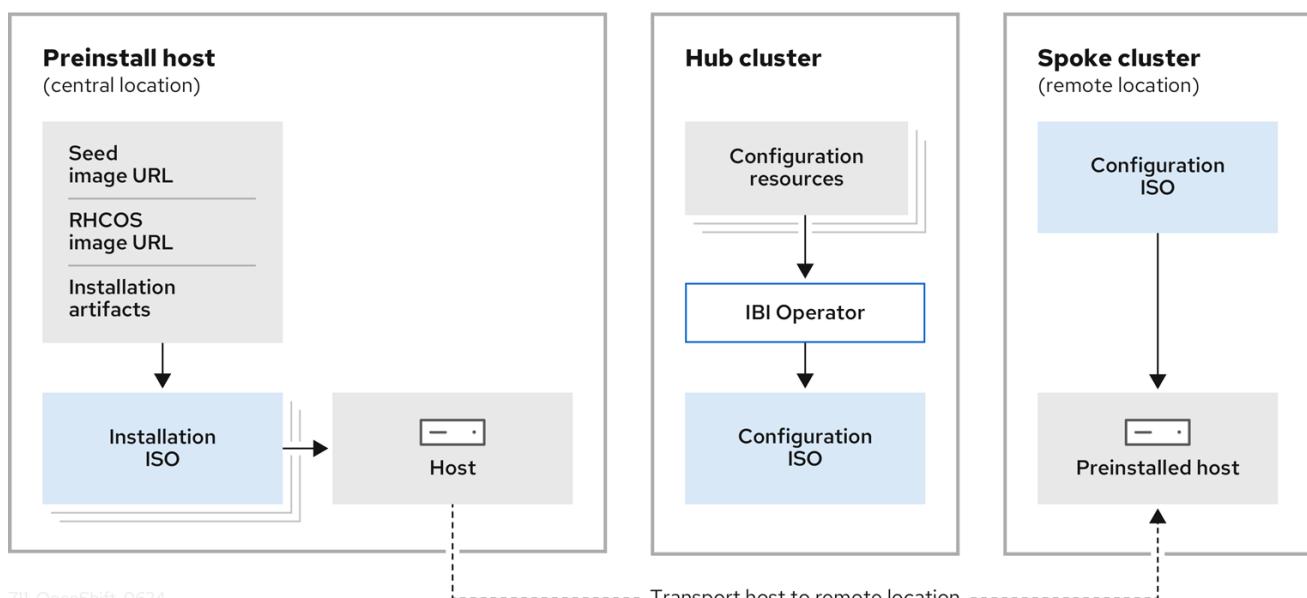
To deploy a managed cluster using an imaged-based approach in combination with GitOps Zero Touch Provisioning (ZTP), you can use the SiteConfig operator. For more information, see [SiteConfig operator](#).

16.1.1. Overview of image-based installation and deployment for single-node OpenShift clusters

Deploying infrastructure at the far edge of the network presents challenges for service providers with low bandwidth, high latency, and disconnected environments. It is also costly and time-consuming to install and deploy single-node OpenShift clusters.

An image-based approach to installing and deploying single-node OpenShift clusters at the far edge of the network overcomes these challenges by separating the installation and deployment stages.

Figure 16.1. Overview of an image-based installation and deployment for managed single-node OpenShift clusters



Imaged-based installation

Preinstall multiple hosts with single-node OpenShift at a central site, such as a service depot or a factory. Then, validate the base configuration for these hosts and leverage the image-based approach to perform reproducible factory installs at scale by using a single live installation ISO.

Image-based deployment

Ship the preinstalled and validated hosts to a remote site and rapidly reconfigure and deploy the clusters in a matter of minutes by using a configuration ISO.

You can choose from two methods to preinstall and configure your SNO clusters.

Using the `openshift-install` program

For a single-node OpenShift cluster, use the **openshift-install** program only to manually create the live installation ISO that is common to all hosts. Then, use the program again to create the configuration ISO which ensures that the host is unique. For more information, see “Deploying managed single-node OpenShift using the `openshift-install` program”.

Using the IBI Operator

For managed single-node OpenShift clusters, you can use the **openshift-install** with the Image Based Install (IBI) Operator to scale up the operations. The program creates the live installation ISO and then the IBI Operator creates one configuration ISO for each host. For more information, see “Deploying single-node OpenShift using the IBI Operator”.

16.1.1.1. Image-based installation for single-node OpenShift clusters

Using the Lifecycle Agent, you can generate an OCI container image that encapsulates an instance of a single-node OpenShift cluster. This image is derived from a dedicated cluster that you can configure with the target OpenShift Container Platform version.

You can reference this image in a live installation ISO to consistently preinstall configured and validated instances of single-node OpenShift to multiple hosts. This approach enables the preparation of hosts at a central location, for example in a factory or service depot, before shipping the preinstalled hosts to a remote site for rapid reconfiguration and deployment. The instructions for preinstalling a host are the same whether you deploy the host by using only the **openshift-install** program or using the program with the IBI Operator.

The following is a high-level overview of the image-based installation process:

1. Generate an image from a single-node OpenShift cluster.
2. Use the **openshift-install** program to embed the seed image URL, and other installation artifacts, in a live installation ISO.
3. Start the host using the live installation ISO to preinstall the host.
During this process, the **openshift-install** program installs Red Hat Enterprise Linux CoreOS (RHCOS) to the disk, pulls the image you generated, and precaches release container images to the disk.
4. When the installation completes, the host is ready to ship to the remote site for rapid reconfiguration and deployment.

16.1.1.2. Image-based deployment for single-node OpenShift clusters

You can use the **openshift-install** program or the IBI Operator to configure and deploy a host that you preinstalled with an image-based installation.

Single-node OpenShift cluster deployment

To configure the target host with site-specific details by using the **openshift-install** program, you must create the following resources:

- The **install-config.yaml** installation manifest
- The **image-based-config.yaml** manifest

The **openshift-install** program uses these resources to generate a configuration ISO that you attach to the preinstalled target host to complete the deployment.

Managed single-node OpenShift cluster deployment

Red Hat Advanced Cluster Management (RHACM) and the multicluster engine for Kubernetes Operator (MCE) use a hub-and-spoke architecture to manage and deploy single-node OpenShift clusters across multiple sites. Using this approach, the hub cluster serves as a central control plane that manages the spoke clusters, which are often remote single-node OpenShift clusters deployed at the far edge of the network.

You can define the site-specific configuration resources for an image-based deployment in the hub cluster. The IBI Operator uses these configuration resources to reconfigure the preinstalled host at the remote site and deploy the host as a managed single-node OpenShift cluster. This approach is especially beneficial for telecommunications providers and other service providers with extensive, distributed infrastructures, where an end-to-end installation at the remote site would be time-consuming and costly.

The following is a high-level overview of the image-based deployment process for hosts preinstalled with an imaged-based installation:

- Define the site-specific configuration resources for the preinstalled host in the hub cluster.
- Apply these resources in the hub cluster. This initiates the deployment process.
- The IBI Operator creates a configuration ISO.
- The IBI Operator boots the target preinstalled host with the configuration ISO attached.
- The host mounts the configuration ISO and begins the reconfiguration process.
- When the reconfiguration completes, the single-node OpenShift cluster is ready.

As the host is already preinstalled using an image-based installation, a technician can reconfigure and deploy the host in a matter of minutes.

16.1.2. Image-based installation and deployment components

The following content describes the components in an image-based installation and deployment.

Seed image

OCI container image generated from a dedicated cluster with the target OpenShift Container Platform version.

Seed cluster

Dedicated single-node OpenShift cluster that you use to create a seed image and is deployed with the target OpenShift Container Platform version.

Lifecycle Agent

Generates the seed image.

Image Based Install (IBI) Operator

When you deploy managed clusters, the IBI Operator creates a configuration ISO from the site-specific resources you define in the hub cluster, and attaches the configuration ISO to the preinstalled host by using a bare-metal provisioning service.

openshift-install program

Creates the installation and configuration ISO, and embeds the seed image URL in the live installation ISO. If the IBI Operator is not used, you must manually attach the configuration ISO to a preinstalled host to complete the deployment.

Additional resources

- [Deploying a single-node OpenShift cluster using the `openshift-install` program](#)

16.1.3. Cluster guidelines for image-based installation and deployment

For a successful image-based installation and deployment, see the following guidelines.

16.1.3.1. Cluster guidelines

- If you are using Red Hat Advanced Cluster Management (RHACM), to avoid including any RHACM resources in your seed image, you need to disable all optional RHACM add-ons before generating the seed image.

16.1.3.2. Seed cluster guidelines

- If your cluster deployment at the edge of the network requires a proxy configuration, you must create a seed image from a seed cluster featuring a proxy configuration. The proxy configurations do not have to match.
- The **clusterNetwork** and **serviceNetwork** network configurations in the seed cluster persist to the deployed cluster. The Lifecycle Agent embeds these settings in the seed image. You cannot change these settings later in the image-based installation and deployment process.
- If you set a maximum transmission unit (MTU) in the seed cluster, you must set the same MTU value in the static network configuration for the image-based configuration ISO.
- Your single-node OpenShift seed cluster must have a shared **/var/lib/containers** directory for precaching images during an image-based installation. For more information see "Configuring a shared container partition between ostree stateroots".
- Create a seed image from a single-node OpenShift cluster that uses the same hardware as your target bare-metal host. The seed cluster must reflect your target cluster configuration for the following items:
 - CPU topology
 - CPU architecture
 - Number of CPU cores
 - Tuned performance configuration, such as number of reserved CPUs
 - IP version

**NOTE**

Dual-stack networking is not supported in this release.

- Disconnected registry

**NOTE**

If the target cluster uses a disconnected registry, your seed cluster must use a disconnected registry. The registries do not have to be the same.

- FIPS configuration

Additional resources

- [Configuring a shared container partition between ostree stateroots](#)

16.1.4. Software prerequisites for an image-based installation and deployment

An image-based installation and deployment requires the following minimum software versions for these required components.

Table 16.1. Minimum software requirements

Component	Software version
Managed cluster version	4.17
Hub cluster version	4.16
Red Hat Advanced Cluster Management (RHACM)	2.12
Lifecycle Agent	4.16 or later
Image Based Install Operator	4.17
openshift-install program	4.17

Additional resources

- [Multicluster architecture](#)
- [Understanding the image-based upgrade for single-node OpenShift clusters](#)

16.2. PREPARING FOR IMAGE-BASED INSTALLATION FOR SINGLE-NODE OPENSHIFT CLUSTERS

To prepare for an image-based installation for single-node OpenShift clusters, you must complete the following tasks:

- Create a seed image by using the Lifecycle Agent.
- Verify that all software components meet the required versions. For further information, see "Software prerequisites for an image-based installation and deployment".

Additional resources

- [Software prerequisites for an image-based installation and deployment](#)

16.2.1. Installing the Lifecycle Agent

Use the Lifecycle Agent to generate a seed image from a seed cluster. You can install the Lifecycle Agent using the OpenShift CLI (**oc**) or the web console.

16.2.1.1. Installing the Lifecycle Agent by using the CLI

You can use the OpenShift CLI (**oc**) to install the Lifecycle Agent.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in as a user with **cluster-admin** privileges.

Procedure

1. Create a **Namespace** object YAML file for the Lifecycle Agent:

```
apiVersion: v1
kind: Namespace
metadata:
  name: openshift-lifecycle-agent
  annotations:
    workload.openshift.io/allowed: management
```

- a. Create the **Namespace** CR by running the following command:

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

2. Create an **OperatorGroup** object YAML file for the Lifecycle Agent:

```
apiVersion: operators.coreos.com/v1
kind: OperatorGroup
metadata:
  name: openshift-lifecycle-agent
  namespace: openshift-lifecycle-agent
spec:
  targetNamespaces:
    - openshift-lifecycle-agent
```

- a. Create the **OperatorGroup** CR by running the following command:

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

3. Create a **Subscription** CR for the Lifecycle Agent:

```
apiVersion: operators.coreos.com/v1alpha1
kind: Subscription
metadata:
  name: openshift-lifecycle-agent-subscription
  namespace: openshift-lifecycle-agent
spec:
  channel: "stable"
  name: lifecycle-agent
  source: redhat-operators
  sourceNamespace: openshift-marketplace
```

a. Create the **Subscription** CR by running the following command:

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

Verification

- To verify that the installation succeeded, inspect the CSV resource by running the following command:

```
$ oc get csv -n openshift-lifecycle-agent
```

Example output

NAME	DISPLAY	VERSION	REPLACES
PHASE			
lifecycle-agent.v4.18.0	Openshift Lifecycle Agent	4.18.0	Succeeded

- Verify that the Lifecycle Agent is up and running by running the following command:

```
$ oc get deploy -n openshift-lifecycle-agent
```

Example output

NAME	READY	UP-TO-DATE	AVAILABLE	AGE
lifecycle-agent-controller-manager	1/1	1	1	14s

16.2.1.2. Installing the Lifecycle Agent by using the web console

You can use the OpenShift Container Platform web console to install the Lifecycle Agent.

Prerequisites

- You have logged in as a user with **cluster-admin** privileges.

Procedure

- In the OpenShift Container Platform web console, navigate to **Operators** → **OperatorHub**.
- Search for the **Lifecycle Agent** from the list of available Operators, and then click **Install**.

3. On the **Install Operator** page, under **A specific namespace on the cluster** select **openshift-lifecycle-agent**.
4. Click **Install**.

Verification

1. To confirm that the installation is successful:
 - a. Click **Operators → Installed Operators**.
 - b. Ensure that the Lifecycle Agent is listed in the **openshift-lifecycle-agent** project with a **Status** of **InstallSucceeded**.



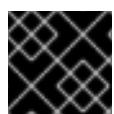
NOTE

During installation an Operator might display a **Failed** status. If the installation later succeeds with an **InstallSucceeded** message, you can ignore the **Failed** message.

If the Operator is not installed successfully:

1. Click **Operators → Installed Operators**, and inspect the **Operator Subscriptions** and **Install Plans** tabs for any failure or errors under **Status**.
2. Click **Workloads → Pods**, and check the logs for pods in the **openshift-lifecycle-agent** project.

16.2.2. Configuring a shared container partition between ostree stateroots



IMPORTANT

You must complete this procedure at installation time.

Apply a **MachineConfig** to the seed cluster to create a separate partition and share the **/var/lib/containers** partition between the two **ostree** stateroots that will be used during the preinstall process.

Procedure

- Apply a **MachineConfig** to create a separate partition:

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: master
  name: 98-var-lib-containers-partitioned
spec:
  config:
    ignition:
      version: 3.2.0
    storage:
      disks:
        - device: /dev/disk/by-path/pci-<root_disk> ①
```

```

partitions:
  - label: var-lib-containers
    startMiB: <start_of_partition> 2
    sizeMiB: <partition_size> 3
filesystems:
  - device: /dev/disk/by-partlabel/var-lib-containers
    format: xfs
    mountOptions:
      - defaults
      - prjquota
    path: /var/lib/containers
    wipeFilesystem: true
systemd:
  units:
    - contents: |-
        # Generated by Butane
        [Unit]
        Before=local-fs.target
        Requires=systemd-fsck@dev-disk-by\x2dpartlabel-var\x2dlib\x2dcontainers.service
        After=systemd-fsck@dev-disk-by\x2dpartlabel-var\x2dlib\x2dcontainers.service

        [Mount]
        Where=/var/lib/containers
        What=/dev/disk/by-partlabel/var-lib-containers
        Type=xfs
        Options=defaults,prjquota

        [Install]
        RequiredBy=local-fs.target
        enabled: true
        name: var-lib-containers.mount

```

- 1** Specify the root disk.
- 2** Specify the start of the partition in MiB. If the value is too small, the installation will fail.
- 3** Specify a minimum size for the partition of 500 GB to ensure adequate disk space for precached images. If the value is too small, the deployments after installation will fail.

16.2.3. Seed image configuration

You can create a seed image from a single-node OpenShift cluster with the same hardware as your bare-metal host, and with a similar target cluster configuration. However, the seed image generated from the seed cluster cannot contain any cluster-specific configuration.

The following table lists the components, resources, and configurations that you must and must not include in your seed image:

Table 16.2. Seed image configuration

Cluster configuration	Include in seed image
Performance profile	Yes

Cluster configuration	Include in seed image
MachineConfig resources for the target cluster	Yes
IP version [1]	Yes
Set of Day 2 Operators, including the Lifecycle Agent and the OADP Operator	Yes
Disconnected registry configuration [2]	Yes
Valid proxy configuration [3]	Yes
FIPS configuration	Yes
Dedicated partition on the primary disk for container storage that matches the size of the target clusters	Yes
Local volumes <ul style="list-style-type: none"> ● StorageClass used in LocalVolume for LSO ● LocalVolume for LSO ● LVMCluster CR for LVMS 	No

1. Dual-stack networking is not supported in this release.
2. If the seed cluster is installed in a disconnected environment, the target clusters must also be installed in a disconnected environment.
3. The proxy configuration must be either enabled or disabled in both the seed and target clusters. However, the proxy servers configured on the clusters does not have to match.

16.2.3.1. Seed image configuration using the RAN DU profile

The following table lists the components, resources, and configurations that you must and must not include in the seed image when using the RAN DU profile:

Table 16.3. Seed image configuration with RAN DU profile

Resource	Include in seed image
All extra manifests that are applied as part of Day 0 installation	Yes
All Day 2 Operator subscriptions	Yes

Resource	Include in seed image
DisableOLMPprof.yaml	Yes
TunedPerformancePatch.yaml	Yes
PerformanceProfile.yaml	Yes
SriovOperatorConfig.yaml	Yes
DisableSnoNetworkDiag.yaml	Yes
StorageClass.yaml	No, if it is used in StorageLV.yaml
StorageLV.yaml	No
StorageLVMCluster.yaml	No

The following list of resources and configurations can be applied as extra manifests or by using RHACM policies:

- **ClusterLogForwarder.yaml**
- **ReduceMonitoringFootprint.yaml**
- **SriovFecClusterConfig.yaml**
- **PtpOperatorConfigForEvent.yaml**
- **DefaultCatsrc.yaml**
- **PtpConfig.yaml**
- **SriovNetwork.yaml**



IMPORTANT

If you are using GitOps ZTP, enable these resources by using RHACM policies to ensure configuration changes can be applied throughout the cluster lifecycle.

16.2.4. Generating a seed image with the Lifecycle Agent

Use the Lifecycle Agent to generate a seed image from a managed cluster. The Operator checks for required system configurations, performs any necessary system cleanup before generating the seed image, and launches the image generation. The seed image generation includes the following tasks:

- Stopping cluster Operators
- Preparing the seed image configuration

- Generating and pushing the seed image to the image repository specified in the **SeedGenerator** CR
- Restoring cluster Operators
- Expiring seed cluster certificates
- Generating new certificates for the seed cluster
- Restoring and updating the **SeedGenerator** CR on the seed cluster

Prerequisites

- RHACM and multicluster engine for Kubernetes Operator are not installed on the seed cluster.
- You have configured a shared container directory on the seed cluster.
- You have installed the minimum version of the OADP Operator and the Lifecycle Agent on the seed cluster.
- Ensure that persistent volumes are not configured on the seed cluster.
- Ensure that the **LocalVolume** CR does not exist on the seed cluster if the Local Storage Operator is used.
- Ensure that the **LVMCluster** CR does not exist on the seed cluster if LVM Storage is used.
- Ensure that the **DataProtectionApplication** CR does not exist on the seed cluster if OADP is used.

Procedure

1. Detach the managed cluster from the hub to delete any RHACM-specific resources from the seed cluster that must not be in the seed image:
 - a. Manually detach the seed cluster by running the following command:


```
$ oc delete managedcluster sno-worker-example
```

 - i. Wait until the managed cluster is removed. After the cluster is removed, create the proper **SeedGenerator** CR. The Lifecycle Agent cleans up the RHACM artifacts.
 - b. If you are using GitOps ZTP, detach your cluster by removing the seed cluster's **SiteConfig** CR from the **kustomization.yaml**.
 - i. If you have a **kustomization.yaml** file that references multiple **SiteConfig** CRs, remove your seed cluster's **SiteConfig** CR from the **kustomization.yaml**:

```
apiVersion: kustomize.config.k8s.io/v1beta1
kind: Kustomization

generators:
#- example-seed-sno1.yaml
- example-target-sno2.yaml
- example-target-sno3.yaml
```

- ii. If you have a **kustomization.yaml** that references one **SiteConfig** CR, remove your seed cluster's **SiteConfig** CR from the **kustomization.yaml** and add the **generators: {}** line:

```
apiVersion: kustomize.config.k8s.io/v1beta1
kind: Kustomization

generators: {}
```

- iii. Commit the **kustomization.yaml** changes in your Git repository and push the changes to your repository.
The ArgoCD pipeline detects the changes and removes the managed cluster.

2. Create the **Secret** object so that you can push the seed image to your registry.

- a. Create the authentication file by running the following commands:

```
$ MY_USER=myuserid
$ AUTHFILE=/tmp/my-auth.json
$ podman login --authfile ${AUTHFILE} -u ${MY_USER} quay.io/${MY_USER}

$ base64 -w 0 ${AUTHFILE} ; echo
```

- b. Copy the output into the **seedAuth** field in the **Secret** YAML file named **seedgen** in the **openshift-lifecycle-agent** namespace:

```
apiVersion: v1
kind: Secret
metadata:
  name: seedgen ①
  namespace: openshift-lifecycle-agent
  type: Opaque
data:
  seedAuth: <encoded_AUTHFILE> ②
```

- ① The **Secret** resource must have the **name: seedgen** and **namespace: openshift-lifecycle-agent** fields.
- ② Specifies a base64-encoded authfile for write-access to the registry for pushing the generated seed images.

- c. Apply the **Secret** by running the following command:

```
$ oc apply -f secretseedgenerator.yaml
```

3. Create the **SeedGenerator** CR:

```
apiVersion: lca.openshift.io/v1
kind: SeedGenerator
metadata:
  name: seedimage ①
spec:
  seedImage: <seed_container_image> ②
```

- 1 The **SeedGenerator** CR must be named **seedimage**.
- 2 Specify the container image URL, for example, `quay.io/example/seed-container-image:<tag>`. It is recommended to use the `<seed_cluster_name>:<ocp_version>` format.

4. Generate the seed image by running the following command:

```
$ oc apply -f seedgenerator.yaml
```



IMPORTANT

The cluster reboots and loses API capabilities while the Lifecycle Agent generates the seed image. Applying the **SeedGenerator** CR stops the **kubelet** and the CRI-O operations, then it starts the image generation.

If you want to generate more seed images, you must provision a new seed cluster with the version that you want to generate a seed image from.

Verification

- After the cluster recovers and it is available, you can check the status of the **SeedGenerator** CR by running the following command:

```
$ oc get seedgenerator -o yaml
```

Example output

```
status:
  conditions:
    - lastTransitionTime: "2024-02-13T21:24:26Z"
      message: Seed Generation completed
      observedGeneration: 1
      reason: Completed
      status: "False"
      type: SeedGenInProgress
    - lastTransitionTime: "2024-02-13T21:24:26Z"
      message: Seed Generation completed
      observedGeneration: 1
      reason: Completed
      status: "True"
      type: SeedGenCompleted ①
  observedGeneration: 1
```

- ① The seed image generation is complete.

16.3. PREINSTALLING SINGLE-NODE OPENSHIFT USING AN IMAGE-BASED INSTALLATION

Use the **openshift-install** program to create a live installation ISO for preinstalling single-node OpenShift on bare-metal hosts. For more information about downloading the installation program, see "Installation process" in the "Additional resources" section.

The installation program takes a seed image URL and other inputs, such as the release version of the seed image and the disk to use for the installation process, and creates a live installation ISO. You can then start the host using the live installation ISO to begin preinstallation. When preinstallation is complete, the host is ready to ship to a remote site for the final site-specific configuration and deployment.

The following are the high-level steps to preinstall a single-node OpenShift cluster using an image-based installation:

- Generate a seed image.
- Create a live installation ISO using the **openshift-install** installation program.
- Boot the host using the live installation ISO to preinstall the host.

Additional resources

- [Installation process](#)

16.3.1. Creating a live installation ISO for a single-node OpenShift image-based installation

You can embed your single-node OpenShift seed image URL, and other installation artifacts, in a live installation ISO by using the **openshift-install** program.



NOTE

For more information about the specification for the **image-based-installation-config.yaml** manifest, see the section "Reference specifications for the **image-based-installation-config.yaml** manifest".

Prerequisites

- You generated a seed image from a single-node OpenShift seed cluster.
- You downloaded the **openshift-install** program. The version of the **openshift-install** program must match the OpenShift Container Platform version in your seed image.
- The target host has network access to the seed image URL and all other installation artifacts.
- If you require static networking, you must install the **nmstatectl** library on the host that creates the live installation ISO.

Procedure

1. Create a live installation ISO and embed your single-node OpenShift seed image URL and other installation artifacts:
 - a. Create a working directory by running the following:

```
$ mkdir ibi-iso-workdir ①
```

- ① Replace **ibi-iso-workdir** with the name of your working directory.

- b. Optional. Create an installation configuration template to use as a reference when configuring the **ImageBasedInstallationConfig** resource:

```
$ openshift-install image-based create image-config-template --dir ibi-iso-workdir ①
```

- ① If you do not specify a working directory, the command uses the current directory.

Example output

```
INFO Image-Config-Template created in: ibi-iso-workdir
```

The command creates the **image-based-installation-config.yaml** installation configuration template in your target directory:

```
#  
# Note: This is a sample ImageBasedInstallationConfig file showing  
# which fields are available to aid you in creating your  
# own image-based-installation-config.yaml file.  
#  
apiVersion: v1beta1  
kind: ImageBasedInstallationConfig  
metadata:  
  name: example-image-based-installation-config  
# The following fields are required  
seedImage: quay.io/openshift-kni/seed-image:4.18.0  
seedVersion: 4.18.0  
installationDisk: /dev/vda  
pullSecret: '<your_pull_secret>'  
# networkConfig is optional and contains the network configuration for the host in  
NMState format.  
# See https://nmstate.io/examples.html for examples.  
# networkConfig:  
#   interfaces:  
#     - name: eth0  
#       type: ethernet  
#       state: up  
#       mac-address: 00:00:00:00:00:00  
#       ipv4:  
#         enabled: true  
#         address:  
#           - ip: 192.168.122.2  
#             prefix-length: 23  
#         dhcp: false
```

- c. Edit your installation configuration file:

Example **image-based-installation-config.yaml** file

```
apiVersion: v1beta1  
kind: ImageBasedInstallationConfig  
metadata:  
  name: example-image-based-installation-config  
seedImage: quay.io/repo-id/seed:latest
```

```

seedVersion: "4.18.0"
extraPartitionStart: "-240G"
installationDisk: /dev/disk/by-id/wwn-0x62c...
sshKey: 'ssh-ed25519 AAAA...'
pullSecret: '{"auths": ...}'
networkConfig:
  interfaces:
    - name: ens1f0
      type: ethernet
      state: up
      ipv4:
        enabled: true
        dhcp: false
        auto-dns: false
        address:
          - ip: 192.168.200.25
            prefix-length: 24
      ipv6:
        enabled: false
  dns-resolver:
    config:
      server:
        - 192.168.15.47
        - 192.168.15.48
  routes:
    config:
      - destination: 0.0.0.0/0
        metric: 150
        next-hop-address: 192.168.200.254
        next-hop-interface: ens1f0

```

- d. Create the live installation ISO by running the following command:

```
$ openshift-install image-based create image --dir ibi-iso-workdir
```

Example output

```

INFO Consuming Image-based Installation ISO Config from target directory
INFO Creating Image-based Installation ISO with embedded ignition

```

Verification

- View the output in the working directory:

```

ibi-iso-workdir/
  └── rhcos-ibi.iso

```

Additional resources

- Reference specifications for the [image-based-installation-config.yaml](#) manifest

16.3.1.1. Configuring additional partitions on the target host

The installation ISO creates a partition for the **/var/lib/containers** directory as part of the image-based installation process.

You can create additional partitions by using the **coreosInstallerArgs** specification. For example, in hard disks with adequate storage, you might need an additional partition for storage options, such as Logical Volume Manager (LVM) Storage.



NOTE

The **/var/lib/containers** partition requires at least 500 GB to ensure adequate disk space for precached images. You must create additional partitions with a starting position larger than the partition for **/var/lib/containers**.

Procedure

- 1 Edit the **image-based-installation-config.yaml** file to configure additional partitions:

Example image-based-installation-config.yaml file

```
apiVersion: v1beta1
kind: ImageBasedInstallationConfig
metadata:
  name: example-extra-partition
seedImage: quay.io/repo-id/seed:latest
seedVersion: "4.18.0"
installationDisk: /dev/sda
pullSecret: '{"auths": ...}'
# ...
skipDiskCleanup: true ①
coreosInstallerArgs:
  - "--save-partindex" ②
  - "6" ③
ignitionConfigOverride: |
{
  "ignition": {
    "version": "3.2.0"
  },
  "storage": {
    "disks": [
      {
        "device": "/dev/sda", ④
        "partitions": [
          {
            "label": "storage", ⑤
            "number": 6, ⑥
            "sizeMiB": 380000, ⑦
            "startMiB": 500000 ⑧
          }
        ]
      }
    ]
  }
}
```

- 1 Specify **true** to skip disk formatting during the installation process.
- 2 Specify this argument to preserve a partition.
- 3 The live installation ISO requires five partitions. Specify a number greater than five to identify the additional partition to preserve.
- 4 Specify the installation disk on the target host.
- 5 Specify the label for the partition.
- 6 Specify the number for the partition.
- 7 Specify the size of partition in MiB.
- 8 Specify the starting position on the disk in MiB for the additional partition. You must specify a starting point larger than the partition for **var/lib/containers**.

Verification

- When you complete the preinstallation of the host with the live installation ISO, login to the target host and run the following command to view the partitions:

```
$ lsblk
```

Example output

```
sda 8:0 0 140G 0 disk
└─sda1 8:1 0 1M 0 part
  ├─sda2 8:2 0 127M 0 part
  ├─sda3 8:3 0 384M 0 part /var/mnt/boot
  ├─sda4 8:4 0 120G 0 part /var/mnt
  └─sda5 8:5 0 500G 0 part /var/lib/containers
    └─sda6 8:6 0 380G 0 part
```

16.3.2. Provisioning the live installation ISO to a host

Using your preferred method, boot the target bare-metal host from the **rhcosh-ibi.iso** live installation ISO to preinstall single-node OpenShift.

Verification

1. Login to the target host.
2. View the system logs by running the following command:

```
$ journalctl -b
```

Example output

```
Aug 13 17:01:44 10.46.26.129 install-rhcos-and-restore-seed.sh[2876]: time="2024-08-13T17:01:44Z" level=info msg="All the precaching threads have finished."
Aug 13 17:01:44 10.46.26.129 install-rhcos-and-restore-seed.sh[2876]: time="2024-08-
```

```

13T17:01:44Z" level=info msg="Total Images: 125"
Aug 13 17:01:44 10.46.26.129 install-rhcos-and-restore-seed.sh[2876]: time="2024-08-
13T17:01:44Z" level=info msg="Images Pulled Successfully: 125"
Aug 13 17:01:44 10.46.26.129 install-rhcos-and-restore-seed.sh[2876]: time="2024-08-
13T17:01:44Z" level=info msg="Images Failed to Pull: 0"
Aug 13 17:01:44 10.46.26.129 install-rhcos-and-restore-seed.sh[2876]: time="2024-08-
13T17:01:44Z" level=info msg="Completed executing pre-caching"
Aug 13 17:01:44 10.46.26.129 install-rhcos-and-restore-seed.sh[2876]: time="2024-08-
13T17:01:44Z" level=info msg="Pre-cached images successfully."
Aug 13 17:01:44 10.46.26.129 install-rhcos-and-restore-seed.sh[2876]: time="2024-08-13
17:01:44" level=info msg="Skipping shutdown"
Aug 13 17:01:44 10.46.26.129 install-rhcos-and-restore-seed.sh[2876]: time="2024-08-13
17:01:44" level=info msg="IBI preparation process finished successfully!"
Aug 13 17:01:44 10.46.26.129 systemd[1]: var-lib-containers-storage-overlay.mount:
Deactivated successfully.
Aug 13 17:01:44 10.46.26.129 systemd[1]: Finished SNO Image-based Installation.
Aug 13 17:01:44 10.46.26.129 systemd[1]: Reached target Multi-User System.
Aug 13 17:01:44 10.46.26.129 systemd[1]: Reached target Graphical Interface.

```

16.3.3. Reference specifications for the image-based-installation-config.yaml manifest

The following content describes the specifications for the **image-based-installation-config.yaml** manifest.

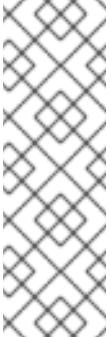
The **openshift-install** program uses the **image-based-installation-config.yaml** manifest to create a live installation ISO for image-based installations of single-node OpenShift.

Table 16.4. Required specifications

Specification	Type	Description
seedImage	string	Specifies the seed image to use in the ISO generation process.
seedVersion	string	Specifies the OpenShift Container Platform release version of the seed image. The release version in the seed image must match the release version that you specify in the seedVersion field.
installationDisk	string	Specifies the disk that will be used for the installation process. Because the disk discovery order is not guaranteed, the kernel name of the disk can change across booting options for machines with multiple disks. For example, /dev/sda becomes /dev/sdb and vice versa. To avoid this issue, you must use a persistent disk attribute, such as the disk World Wide Name (WWN), for example: /dev/disk/by-id/wwn-<disk-id> .

Specification	Type	Description
pullSecret	string	<p>Specifies the pull secret to use during the precache process. The pull secret contains authentication credentials for pulling the release payload images from the container registry.</p> <p>If the seed image requires a separate private registry authentication, add the authentication details to the pull secret.</p>

Table 16.5. Optional specifications

Specification	Type	Description
shutdown	boolean	Specifies if the host shuts down after the installation process completes. The default value is false .
extraPartitionStart	string	Specifies the start of the extra partition used for /var/lib/containers . The default value is -40G , which means that the partition will be exactly 40GiB in size and uses the space 40GiB from the end of the disk. If you specify a positive value, the partition will start at that position of the disk and extend to the end of the disk.
extraPartitionLabel	string	<p>The label of the extra partition you use for /var/lib/containers. The default partition label is var-lib-containers.</p>  <p>NOTE</p> <p>You must ensure that the partition label in the installation ISO matches the partition label set in the machine configuration for the seed image. If the partition labels are different, the partition mount fails during installation on the host. For more information, see "Configuring a shared container partition between ostree stateroots".</p>
extraPartitionNumber	unsigned integer	The number of the extra partition you use for /var/lib/containers . The default number is 5 .
skipDiskCleanup	boolean	The installation process formats the disk on the host. Set this specification to 'true' to skip this step. The default is false .

Specification	Type	Description
networkConfig	string	<p>Specifies networking configurations for the host, for example:</p> <pre>networkConfig: interfaces: - name: ens1f0 type: ethernet state: up ...</pre> <p>If you require static networking, you must install the nmstatectl library on the host that creates the live installation ISO. For further information about defining network configurations by using nmstate, see nmstate.io.</p> <p> IMPORTANT</p> <p>The name of the interface must match the actual NIC name as shown in the operating system.</p>
proxy	string	<p>Specifies proxy settings to use during the installation ISO generation, for example:</p> <pre>proxy: httpProxy: "http://proxy.example.com:8080" httpsProxy: "http://proxy.example.com:8080" noProxy: "no_proxy.example.com"</pre>
imageDigestSources	string	<p>Specifies the sources or repositories for the release-image content, for example:</p> <pre>imageDigestSources: - mirrors: - "registry.example.com:5000/ocp4/openshift4" source: "quay.io/openshift-release-dev/ocp-release"</pre>

Specification	Type	Description
additionalTrustBundle	string	<p>Specifies the PEM-encoded X.509 certificate bundle. The installation program adds this to the /etc/pki/ca-trust/source/anchors directory in the installation ISO.</p> <pre>additionalTrustBundle: -----BEGIN CERTIFICATE----- MTICLDCCAdKgAwfBAglBAGAKBggqhkjOPQRDAjB 9MQswCQYRVEQGE ... I2wOuDwKQa+upc4GftXE7C//4mKBNBC6Ty01gUaT lpo= -----END CERTIFICATE-----</pre>
sshKey	string	Specifies the SSH key to authenticate access to the host.
ignitionConfigOverride	string	Specifies a JSON string containing the user overrides for the Ignition config. The configuration merges with the Ignition config file generated by the installation program. This feature requires Ignition version is 3.2 or later.
coreosInstallerArgs	string	Specifies custom arguments for the coreos-install command that you can use to configure kernel arguments and disk partitioning options.

Additional resources

- [Configuring a shared container partition between ostree stateroots](#)

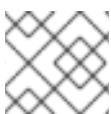
16.4. DEPLOYING SINGLE-NODE OPENSHIFT CLUSTERS

16.4.1. About image-based deployments for managed single-node OpenShift

When a host preinstalled with single-node OpenShift using an image-based installation arrives at a remote site, a technician can easily reconfigure and deploy the host in a matter of minutes.

For clusters with a hub-and-spoke architecture, to complete the deployment of a preinstalled host, you must first define site-specific configuration resources on the hub cluster for each host. These resources contain configuration information such as the properties of the bare-metal host, authentication details, and other deployment and networking information.

The Image Based Install (IBI) Operator creates a configuration ISO from these resources, and then boots the host with the configuration ISO attached. The host mounts the configuration ISO and runs the reconfiguration process. When the reconfiguration completes, the single-node OpenShift cluster is ready.

**NOTE**

You must create distinct configuration resources for each bare-metal host.

See the following high-level steps to deploy a preinstalled host in a cluster with a hub-and-spoke architecture:

1. Install the IBI Operator on the hub cluster.
2. Create site-specific configuration resources in the hub cluster for each host.
3. The IBI Operator creates a configuration ISO from these resources and boots the target host with the configuration ISO attached.
4. The host mounts the configuration ISO and runs the reconfiguration process. When the reconfiguration completes, the single-node OpenShift cluster is ready.

**NOTE**

Alternatively, you can manually deploy a preinstalled host for a cluster without using a hub cluster. You must define an **ImageBasedConfig** resource and an installation manifest, and provide these as inputs to the **openshift-install** installation program. For more information, see "Deploying a single-node OpenShift cluster using the **openshift-install** program".

Additional resources

- [Deploying a single-node OpenShift cluster using the **openshift-install** program](#)

16.4.1.1. Installing the Image Based Install Operator

The Image Based Install (IBI) Operator is part of the image-based deployment workflow for preinstalled single-node OpenShift on bare-metal hosts.

**NOTE**

The IBI Operator is part of the multicluster engine for Kubernetes Operator from MCE version 2.7.

Prerequisites

- You logged in as a user with **cluster-admin** privileges.
- You deployed a Red Hat Advanced Cluster Management (RHACM) hub cluster or you deployed the multicluster engine for Kubernetes Operator.
- You reviewed the required versions of software components in the section "Software prerequisites for an image-based installation".

Procedure

- Set the **enabled** specification to **true** for the **image-based-install-operator** component in the **MultiClusterEngine** resource by running the following command:

```
$ oc patch multiclusterengines.multicloud.openshift.io multicloudengine --type json \
--patch '[{"op": "add", "path": "/spec/overrides/components/-", "value": {"name": "image-based-install-operator", "enabled": true}}]'
```

Verification

- Check that the Image Based Install Operator pod is running by running the following command:

```
$ oc get pods -A | grep image-based
```

Example output

multicloud-engine	image-based-install-operator-57fb8sc423-bxdj8	2/2
Running	0	5m

16.4.1.2. Deploying a managed single-node OpenShift cluster using the IBI Operator

Create the site-specific configuration resources in the hub cluster to initiate the image-based deployment of a preinstalled host.

When you create these configuration resources in the hub cluster, the Image Based Install (IBI) Operator generates a configuration ISO and attaches it to the target host to begin the site-specific configuration process. When the configuration process completes, the single-node OpenShift cluster is ready.



NOTE

For more information about the configuration resources that you must configure in the hub cluster, see "Cluster configuration resources for deploying a preinstalled host".

Prerequisites

- You preinstalled a host with single-node OpenShift using an image-based installation.
- You logged in as a user with **cluster-admin** privileges.
- You deployed a Red Hat Advanced Cluster Management (RHACM) hub cluster or you deployed the multicloud engine for Kubernetes operator (MCE).
- You installed the IBI Operator on the hub cluster.
- You created a pull secret to authenticate pull requests. For more information, see "Using image pull secrets".

Procedure

- Create the **ibi-ns** namespace by running the following command:

```
$ oc create namespace ibi-ns
```

- Create the **Secret** resource for your image registry:

- Create a YAML file that defines the **Secret** resource for your image registry:

Example secret-image-registry.yaml file

```
apiVersion: v1
kind: Secret
metadata:
  name: ibi-image-pull-secret
  namespace: ibi-ns
stringData:
  .dockerconfigjson: <base64-docker-auth-code> ①
type: kubernetes.io/dockerconfigjson
```

- ① You must provide base64-encoded credential details. See the "Additional resources" section for more information about using image pull secrets.

- b. Create the **Secret** resource for your image registry by running the following command:

```
$ oc create -f secret-image-registry.yaml
```

3. Optional: Configure static networking for the host:

- a. Create a **Secret** resource containing the static network configuration in **nmstate** format:

Example host-network-config-secret.yaml file

```
apiVersion: v1
kind: Secret
metadata:
  name: host-network-config-secret ①
  namespace: ibi-ns
type: Opaque
stringData:
  nmstate: | ②
  interfaces:
    - name: ens1f0 ③
      type: ethernet
      state: up
      ipv4:
        enabled: true
        address:
          - ip: 192.168.200.25
            prefix-length: 24
        dhcp: false ④
      ipv6:
        enabled: false
  dns-resolver:
    config:
      server:
        - 192.168.15.47 ⑤
        - 192.168.15.48
  routes:
    config: ⑥
      - destination: 0.0.0.0/0
        metric: 150
```

```
next-hop-address: 192.168.200.254
next-hop-interface: ens1f0
table-id: 254
```

- 1 Specify the name for the **Secret** resource.
- 2 Define the static network configuration in **nmstate** format.
- 3 Specify the name of the interface on the host. The name of the interface must match the actual NIC name as shown in the operating system. To use your MAC address for NIC matching, set the **identifier** field to **mac-address**.
- 4 You must specify **dhcp: false** to ensure **nmstate** assigns the static IP address to the interface.
- 5 Specify one or more DNS servers that the system will use to resolve domain names.
- 6 In this example, the default route is configured through the **ens1f0** interface to the next hop IP address **192.168.200.254**.

4. Create the **BareMetalHost** and **Secret** resources:

a. Create a YAML file that defines the **BareMetalHost** and **Secret** resources:

Example **ibi-bmh.yaml** file

```
apiVersion: metal3.io/v1alpha1
kind: BareMetalHost
metadata:
  name: ibi-bmh 1
  namespace: ibi-ns
spec:
  online: false 2
  bootMACAddress: 00:a5:12:55:62:64 3
  bmc:
    address: redfish-
    virtualmedia+http://192.168.111.1:8000/redfish/v1/Systems/8a5babac-94d0-4c20-b282-
    50dc3a0a32b5 4
    credentialsName: ibi-bmh-bmc-secret 5
    preprovisioningNetworkDataName: host-network-config-secret 6
    automatedCleaningMode: disabled 7
    externallyProvisioned: true 8
---
apiVersion: v1
kind: Secret
metadata:
  name: ibi-bmh-secret 9
  namespace: ibi-ns
  type: Opaque
data:
  username: <user_name> 10
  password: <password> 11
```

- 1 Specify the name for the **BareMetalHost** resource.
- 2 Specify if the host should be online.
- 3 Specify the host boot MAC address.
- 4 Specify the BMC address. You can only use bare-metal host drivers that support virtual media networking booting, for example redfish-virtualmedia and idrac-virtualmedia.
- 5 Specify the name of the bare-metal host **Secret** resource.
- 6 Optional: If you require static network configuration for the host, specify the name of the **Secret** resource containing the configuration.
- 7 You must specify **automatedCleaningMode:disabled** to prevent the provisioning service from deleting all preinstallation artifacts, such as the seed image, during disk inspection.
- 8 You must specify **externallyProvisioned: true** to enable the host to boot from the preinstalled disk, instead of the configuration ISO.
- 9 Specify the name for the **Secret** resource.
- 10 Specify the username.
- 11 Specify the password.

b. Create the **BareMetalHost** and **Secret** resources by running the following command:

```
$ oc create -f ibi-bmh.yaml
```

5. Create the **ClusterImageSet** resource:

a. Create a YAML file that defines the **ClusterImageSet** resource:

Example **ibi-cluster-image-set.yaml** file

```
apiVersion: hive.openshift.io/v1
kind: ClusterImageSet
metadata:
  name: ibi-img-version-arch ①
spec:
  releaseImage: ibi.example.com:path/to/release/images:version-arch ②
```

- 1 Specify the name for the **ClusterImageSet** resource.
- 2 Specify the address for the release image to use for the deployment. If you use a different image registry compared to the image registry used during seed image generation, ensure that the OpenShift Container Platform version for the release image remains the same.

b. Create the **ClusterImageSet** resource by running the following command:

```
$ oc apply -f ibi-cluster-image-set.yaml
```

6. Create the **ImageClusterInstall** resource:

- Create a YAML file that defines the **ImageClusterInstall** resource:

Example ibi-image-cluster-install.yaml file

```
apiVersion: extensions.hive.openshift.io/v1alpha1
kind: ImageClusterInstall
metadata:
  name: ibi-image-install ①
  namespace: ibi-ns
spec:
  bareMetalHostRef:
    name: ibi-bmh ②
    namespace: ibi-ns
  clusterDeploymentRef:
    name: ibi-cluster-deployment ③
  hostname: ibi-host ④
  imageSetRef:
    name: ibi-img-version-arch ⑤
  machineNetwork: 10.0.0.0/24 ⑥
  proxy: ⑦
    httpProxy: "http://proxy.example.com:8080"
    #httpsProxy: "http://proxy.example.com:8080"
    #noProxy: "no_proxy.example.com"
```

- Specify the name for the **ImageClusterInstall** resource.
- Specify the **BareMetalHost** resource that you want to target for the image-based installation.
- Specify the name of the **ClusterDeployment** resource that you want to use for the image-based installation of the target host.
- Specify the hostname for the cluster.
- Specify the name of the **ClusterImageSet** resource you used to define the container release images to use for deployment.
- Specify the public CIDR (Classless Inter-Domain Routing) of the external network.
- Optional: Specify a proxy to use for the cluster deployment.



IMPORTANT

If your cluster deployment requires a proxy configuration, you must do the following:

- Create a seed image from a seed cluster featuring a proxy configuration. The proxy configurations do not have to match.
- Configure the **machineNetwork** field in your installation manifest.

- b. Create the **ImageClusterInstall** resource by running the following command:

```
$ oc create -f ibi-image-cluster-install.yaml
```

7. Create the **ClusterDeployment** resource:

- a. Create a YAML file that defines the **ClusterDeployment** resource:

Example ibi-cluster-deployment.yaml file

```
apiVersion: hive.openshift.io/v1
kind: ClusterDeployment
metadata:
  name: ibi-cluster-deployment ①
  namespace: ibi-ns ②
spec:
  baseDomain: example.com ③
  clusterInstallRef:
    group: extensions.hive.openshift.io
    kind: ImageClusterInstall
    name: ibi-image-install ④
    version: v1alpha1
  clusterName: ibi-cluster ⑤
  platform:
    none: {}
  pullSecretRef:
    name: ibi-image-pull-secret ⑥
```

- ① Specify the name for the **ClusterDeployment** resource.
- ② Specify the namespace for the **ClusterDeployment** resource.
- ③ Specify the base domain that the cluster should belong to.
- ④ Specify the name of the **ImageClusterInstall** in which you defined the container images to use for the image-based installation of the target host.
- ⑤ Specify a name for the cluster.
- ⑥ Specify the secret to use for pulling images from your image registry.

- b. Create the **ClusterDeployment** resource by running the following command:

```
$ oc apply -f ibi-cluster-deployment.yaml
```

8. Create the **ManagedCluster** resource:

- Create a YAML file that defines the **ManagedCluster** resource:

Example ibi-managed.yaml file

```
apiVersion: cluster.open-cluster-management.io/v1
kind: ManagedCluster
metadata:
  name: sno-ibi 1
spec:
  hubAcceptsClient: true 2
```

- Specify the name for the **ManagedCluster** resource.
- Specify **true** to enable RHACM to manage the cluster.

- Create the **ManagedCluster** resource by running the following command:

```
$ oc apply -f ibi-managed.yaml
```

Verification

- Check the status of the **ImageClusterInstall** in the hub cluster to monitor the progress of the target host installation by running the following command:

```
$ oc get imageclusterinstall
```

Example output

NAME	REQUIREMENTSMET	COMPLETED	BAREMETALHOSTREF
target-0	HostValidationSucceeded	ClusterInstallationSucceeded	ibi-bmh



WARNING

If the **ImageClusterInstall** resource is deleted, the IBI Operator reattaches the **BareMetalHost** resource and reboots the machine.

- When the installation completes, you can retrieve the **kubeconfig** secret to log in to the managed cluster by running the following command:

```
$ oc extract secret/<cluster_name>-admin-kubeconfig -n <cluster_namespace> --to - > <directory>/<cluster_name>-kubeconfig
```

- **<cluster_name>** is the name of the cluster.

- **<cluster_namespace>** is the namespace of the cluster.
- **<directory>** is the directory in which to create the file.

Additional resources

- [Using image pull secrets](#)
- [Cluster configuration resources for deploying a preinstalled host](#)

16.4.1.2.1. Cluster configuration resources for deploying a preinstalled host

To complete a deployment for a preinstalled host at a remote site, you must configure the following site-specific cluster configuration resources in the hub cluster for each bare-metal host.

Table 16.6. Cluster configuration resources reference

Resource	Description
Namespace	Namespace for the managed single-node OpenShift cluster.
BareMetalHost	Describes the physical host and its properties, such as the provisioning and hardware configuration.
Secret for the bare-metal host	Credentials for the host BMC.
Secret for the bare-metal host static network configuration	Optional: Describes static network configuration for the target host.
Secret for the image registry	Credentials for the image registry. The secret for the image registry must be of type kubernetes.io/dockerconfigjson .
ImageClusterInstall	References the bare-metal host, deployment, and image set resources.
ClusterImageSet	Describes the release images to use for the cluster.
ClusterDeployment	Describes networking, authentication, and platform-specific settings.
ManagedCluster	Describes cluster details to enable Red Hat Advanced Cluster Management (RHACM) to register and manage.
ConfigMap	Optional: Describes additional configurations for the cluster deployment, such as adding a bundle of trusted certificates for the host to ensure trusted communications for cluster services.

16.4.1.2.2. ImageClusterInstall resource API specifications

The following content describes the API specifications for the **ImageClusterInstall** resource. This resource is the endpoint for the Image Based Install Operator.

Table 16.7. Required specifications

Specification	Type	Description
imageSetRef	string	Specify the name of the ClusterImageSet resource that defines the release images for the deployment.
hostname	string	Specify the hostname for the cluster.
sshKey	string	Specify your SSH key to provide SSH access to the target host.

Table 16.8. Optional specifications

Specification	Type	Description
clusterDeploymentRef	string	Specify the name of the ClusterDeployment resource that you want to use for the image-based installation of the target host.
clusterMetadata	string	After the deployment completes, this specification is automatically populated with metadata information about the cluster, including the cluster-admin kubeconfig credentials for logging in to the cluster.
imageDigestSources	string	Specifies the sources or repositories for the release-image content, for example:
		<pre>imageDigestSources: - mirrors: - "registry.example.com:5000/ocp4/openshift4" source: "quay.io/openshift-release-dev/ocp-release"</pre>
extraManifestsRefs	string	Specify a ConfigMap resource containing additional manifests to be applied to the target cluster.
bareMetalHostRef	string	Specify the bareMetalHost resource to use for the cluster deployment
machineNetwork	string	Specify the public CIDR (Classless Inter-Domain Routing) of the external network.
proxy	string	Specifies proxy settings for the cluster, for example:
		<pre>proxy: httpProxy: "http://proxy.example.com:8080" httpsProxy: "http://proxy.example.com:8080" noProxy: "no_proxy.example.com"</pre>

Specification	Type	Description
caBundleRef	string	Specify a ConfigMap resource containing the new bundle of trusted certificates for the host.

16.4.1.3. ConfigMap resources for extra manifests

You can optionally create a **ConfigMap** resource to define additional manifests in an image-based deployment for managed single-node OpenShift clusters.

After you create the **ConfigMap** resource, reference it in the **ImageClusterInstall** resource. During deployment, the IBI Operator includes the extra manifests in the deployment.

16.4.1.3.1. Creating a ConfigMap resource to add extra manifests in an image-based deployment

You can use a **ConfigMap** resource to add extra manifests to the image-based deployment for single-node OpenShift clusters.

The following example adds an single-root I/O virtualization (SR-IOV) network to the deployment.



NOTE

Filenames for extra manifests must not exceed 30 characters. Longer filenames might cause deployment failures.

Prerequisites

- You preinstalled a host with single-node OpenShift using an image-based installation.
- You logged in as a user with **cluster-admin** privileges.

Procedure

1. Create the **SriovNetworkNodePolicy** and **SriovNetwork** resources:

- a. Create a YAML file that defines the resources:

Example sriov-extra-manifest.yaml file

```

apiVersion: sriovnetwork.openshift.io/v1
kind: SriovNetworkNodePolicy
metadata:
  name: "example-sriov-node-policy"
  namespace: openshift-sriov-network-operator
spec:
  deviceType: vfio-pci
  isRdma: false
  nicSelector:
    pfNames: [ens1f0]
  nodeSelector:
    node-role.kubernetes.io/master: ""
  mtu: 1500
  numVfs: 8

```

```

priority: 99
resourceName: example-sriov-node-policy
---
apiVersion: sriovnetwork.openshift.io/v1
kind: SriovNetwork
metadata:
  name: "example-sriov-network"
  namespace: openshift-sriov-network-operator
spec:
  ipam: |-  

    {  

    }  

  linkState: auto  

  networkNamespace: sriov-namespace  

  resourceName: example-sriov-node-policy  

  spoofChk: "on"  

  trust: "off"

```

- b. Create the **ConfigMap** resource by running the following command:

```
$ oc create configmap sr-iov-extra-manifest --from-file=sriov-extra-manifest.yaml -n ibis  
ns ①
```

- ① Specify the namespace that has the **ImageClusterInstall** resource.

Example output

```
configmap/sr-iov-extra-manifest created
```



NOTE

If you add more than one extra manifest, and the manifests must be applied in a specific order, you must prefix the filenames of the manifests with numbers that represent the required order. For example, **00-namespace.yaml**, **01-sriov-extra-manifest.yaml**, and so on.

2. Reference the **ConfigMap** resource in the **spec.extraManifestsRefs** field of the **ImageClusterInstall** resource:

```
#...
spec:
  extraManifestsRefs:
    - name: sr-iov-extra-manifest
#...
```

16.4.1.3.2. Creating a ConfigMap resource to add a CA bundle in an image-based deployment

You can use a **ConfigMap** resource to add a certificate authority (CA) bundle to the host to ensure trusted communications for cluster services.

After you create the **ConfigMap** resource, reference it in the **spec.caBundleRef** field of the **ImageClusterInstall** resource.

Prerequisites

- You preinstalled a host with single-node OpenShift using an image-based installation.
- You logged in as a user with **cluster-admin** privileges.

Procedure

1. Create a CA bundle file called **tls-ca-bundle.pem**:

Example **tls-ca-bundle.pem** file

```
-----BEGIN CERTIFICATE-----
MIIDXTCCAKWgAwIBAgIJAKmJYKJblyz3MA0GCSqGSIb3DQEBCwUAMEUxCzAJBgNV
...Custom CA certificate bundle...
4WPi0Qb27Sb1xZyAsy1ww6MYb98EovazUSfjYr2EVF6ThcAPu4/sMxUV7He2J6Jd
cA8SMRwpUbz3LXY=
-----END CERTIFICATE-----
```

2. Create the **ConfigMap** object by running the following command:

```
$ oc create configmap custom-ca --from-file=tls-ca-bundle.pem -n ibi-ns
```

- **custom-ca** specifies the name for the **ConfigMap** resource.
- **tls-ca-bundle.pem** defines the key for the **data** entry in the **ConfigMap** resource. You must include a **data** entry with the **tls-ca-bundle.pem** key.
- **ibi-ns** specifies the namespace that has the **ImageClusterInstall** resource.

Example output

```
configmap/custom-ca created
```

3. Reference the **ConfigMap** resource in the **spec.caBundleRef** field of the **ImageClusterInstall** resource:

```
#...
spec:
  caBundleRef:
    name: custom-ca
#...
```

Additional resources

- [About the BareMetalHost resource](#)
- [Using image pull secrets](#)
- [Reference specifications for the image-based-config.yaml manifest](#)

16.4.2. About image-based deployments for single-node OpenShift

You can manually generate a configuration ISO by using the **openshift-install** program. Attach the configuration ISO to your preinstalled target host to complete the deployment.

16.4.2.1. Deploying a single-node OpenShift cluster using the **openshift-install** program

You can use the **openshift-install** program to configure and deploy a host that you preinstalled with an image-based installation. To configure the target host with site-specific details, you must create the following resources:

- The **install-config.yaml** installation manifest
- The **image-based-config.yaml** manifest

The **openshift-install** program uses these resources to generate a configuration ISO that you attach to the preinstalled target host to complete the deployment.



NOTE

For more information about the specifications for the **image-based-config.yaml** manifest, see "Reference specifications for the image-based-config.yaml manifest".

Prerequisites

- You preinstalled a host with single-node OpenShift using an image-based installation.
- You downloaded the latest version of the **openshift-install** program.
- You created a pull secret to authenticate pull requests. For more information, see "Using image pull secrets".

Procedure

1. Create a working directory by running the following:

```
$ mkdir ibi-config-iso-workdir ①
```

① Replace **ibi-config-iso-workdir** with the name of your working directory.

2. Create the installation manifest:

- a. Create a YAML file that defines the **install-config** manifest:

Example **install-config.yaml** file

```
apiVersion: v1
metadata:
  name: sno-cluster-name
baseDomain: host.example.com
compute:
  - architecture: amd64
    hyperthreading: Enabled
    name: worker
    replicas: 0
controlPlane:
```

```

architecture: amd64
hyperthreading: Enabled
name: master
replicas: 1
networking:
  machineNetwork:
    - cidr: 192.168.200.0/24
platform:
  none: {}
fips: false
cpuPartitioningMode: "AllNodes"
pullSecret: '{"auths": {"<your_pull_secret>": {}}}'
sshKey: 'ssh-rsa <your_ssh_pub_key>'
```



IMPORTANT

If your cluster deployment requires a proxy configuration, you must do the following:

- Create a seed image from a seed cluster featuring a proxy configuration. The proxy configurations do not have to match.
- Configure the **machineNetwork** field in your installation manifest.

- Save the file in your working directory.
- Optional. Create a configuration template in your working directory by running the following command:

```
$ openshift-install image-based create config-template --dir ibi-config-iso-workdir/
```

Example output

```
INFO Config-Template created in: ibi-config-iso-workdir
```

The command creates the **image-based-config.yaml** configuration template in your working directory:

```

#
# Note: This is a sample ImageBasedConfig file showing
# which fields are available to aid you in creating your
# own image-based-config.yaml file.
#
apiVersion: v1beta1
kind: ImageBasedConfig
metadata:
  name: example-image-based-config
additionalNTPSources:
  - 0.rhel.pool.ntp.org
  - 1.rhel.pool.ntp.org
hostname: change-to-hostname
releaseRegistry: quay.io
# networkConfig contains the network configuration for the host in NMState format.
# See https://nmstate.io/examples.html for examples.
```

```

networkConfig:
  interfaces:
    - name: eth0
      type: ethernet
      state: up
      mac-address: 00:00:00:00:00:00
      ipv4:
        enabled: true
        address:
          - ip: 192.168.122.2
            prefix-length: 23
        dhcp: false

```

4. Edit your configuration file:

Example `image-based-config.yaml` file

```

#
# Note: This is a sample ImageBasedConfig file showing
# which fields are available to aid you in creating your
# own image-based-config.yaml file.
#
apiVersion: v1beta1
kind: ImageBasedConfig
metadata:
  name: sno-cluster-name
additionalNTPSources:
  - 0.rhel.pool.ntp.org
  - 1.rhel.pool.ntp.org
hostname: host.example.com
releaseRegistry: quay.io
# networkConfig contains the network configuration for the host in NMState format.
# See https://nmstate.io/examples.html for examples.
networkConfig:
  interfaces:
    - name: ens1f0
      type: ethernet
      state: up
      ipv4:
        enabled: true
        dhcp: false
        auto-dns: false
        address:
          - ip: 192.168.200.25
            prefix-length: 24
      ipv6:
        enabled: false
  dns-resolver:
    config:
      server:
        - 192.168.15.47
        - 192.168.15.48
  routes:
    config:
      - destination: 0.0.0.0/0

```

```
metric: 150
next-hop-address: 192.168.200.254
next-hop-interface: ens1f0
```

5. Create the configuration ISO in your working directory by running the following command:

```
$ openshift-install image-based create config-image --dir ibi-config-iso-workdir/
```

Example output

```
INFO Adding NMConnection file <ens1f0.nmconnection>
INFO Consuming Install Config from target directory
INFO Consuming Image-based Config ISO configuration from target directory
INFO Config-Image created in: ibi-config-iso-workdir/auth
```

View the output in the working directory:

Example output

```
ibi-config-iso-workdir/
└── auth
    ├── kubeadmin-password
    └── kubeconfig
        └── imagebasedconfig.iso
```

6. Attach the **imagebasedconfig.iso** to the preinstalled host using your preferred method and restart the host to complete the configuration process and deploy the cluster.

Verification

When the configuration process completes on the host, access the cluster to verify its status.

1. Export the **kubeconfig** environment variable to your kubeconfig file by running the following command:

```
$ export KUBECONFIG=ibi-config-iso-workdir/auth/kubeconfig
```

2. Verify that the cluster is responding by running the following command:

```
$ oc get nodes
```

Example output

NAME	STATUS	ROLES	AGE	VERSION
node/sno-cluster-name.host.example.com	Ready	control-plane,master	5h15m	v1.31.3

Additional resources

- [Using image pull secrets](#)
- [Reference specifications for the **image-based-installation-config.yaml** manifest](#)

16.4.2.1.1. Reference specifications for the image-based-config.yaml manifest

The following content describes the specifications for the **image-based-config.yaml** manifest.

The **openshift-install** program uses the **image-based-config.yaml** manifest to create a site-specific configuration ISO for image-based deployments of single-node OpenShift.

Table 16.9. Required specifications

Specification	Type	Description
hostname	string	Define the name of the node for the single-node OpenShift cluster.

Table 16.10. Optional specifications

Specification	Type	Description
networkConfig	string	<p>Specifies networking configurations for the host, for example:</p> <pre>networkConfig: interfaces: - name: ens1f0 type: ethernet state: up ... </pre> <p>If you require static networking, you must install the nmstatectl library on the host that creates the live installation ISO. For further information about defining network configurations by using nmstate, see nmstate.io.</p> <p> IMPORTANT</p> <p>The name of the interface must match the actual NIC name as shown in the operating system.</p>
additionalINTPSources	string	Specifies a list of NTP sources for all cluster hosts. These NTP sources are added to any existing NTP sources in the cluster. You can use the hostname or IP address for the NTP source.
releaseRegistry	string	Specifies the container image registry that you used for the release image of the seed cluster.

Specification	Type	Description
nodeLabels	map[string]string	<p>Specifies custom node labels for the single-node OpenShift node, for example:</p> <pre>nodeLabels: node-role.kubernetes.io/edge: true environment: production</pre>

16.4.2.2. Configuring resources for extra manifests

You can optionally define additional resources in an image-based deployment for single-node OpenShift clusters.

Create the additional resources in an **extra-manifests** folder in the same working directory that has the **install-config.yaml** and **image-based-config.yaml** manifests.



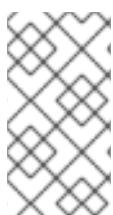
NOTE

Filenames for additional resources in the **extra-manifests** directory must not exceed 30 characters. Longer filenames might cause deployment failures.

16.4.2.2.1. Creating a resource in the extra-manifests folder

You can create a resource in the **extra-manifests** folder of your working directory to add extra manifests to the image-based deployment for single-node OpenShift clusters.

The following example adds an single-root I/O virtualization (SR-IOV) network to the deployment.



NOTE

If you add more than one extra manifest, and the manifests must be applied in a specific order, you must prefix the filenames of the manifests with numbers that represent the required order. For example, **00-namespace.yaml**, **01-sriov-extra-manifest.yaml**, and so on.

Prerequisites

- You created a working directory with the **install-config.yaml** and **image-based-config.yaml** manifests

Procedure

1. Go to your working directory and create the **extra-manifests** folder by running the following command:

```
$ mkdir extra-manifests
```

2. Create the **SriovNetworkNodePolicy** and **SriovNetwork** resources in the **extra-manifests** folder:

- a. Create a YAML file that defines the resources:

Example sriov-extra-manifest.yaml file

```

apiVersion: sriovnetwork.openshift.io/v1
kind: SriovNetworkNodePolicy
metadata:
  name: "example-sriov-node-policy"
  namespace: openshift-sriov-network-operator
spec:
  deviceType: vfio-pci
  isRdma: false
  nicSelector:
    pfNames: [ens1f0]
  nodeSelector:
    node-role.kubernetes.io/master: ""
  mtu: 1500
  numVfs: 8
  priority: 99
  resourceName: example-sriov-node-policy
---
apiVersion: sriovnetwork.openshift.io/v1
kind: SriovNetwork
metadata:
  name: "example-sriov-network"
  namespace: openshift-sriov-network-operator
spec:
  ipam: |- 
    {
    }
  linkState: auto
  networkNamespace: sriov-namespace
  resourceName: example-sriov-node-policy
  spoofChk: "on"
  trust: "off"

```

Verification

- When you create the configuration ISO, you can view the reference to the extra manifests in the **.openshift_install_state.json** file in your working directory:

```

  "*configimage.ExtraManifests": {
    "FileList": [
      {
        "Filename": "extra-manifests/sriov-extra-manifest.yaml",
        "Data": "YXBFDFFD..."
      }
    ]
  }

```

CHAPTER 17. DAY 2 OPERATIONS FOR TELCO CORE CNF CLUSTERS

17.1. DAY 2 OPERATIONS FOR TELCO CORE CNF CLUSTERS

You can use the following Day 2 operations to manage telco core CNF clusters.

Updating a telco core CNF cluster

Updating your cluster is a critical task that ensures that bugs and potential security vulnerabilities are patched. For more information, see [Updating a telco core CNF cluster](#).

Troubleshooting and maintaining telco core CNF clusters

To maintain and troubleshoot a bare-metal environment where high-bandwidth network throughput is required, see [see Troubleshooting and maintaining telco core CNF clusters](#).

Observability in telco core CNF clusters

OpenShift Container Platform generates a large amount of data, such as performance metrics and logs from the platform and the workloads running on it. As an administrator, you can use tools to collect and analyze the available data. For more information, see [Observability in telco core CNF clusters](#).

Security

You can enhance security for high-bandwidth network deployments in telco environments by following key security considerations. For more information, see [Security basics](#).

17.2. UPGRADING TELCO CORE CNF CLUSTERS

17.2.1. Updating a telco core CNF cluster

OpenShift Container Platform has long term support or extended update support (EUS) on all even releases and update paths between EUS releases. You can update from one EUS version to the next EUS version. It is also possible to update between y-stream and z-stream versions.

17.2.1.1. Cluster updates for telco core CNF clusters

Updating your cluster is a critical task that ensures that bugs and potential security vulnerabilities are patched. Often, updates to cloud-native network functions (CNF) require additional functionality from the platform that comes when you update the cluster version. You also must update the cluster periodically to ensure that the cluster platform version is supported.

You can minimize the effort required to stay current with updates by keeping up-to-date with EUS releases and upgrading to select important z-stream releases only.



NOTE

The update path for the cluster can vary depending on the size and topology of the cluster. The update procedures described here are valid for most clusters from 3-node clusters up to the largest size clusters certified by the telco scale team. This includes some scenarios for mixed-workload clusters.

The following update scenarios are described:

- Control Plane Only updates

- Y-stream updates
- Z-stream updates



IMPORTANT

Control Plane Only updates were previously known as EUS-to-EUS updates. Control Plane Only updates are only viable between even-numbered minor versions of OpenShift Container Platform.

17.2.2. Verifying cluster API versions between update versions

APIs change over time as components are updated. It is important to verify that cloud-native network function (CNF) APIs are compatible with the updated cluster version.

17.2.2.1. OpenShift Container Platform API compatibility

When considering what z-stream release to update to as part of a new y-stream update, you must be sure that all the patches that are in the z-stream version you are moving from are in the new z-stream version. If the version you update to does not have all the required patches, the built-in compatibility of Kubernetes is broken.

For example, if the cluster version is 4.15.32, you must update to 4.16 z-stream release that has all of the patches that are applied to 4.15.32.

17.2.2.1.1. About Kubernetes version skew

Each cluster Operator supports specific API versions. Kubernetes APIs evolve over time, and newer versions can be deprecated or change existing APIs. This is referred to as "version skew". For every new release, you must review the API changes. The APIs might be compatible across several releases of an Operator, but compatibility is not guaranteed. To mitigate against problems that arise from version skew, follow a well-defined update strategy.

Additional resources

- [Understanding API tiers](#)
- [Kubernetes version skew policy](#)

17.2.2.2. Determining the cluster version update path

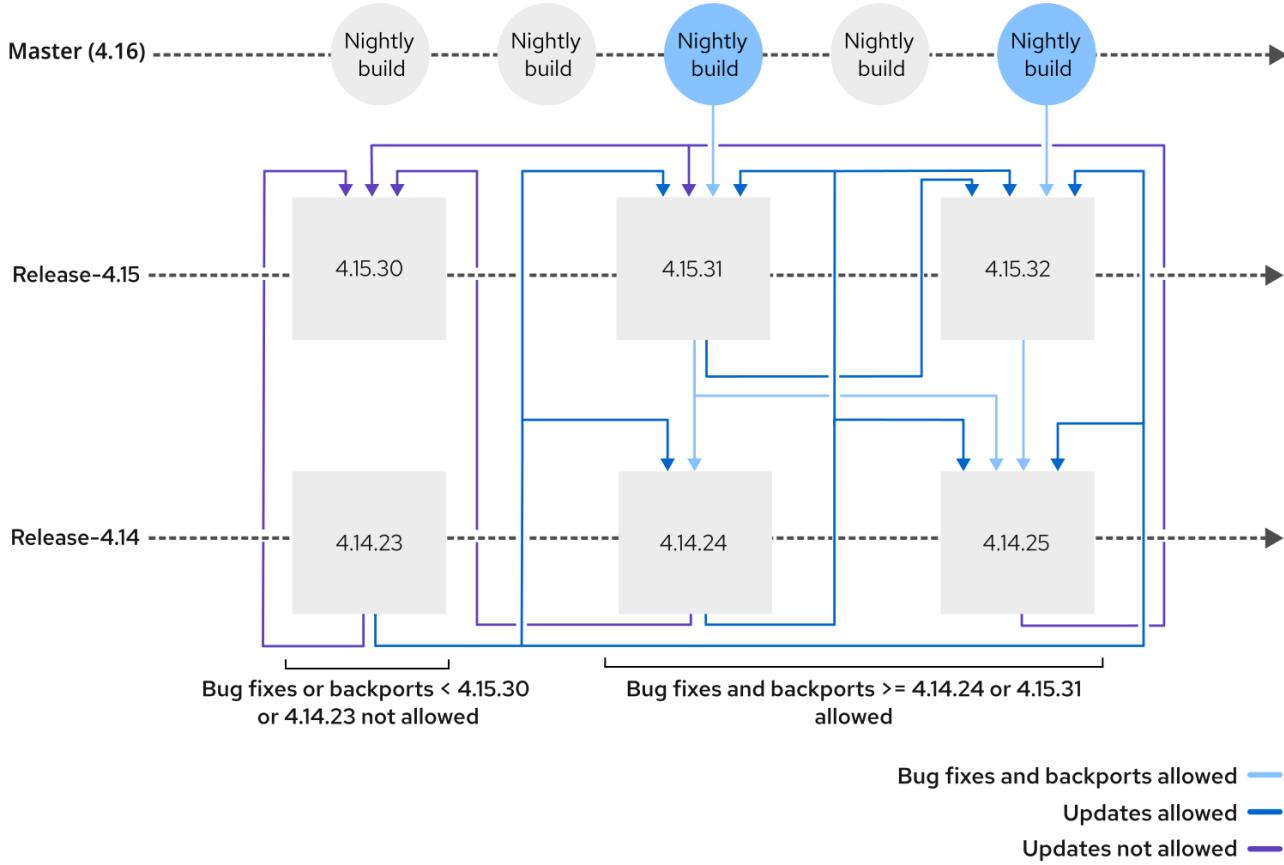
Use the [Red Hat OpenShift Container Platform Update Graph](#) tool to determine if the path is valid for the z-stream release you want to update to. Verify the update with your Red Hat Technical Account Manager to ensure that the update path is valid for telco implementations.



IMPORTANT

The <4.y+1.z> or <4.y+2.z> version that you update to must have the same patch level as the <4.y.z> release you are updating from.

The OpenShift update process mandates that if a fix is present in a specific <4.y.z> release, then that fix must be present in the <4.y+1.z> release that you update to.

Figure 17.1. Bug fix backporting and the update graph

IMPORTANT

OpenShift development has a strict backport policy that prevents regressions. For example, a bug must be fixed in 4.16.z before it is fixed in 4.15.z. This means that the update graph does not allow for updates to chronologically older releases even if the minor version is greater, for example, updating from 4.15.24 to 4.16.2.

Additional resources

- [Understanding update channels and releases](#)

17.2.2.3. Selecting the target release

Use the [Red Hat OpenShift Container Platform Update Graph](#) or the [cincinnati-graph-data repository](#) to determine what release to update to.

17.2.2.3.1. Determining what z-stream updates are available

Before you can update to a new z-stream release, you need to know what versions are available.



NOTE

You do not need to change the channel when performing a z-stream update.

Procedure

1. Determine which z-stream releases are available. Run the following command:

```
$ oc adm upgrade
```

Example output

Cluster version is 4.14.34

Upstream is unset, so the cluster will use an appropriate default.
Channel: stable-4.14 (available channels: candidate-4.14, candidate-4.15, eus-4.14, eus-4.16, fast-4.14, fast-4.15, stable-4.14, stable-4.15)

Recommended updates:

VERSION	IMAGE
4.14.37	quay.io/openshift-release-dev/ocp-release@sha256:14e6ba3975e6c73b659fa55af25084b20ab38a543772ca70e184b903db73092b
4.14.36	quay.io/openshift-release-dev/ocp-release@sha256:4bc4925e8028158e3f313aa83e59e181c94d88b4aa82a3b00202d6f354e8fed
4.14.35	quay.io/openshift-release-dev/ocp-release@sha256:883088e3e6efa7443b0ac28cd7682c2fdbda889b576edad626769bf956ac0858

17.2.2.3.2. Changing the channel for a Control Plane Only update

You must change the channel to the required version for a Control Plane Only update.



NOTE

You do not need to change the channel when performing a z-stream update.

Procedure

- Determine the currently configured update channel:

```
$ oc get clusterversion -o=jsonpath='{.items[*].spec}' | jq
```

Example output

```
{
  "channel": "stable-4.14",
  "clusterID": "01eb9a57-2fb-4f50-9d37-dc04bd5bac75"
}
```

- Change the channel to point to the new channel you want to update to:

```
$ oc adm upgrade channel eus-4.16
```

- Confirm the updated channel:

```
$ oc get clusterversion -o=jsonpath='{.items[*].spec}' | jq
```

Example output

```
{
  "channel": "eus-4.16",
  "clusterID": "01eb9a57-2bfb-4f50-9d37-dc04bd5bac75"
}
```

17.2.2.3.2.1. Changing the channel for an early EUS to EUS update

The update path to a brand new release of OpenShift Container Platform is not available in either the EUS channel or the stable channel until 45 to 90 days after the initial GA of a minor release.

To begin testing an update to a new release, you can use the fast channel.

Procedure

1. Change the channel to **fast-<y+1>**. For example, run the following command:

```
$ oc adm upgrade channel fast-4.16
```

2. Check the update path from the new channel. Run the following command:

```
$ oc adm upgrade
```

Cluster version is 4.15.33

Upgradeable=False

Reason: AdminAckRequired

Message: Kubernetes 1.28 and therefore OpenShift 4.16 remove several APIs which require admin consideration. Please see the knowledge article <https://access.redhat.com/articles/6958394> for details and instructions.

Upstream is unset, so the cluster will use an appropriate default.

Channel: fast-4.16 (available channels: candidate-4.15, candidate-4.16, eus-4.15, eus-4.16, fast-4.15, fast-4.16, stable-4.15, stable-4.16)

Recommended updates:

VERSION	IMAGE
4.16.14	quay.io/openshift-release-dev/ocp-release@sha256:6618dd3c0f5
4.16.13	quay.io/openshift-release-dev/ocp-release@sha256:7a72abc3
4.16.12	quay.io/openshift-release-dev/ocp-release@sha256:1c8359fc2
4.16.11	quay.io/openshift-release-dev/ocp-release@sha256:bc9006febfe
4.16.10	quay.io/openshift-release-dev/ocp-release@sha256:dece7b61b1
4.15.36	quay.io/openshift-release-dev/ocp-release@sha256:c31a56d19
4.15.35	quay.io/openshift-release-dev/ocp-release@sha256:f21253
4.15.34	quay.io/openshift-release-dev/ocp-release@sha256:2dd69c5

3. Follow the update procedure to get to version 4.16 (<y+1> from version 4.15)

**NOTE**

You can keep your worker nodes paused between EUS releases even if you are using the fast channel.

4. When you get to the required <y+1> release, change the channel again, this time to **fast-<y+2>**.
5. Follow the EUS update procedure to get to the required <y+2> release.

17.2.2.3.3. Changing the channel for a y-stream update

In a y-stream update you change the channel to the next release channel.

**NOTE**

Use the stable or EUS release channels for production clusters.

Procedure

1. Change the update channel:

```
$ oc adm upgrade channel stable-4.15
```

2. Check the update path from the new channel. Run the following command:

```
$ oc adm upgrade
```

Example output

```
Cluster version is 4.14.34
```

```
Upgradeable=False
```

```
Reason: AdminAckRequired
```

```
Message: Kubernetes 1.27 and therefore OpenShift 4.15 remove several APIs which require admin consideration. Please see the knowledge article  

https://access.redhat.com/articles/6958394 for details and instructions.
```

```
Upstream is unset, so the cluster will use an appropriate default.
```

```
Channel: stable-4.15 (available channels: candidate-4.14, candidate-4.15, eus-4.14, eus-4.15, fast-4.14, fast-4.15, stable-4.14, stable-4.15)
```

```
Recommended updates:
```

VERSION	IMAGE
4.15.33	quay.io/openshift-release-dev/ocp-release@sha256:7142dd4b560
4.15.32	quay.io/openshift-release-dev/ocp-release@sha256:cda8ea5b13dc9
4.15.31	quay.io/openshift-release-dev/ocp-release@sha256:07cf61e67d3eeee
4.15.30	quay.io/openshift-release-dev/ocp-release@sha256:6618dd3c0f5
4.15.29	quay.io/openshift-release-dev/ocp-release@sha256:7a72abc3
4.15.28	quay.io/openshift-release-dev/ocp-release@sha256:1c8359fc2
4.15.27	quay.io/openshift-release-dev/ocp-release@sha256:bc9006febfe
4.15.26	quay.io/openshift-release-dev/ocp-release@sha256:dece7b61b1
4.14.38	quay.io/openshift-release-dev/ocp-release@sha256:c93914c62d7

- 4.14.37 quay.io/openshift-release-dev/ocp-release@sha256:c31a56d19
- 4.14.36 quay.io/openshift-release-dev/ocp-release@sha256:f21253
- 4.14.35 quay.io/openshift-release-dev/ocp-release@sha256:2dd69c5

17.2.3. Preparing the telco core cluster platform for update

Typically, telco clusters run on bare-metal hardware. Often you must update the firmware to take on important security fixes, take on new functionality, or maintain compatibility with the new release of OpenShift Container Platform.

17.2.3.1. Ensuring the host firmware is compatible with the update

You are responsible for the firmware versions that you run in your clusters. Updating host firmware is not a part of the OpenShift Container Platform update process. It is not recommended to update firmware in conjunction with the OpenShift Container Platform version.



IMPORTANT

Hardware vendors advise that it is best to apply the latest certified firmware version for the specific hardware that you are running. For telco use cases, always verify firmware updates in test environments before applying them in production. The high throughput nature of telco CNF workloads can be adversely affected by sub-optimal host firmware.

You should thoroughly test new firmware updates to ensure that they work as expected with the current version of OpenShift Container Platform. Ideally, you test the latest firmware version with the target OpenShift Container Platform update version.

17.2.3.2. Ensuring that layered products are compatible with the update

Verify that all layered products run on the version of OpenShift Container Platform that you are updating to before you begin the update. This generally includes all Operators.

Procedure

- Verify the currently installed Operators in the cluster. For example, run the following command:

```
$ oc get csv -A
```

Example output

NAMESPACE PHASE	NAME	DISPLAY	VERSION	REPLACES
gitlab-operator-kubernetes.v0.17.2	GitLab		0.17.2	gitlab-operator-
kubernetes.v0.17.1	Succeeded			
openshift-operator-lifecycle-manager	packageserver	Package Server	0.19.0	
				Succeeded

- Check that Operators that you install with OLM are compatible with the update version. Operators that are installed with the Operator Lifecycle Manager (OLM) are not part of the standard cluster Operators set.

Use the [Operator Update Information Checker](#) to understand if you must update an Operator after each y-stream update or if you can wait until you have fully updated to the next EUS release.

TIP

You can also use the [Operator Update Information Checker](#) to see what versions of OpenShift Container Platform are compatible with specific releases of an Operator.

3. Check that Operators that you install outside of OLM are compatible with the update version. For all OLM-installed Operators that are not directly supported by Red Hat, contact the Operator vendor to ensure release compatibility.
 - Some Operators are compatible with several releases of OpenShift Container Platform. You might not must update the Operators until after you complete the cluster update. See "Updating the worker nodes" for more information.
 - See "Updating all the OLM Operators" for information about updating an Operator after performing the first y-stream control plane update.

Additional resources

- [Updating the worker nodes](#)
- [Updating all the OLM Operators](#)

17.2.3.3. Applying MachineConfigPool labels to nodes before the update

Prepare **MachineConfigPool (mcp)** node labels to group nodes together in groups of roughly 8 to 10 nodes. With **mcp** groups, you can reboot groups of nodes independently from the rest of the cluster.

You use the **mcp** node labels to pause and unpause the set of nodes during the update process so that you can do the update and reboot at a time of your choosing.

17.2.3.3.1. Staggering the cluster update

Sometimes there are problems during the update. Often the problem is related to hardware failure or nodes needing to be reset. Using **mcp** node labels, you can update nodes in stages by pausing the update at critical moments, tracking paused and unpause nodes as you proceed. When a problem occurs, you use the nodes that are in an unpause state to ensure that there are enough nodes running to keep all applications pods running.

17.2.3.3.2. Dividing worker nodes into MachineConfigPool groups

How you divide worker nodes into **mcp** groups can vary depending on how many nodes are in the cluster or how many nodes you assign to a node role. By default the 2 roles in a cluster are control plane and worker.

In clusters that run telco workloads, you can further split the worker nodes between CNF control plane and CNF data plane roles. Add **mcp** role labels that split the worker nodes into each of these two groups.

**NOTE**

Larger clusters can have as many as 100 worker nodes in the CNF control plane role. No matter how many nodes there are in the cluster, keep each **MachineConfigPool** group to around 10 nodes. This allows you to control how many nodes are taken down at a time. With multiple **MachineConfigPool** groups, you can unpause several groups at a time to accelerate the update, or separate the update over 2 or more maintenance windows.

Example cluster with 15 worker nodes

Consider a cluster with 15 worker nodes:

- 10 worker nodes are CNF control plane nodes.
- 5 worker nodes are CNF data plane nodes.

Split the CNF control plane and data plane worker node roles into at least 2 **mcp** groups each. Having 2 **mcp** groups per role means that you can have one set of nodes that are not affected by the update.

Example cluster with 6 worker nodes

Consider a cluster with 6 worker nodes:

- Split the worker nodes into 3 **mcp** groups of 2 nodes each.

Upgrade one of the **mcp** groups. Allow the updated nodes to sit through a day to allow for verification of CNF compatibility before completing the update on the other 4 nodes.

**IMPORTANT**

The process and pace at which you unpause the **mcp** groups is determined by your CNF applications and configuration.

If your CNF pod can handle being scheduled across nodes in a cluster, you can unpause several **mcp** groups at a time and set the **MaxUnavailable** in the **mcp** custom resource (CR) to as high as 50%. This allows up to half of the nodes in an **mcp** group to restart and get updated.

17.2.3.3.3. Reviewing configured cluster MachineConfigPool roles

Review the currently configured **MachineConfigPool** roles in the cluster.

Procedure

1. Get the currently configured **mcp** groups in the cluster:

```
$ oc get mcp
```

Example output

NAME	CONFIG	UPDATED	UPDATING	DEGRADED	MACHINECOUNT	READYMACHINECOUNT	UPDATEDMACHINECOUNT	DEGRADEDMACHINECOUNT	AGE
master	rendered-master-bere83	True	False	False	3	3	3	3	3

0	25d									
worker	rendered-worker-245c4f	True	False	False	2					2
0	25d									

2. Compare the list of **mcp** roles to list of nodes in the cluster:

```
$ oc get nodes
```

Example output

NAME	STATUS	ROLES	AGE	VERSION
ctrl-plane-0	Ready	control-plane,master	39d	v1.27.15+6147456
ctrl-plane-1	Ready	control-plane,master	39d	v1.27.15+6147456
ctrl-plane-2	Ready	control-plane,master	39d	v1.27.15+6147456
worker-0	Ready	worker	39d	v1.27.15+6147456
worker-1	Ready	worker	39d	v1.27.15+6147456



NOTE

When you apply an **mcp** group change, the node roles are updated.

Determine how you want to separate the worker nodes into **mcp** groups.

17.2.3.3.4. Creating MachineConfigPool groups for the cluster

Creating **mcp** groups is a 2-step process:

1. Add an **mcp** label to the nodes in the cluster
2. Apply an **mcp** CR to the cluster that organizes the nodes based on their labels

Procedure

1. Label the nodes so that they can be put into **mcp** groups. Run the following commands:

```
$ oc label node worker-0 node-role.kubernetes.io/mcp-1=
```

```
$ oc label node worker-1 node-role.kubernetes.io/mcp-2=
```

The **mcp-1** and **mcp-2** labels are applied to the nodes. For example:

Example output

NAME	STATUS	ROLES	AGE	VERSION
ctrl-plane-0	Ready	control-plane,master	39d	v1.27.15+6147456
ctrl-plane-1	Ready	control-plane,master	39d	v1.27.15+6147456
ctrl-plane-2	Ready	control-plane,master	39d	v1.27.15+6147456
worker-0	Ready	mcp-1,worker	39d	v1.27.15+6147456
worker-1	Ready	mcp-2,worker	39d	v1.27.15+6147456

2. Create YAML custom resources (CRs) that apply the labels as **mcp** CRs in the cluster. Save the following YAML in the **mcps.yaml** file:

-

```

---
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfigPool
metadata:
  name: mcp-2
spec:
  machineConfigSelector:
    matchExpressions:
      - {
        key: machineconfiguration.openshift.io/role,
        operator: In,
        values: [worker,mcp-2]
      }
  nodeSelector:
    matchLabels:
      node-role.kubernetes.io/mcp-2: ""
---
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfigPool
metadata:
  name: mcp-1
spec:
  machineConfigSelector:
    matchExpressions:
      - {
        key: machineconfiguration.openshift.io/role,
        operator: In,
        values: [worker,mcp-1]
      }
  nodeSelector:
    matchLabels:
      node-role.kubernetes.io/mcp-1: ""

```

3. Create the **MachineConfigPool** resources:

```
$ oc apply -f mcps.yaml
```

Example output

```
machineconfigpool.machineconfiguration.openshift.io/mcp-2 created
```

Verification

Monitor the **MachineConfigPool** resources as they are applied in the cluster. After you apply the **mcp** resources, the nodes are added into the new machine config pools. This takes a few minutes.



NOTE

The nodes do not reboot while being added into the **mcp** groups. The original worker and master **mcp** groups remain unchanged.

- Check the status of the new **mcp** resources:

```
$ oc get mcp
```

Example output

	NAME	CONFIG	UPDATED	UPDATING	DEGRADED	MACHINECOUNT	READYMACHINECOUNT	UPDATEDMACHINECOUNT	DEGRADEDMACHINECOUNT
	AGE								
0	master	rendered-master-be3e83	True	False	False	3	3	3	3
0	mcp-1	rendered-mcp-1-2f4c4f	False	True	True	1	0	0	0
0	mcp-2	rendered-mcp-2-2r4s1f	False	True	True	1	0	0	0
2	worker	rendered-worker-23fc4f	False	True	True	0	0	0	0
		25d							

Eventually, the resources are fully applied:

	NAME	CONFIG	UPDATED	UPDATING	DEGRADED	MACHINECOUNT	READYMACHINECOUNT	UPDATEDMACHINECOUNT	DEGRADEDMACHINECOUNT
	AGE								
0	master	rendered-master-be3e83	True	False	False	3	3	3	3
0	mcp-1	rendered-mcp-1-2f4c4f	True	False	False	1	1	1	1
0	mcp-2	rendered-mcp-2-2r4s1f	True	False	False	1	1	1	1
0	worker	rendered-worker-23fc4f	True	False	False	0	0	0	0
		25d							

Additional resources

- [Performing a Control Plane Only update](#)
- [Factors affecting update duration](#)
- [Ensuring that CNF workloads run uninterrupted with pod disruption budgets](#)
- [Ensuring that pods do not run on the same cluster node](#)

17.2.3.4. Telco deployment environment considerations

In telco environments, most clusters are in disconnected networks. To update clusters in these environments, you must update your offline image repository.

Additional resources

- [API compatibility guidelines](#)
- [Mirroring images for a disconnected installation by using the oc-mirror plugin v2](#)

17.2.3.5. Preparing the cluster platform for update

Before you update the cluster, perform some basic checks and verifications to make sure that the cluster is ready for the update.

Procedure

- Verify that there are no failed or in progress pods in the cluster by running the following command:

```
$ oc get pods -A | grep -E -vi 'complete|running'
```



NOTE

You might have to run this command more than once if there are pods that are in a pending state.

- Verify that all nodes in the cluster are available:

```
$ oc get nodes
```

Example output

NAME	STATUS	ROLES	AGE	VERSION
ctrl-plane-0	Ready	control-plane,master	32d	v1.27.15+6147456
ctrl-plane-1	Ready	control-plane,master	32d	v1.27.15+6147456
ctrl-plane-2	Ready	control-plane,master	32d	v1.27.15+6147456
worker-0	Ready	mcp-1,worker	32d	v1.27.15+6147456
worker-1	Ready	mcp-2,worker	32d	v1.27.15+6147456

- Verify that all bare-metal nodes are provisioned and ready.

```
$ oc get bmh -n openshift-machine-api
```

Example output

NAME	STATE	CONSUMER	ONLINE	ERROR	AGE
ctrl-plane-0	unmanaged	cnf-58879-master-0	true		33d
ctrl-plane-1	unmanaged	cnf-58879-master-1	true		33d
ctrl-plane-2	unmanaged	cnf-58879-master-2	true		33d
worker-0	unmanaged	cnf-58879-worker-0-45879	true		33d
worker-1	progressing	cnf-58879-worker-0-dszsh	false		1d 1

- An error occurred while provisioning the **worker-1** node.

Verification

- Verify that all cluster Operators are ready:

```
$ oc get co
```

Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED
SINCE MESSAGE authentication	4.14.34	True	False	False 17h

baremetal	4.14.34	True	False	False	32d
...					
service-ca	4.14.34	True	False	False	32d
storage	4.14.34	True	False	False	32d

Additional resources

- [Investigating pod issues](#)

17.2.4. Configuring CNF pods before updating the telco core CNF cluster

Follow the guidance in [Red Hat best practices for Kubernetes](#) when developing cloud-native network functions (CNFs) to ensure that the cluster can schedule pods during an update.



IMPORTANT

Always deploy pods in groups by using **Deployment** resources. **Deployment** resources spread the workload across all of the available pods ensuring there is no single point of failure. When a pod that is managed by a **Deployment** resource is deleted, a new pod takes its place automatically.

Additional resources

- [Red Hat best practices for Kubernetes](#)

17.2.4.1. Ensuring that CNF workloads run uninterrupted with pod disruption budgets

You can configure the minimum number of pods in a deployment to allow the CNF workload to run uninterrupted by setting a pod disruption budget in a **PodDisruptionBudget** custom resource (CR) that you apply. Be careful when setting this value; setting it improperly can cause an update to fail.

For example, if you have 4 pods in a deployment and you set the pod disruption budget to 4, the cluster scheduler keeps 4 pods running at all times – no pods can be scaled down.

Instead, set the pod disruption budget to 2, letting 2 of the 4 pods be scheduled as down. Then, the worker nodes where those pods are located can be rebooted.



NOTE

Setting the pod disruption budget to 2 does not mean that your deployment runs on only 2 pods for a period of time, for example, during an update. The cluster scheduler creates 2 new pods to replace the 2 older pods. However, there is short period of time between the new pods coming online and the old pods being deleted.

Additional resources

- [Specifying the number of pods that must be up with pod disruption budgets](#)
- [Pod preemption and other scheduler settings](#)

17.2.4.2. Ensuring that pods do not run on the same cluster node

High availability in Kubernetes requires duplicate processes to be running on separate nodes in the cluster. This ensures that the application continues to run even if one node becomes unavailable. In OpenShift Container Platform, processes can be automatically duplicated in separate pods in a deployment. You configure anti-affinity in the **Pod** spec to ensure that the pods in a deployment do not run on the same cluster node.

During an update, setting pod anti-affinity ensures that pods are distributed evenly across nodes in the cluster. This means that node reboots are easier during an update. For example, if there are 4 pods from a single deployment on a node, and the pod disruption budget is set to only allow 1 pod to be deleted at a time, then it will take 4 times as long for that node to reboot. Setting pod anti-affinity spreads pods across the cluster to prevent such occurrences.

Additional resources

- [Configuring a pod affinity rule](#)

17.2.4.3. Application liveness, readiness, and startup probes

You can use liveness, readiness and startup probes to check the health of your live application containers before you schedule an update. These are very useful tools to use with pods that are dependent upon keeping state for their application containers.

Liveness health check

Determines if a container is running. If the liveness probe fails for a container, the pod responds based on the restart policy.

Readiness probe

Determines if a container is ready to accept service requests. If the readiness probe fails for a container, the kubelet removes the container from the list of available service endpoints.

Startup probe

A startup probe indicates whether the application within a container is started. All other probes are disabled until the startup succeeds. If the startup probe does not succeed, the kubelet kills the container, and the container is subject to the pod **restartPolicy** setting.

Additional resources

- [Understanding health checks](#)

17.2.5. Before you update the telco core CNF cluster

Before you start the cluster update, you must pause worker nodes, back up the etcd database, and do a final cluster health check before proceeding.

17.2.5.1. Pausing worker nodes before the update

You must pause the worker nodes before you proceed with the update. In the following example, there are 2 **mcp** groups, **mcp-1** and **mcp-2**. You patch the **spec.paused** field to **true** for each of these **MachineConfigPool** groups.

Procedure

1. Patch the **mcp** CRs to pause the nodes and drain and remove the pods from those nodes by running the following command:

```
$ oc patch mcp/mcp-1 --type merge --patch '{"spec":{"paused":true}}'
```

```
$ oc patch mcp/mcp-2 --type merge --patch '{"spec":{"paused":true}}'
```

2. Get the status of the paused **mcp** groups:

```
$ oc get mcp -o json | jq -r '[["MCP","Paused"], [---,-----], (.items[]) | [(.metadata.name), (.spec.paused)]]) | @tsv' | grep -v worker
```

Example output

```
MCP    Paused
---   -----
master  false
mcp-1   true
mcp-2   true
```



NOTE

The default control plane and worker **mcp** groups are not changed during an update.

17.2.5.2. Backup the etcd database before you proceed with the update

You must backup the etcd database before you proceed with the update.

17.2.5.2.1. Backing up etcd data

Follow these steps to back up etcd data by creating an etcd snapshot and backing up the resources for the static pods. This backup can be saved and used at a later time if you need to restore etcd.



IMPORTANT

Only save a backup from a single control plane host. Do not take a backup from each control plane host in the cluster.

Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.
- You have checked whether the cluster-wide proxy is enabled.

TIP

You can check whether the proxy is enabled by reviewing the output of **oc get proxy cluster -o yaml**. The proxy is enabled if the **httpProxy**, **httpsProxy**, and **noProxy** fields have values set.

Procedure

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

```
$ oc debug --as-root node/<node_name>
```

2. Change your root directory to **/host** in the debug shell:

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

3. If the cluster-wide proxy is enabled, export the **NO_PROXY**, **HTTP_PROXY**, and **HTTPS_PROXY** environment variables by running the following commands:

```
$ export HTTP_PROXY=http://<your_proxy.example.com>:8080
```

```
$ export HTTPS_PROXY=https://<your_proxy.example.com>:8080
```

```
$ export NO_PROXY=<example.com>
```

4. Run the **cluster-backup.sh** script in the debug shell and pass in the location to save the backup to.

TIP

The **cluster-backup.sh** script is maintained as a component of the etcd Cluster Operator and is a wrapper around the **etcdctl snapshot save** command.

```
sh-4.4# /usr/local/bin/cluster-backup.sh /home/core/assets/backup
```

Example script output

```
found latest kube-apiserver: /etc/kubernetes/static-pod-resources/kube-apiserver-pod-6
found latest kube-controller-manager: /etc/kubernetes/static-pod-resources/kube-controller-
manager-pod-7
found latest kube-scheduler: /etc/kubernetes/static-pod-resources/kube-scheduler-pod-6
found latest etcd: /etc/kubernetes/static-pod-resources/etcd-pod-3
ede95fe6b88b87ba86a03c15e669fb4aa5bf0991c180d3c6895ce72eaade54a1
etcdctl version: 3.4.14
API version: 3.4
{"level":"info","ts":1624647639.0188997,"caller":"snapshot/v3_snapshot.go:119","msg":"created temporary db file","path":"/home/core/assets/backup/snapshot_2021-06-25_190035.db.part"}
{"level":"info","ts":"2021-06-
25T19:00:39.030Z","caller":"clientv3/maintenance.go:200","msg":"opened snapshot stream;
downloading"}
{"level":"info","ts":1624647639.0301006,"caller":"snapshot/v3_snapshot.go:127","msg":"fetching snapshot","endpoint":"https://10.0.0.5:2379"}
 {"level":"info","ts":"2021-06-
25T19:00:40.215Z","caller":"clientv3/maintenance.go:208","msg":"completed snapshot read;
closing"}
 {"level":"info","ts":1624647640.6032252,"caller":"snapshot/v3_snapshot.go:142","msg":"fetched snapshot","endpoint":"https://10.0.0.5:2379","size":"114 MB","took":1.584090459}
 {"level":"info","ts":1624647640.6047094,"caller":"snapshot/v3_snapshot.go:152","msg":"saved",
"path":"/home/core/assets/backup/snapshot_2021-06-25_190035.db"}
Snapshot saved at /home/core/assets/backup/snapshot_2021-06-25_190035.db
 {"hash":3866667823,"revision":31407,"totalKey":12828,"totalSize":114446336}
snapshot db and kube resources are successfully saved to /home/core/assets/backup
```

In this example, two files are created in the `/home/core/assets/backup/` directory on the control plane host:

- **snapshot_<datetimestamp>.db**: This file is the etcd snapshot. The `cluster-backup.sh` script confirms its validity.
- **static_kuberestores_<datetimestamp>.tar.gz**: This file contains the resources for the static pods. If etcd encryption is enabled, it also contains the encryption keys for the etcd snapshot.



NOTE

If etcd encryption is enabled, it is recommended to store this second file separately from the etcd snapshot for security reasons. However, this file is required to restore from the etcd snapshot.

Keep in mind that etcd encryption only encrypts values, not keys. This means that resource types, namespaces, and object names are unencrypted.

17.2.5.2.2. Creating a single etcd backup

Follow these steps to create a single etcd backup by creating and applying a custom resource (CR).

Prerequisites

- You have access to the cluster as a user with the `cluster-admin` role.
- You have access to the OpenShift CLI (`oc`).

Procedure

- If dynamically-provisioned storage is available, complete the following steps to create a single automated etcd backup:
 - a. Create a persistent volume claim (PVC) named `etcd-backup-pvc.yaml` with contents such as the following example:

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: etcd-backup-pvc
  namespace: openshift-etcd
spec:
  accessModes:
    - ReadWriteOnce
  resources:
    requests:
      storage: 200Gi 1
  volumeMode: Filesystem
```

1 The amount of storage available to the PVC. Adjust this value for your requirements.

- b. Apply the PVC by running the following command:

```
$ oc apply -f etcd-backup-pvc.yaml
```

- c. Verify the creation of the PVC by running the following command:

```
$ oc get pvc
```

Example output

NAME	STATUS	VOLUME	CAPACITY	ACCESS MODES
STORAGECLASS	AGE			
etcd-backup-pvc	Bound			51s



NOTE

Dynamic PVCs stay in the **Pending** state until they are mounted.

- d. Create a CR file named **etcd-single-backup.yaml** with contents such as the following example:

```
apiVersion: operator.openshift.io/v1alpha1
kind: EtcdBackup
metadata:
  name: etcd-single-backup
  namespace: openshift-etcd
spec:
  pvcName: etcd-backup-pvc ①
```

- ① The name of the PVC to save the backup to. Adjust this value according to your environment.

- e. Apply the CR to start a single backup:

```
$ oc apply -f etcd-single-backup.yaml
```

- If dynamically-provisioned storage is not available, complete the following steps to create a single automated etcd backup:

- a. Create a **StorageClass** CR file named **etcd-backup-local-storage.yaml** with the following contents:

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: etcd-backup-local-storage
provisioner: kubernetes.io/no-provisioner
volumeBindingMode: Immediate
```

- b. Apply the **StorageClass** CR by running the following command:

```
$ oc apply -f etcd-backup-local-storage.yaml
```

- c. Create a PV named **etcd-backup-pv-fs.yaml** with contents such as the following example:

```

apiVersion: v1
kind: PersistentVolume
metadata:
  name: etcd-backup-pv-fs
spec:
  capacity:
    storage: 100Gi 1
  volumeMode: Filesystem
  accessModes:
    - ReadWriteOnce
  persistentVolumeReclaimPolicy: Retain
  storageClassName: etcd-backup-local-storage
  local:
    path: /mnt
  nodeAffinity:
    required:
      nodeSelectorTerms:
        - matchExpressions:
          - key: kubernetes.io/hostname
            operator: In
            values:
              - <example_master_node> 2

```

- 1** The amount of storage available to the PV. Adjust this value for your requirements.
- 2** Replace this value with the node to attach this PV to.

d. Verify the creation of the PV by running the following command:

```
$ oc get pv
```

Example output

NAME	CAPACITY	ACCESS MODES	RECLAIM POLICY	STATUS
CLAIM	STORAGECLASS	REASON	AGE	
etcd-backup-pv-fs	100Gi	RWO	Retain	Available
local-storage	10s			etcd-backup-

e. Create a PVC named **etcd-backup-pvc.yaml** with contents such as the following example:

```

kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: etcd-backup-pvc
  namespace: openshift-etcd
spec:
  accessModes:
    - ReadWriteOnce
  volumeMode: Filesystem
  resources:
    requests:
      storage: 10Gi 1

```

- 1 The amount of storage available to the PVC. Adjust this value for your requirements.

- f. Apply the PVC by running the following command:

```
$ oc apply -f etcd-backup-pvc.yaml
```

- g. Create a CR file named **etcd-single-backup.yaml** with contents such as the following example:

```
apiVersion: operator.openshift.io/v1alpha1
kind: EtcdBackup
metadata:
  name: etcd-single-backup
  namespace: openshift-etcd
spec:
  pvcName: etcd-backup-pvc 1
```

- 1 The name of the persistent volume claim (PVC) to save the backup to. Adjust this value according to your environment.

- h. Apply the CR to start a single backup:

```
$ oc apply -f etcd-single-backup.yaml
```

Additional resources

- Backing up etcd

17.2.5.3. Checking the cluster health

You should check the cluster health often during the update. Check for the node status, cluster Operators status and failed pods.

Procedure

- Check the status of the cluster Operators by running the following command:

```
$ oc get co
```

Example output

NAME SINCE MESSAGE	VERSION	AVAILABLE	PROGRESSING	DEGRADED
authentication	4.14.34	True	False	False 4d22h
baremetal	4.14.34	True	False	False 4d22h
cloud-controller-manager	4.14.34	True	False	False 4d23h
cloud-credential	4.14.34	True	False	False 4d23h
cluster-autoscaler	4.14.34	True	False	False 4d22h
config-operator	4.14.34	True	False	False 4d22h
console	4.14.34	True	False	False 4d22h

...						
service-ca	4.14.34	True	False	False	4d22h	
storage	4.14.34	True	False	False	4d22h	

2. Check the status of the cluster nodes:

```
$ oc get nodes
```

Example output

NAME	STATUS	ROLES	AGE	VERSION
ctrl-plane-0	Ready	control-plane,master	4d22h	v1.27.15+6147456
ctrl-plane-1	Ready	control-plane,master	4d22h	v1.27.15+6147456
ctrl-plane-2	Ready	control-plane,master	4d22h	v1.27.15+6147456
worker-0	Ready	mcp-1,worker	4d22h	v1.27.15+6147456
worker-1	Ready	mcp-2,worker	4d22h	v1.27.15+6147456

3. Check that there are no in-progress or failed pods. There should be no pods returned when you run the following command.

```
$ oc get po -A | grep -E -iv 'running|complete'
```

17.2.6. Completing the Control Plane Only cluster update

Follow these steps to perform the Control Plane Only cluster update and monitor the update through to completion.



IMPORTANT

Control Plane Only updates were previously known as EUS-to-EUS updates. Control Plane Only updates are only viable between even-numbered minor versions of OpenShift Container Platform.

17.2.6.1. Acknowledging the Control Plane Only or y-stream update

When you update to all versions from 4.11 and later, you must manually acknowledge that the update can continue.



IMPORTANT

Before you acknowledge the update, verify that you are not using any of the Kubernetes APIs that are removed from the version you are updating to. For example, in OpenShift Container Platform 4.17, there are no API removals. See "Kubernetes API removals" for more information.

Prerequisites

- You have verified that APIs for all of the applications running on your cluster are compatible with the next Y-stream release of OpenShift Container Platform. For more details about compatibility, see "Verifying cluster API versions between update versions".

Procedure

- Complete the administrative acknowledgment to start the cluster update by running the following command:

```
$ oc adm upgrade
```

If the cluster update does not complete successfully, more details about the update failure are provided in the **Reason** and **Message** sections.

Example output

```
Cluster version is 4.15.45
```

```
Upgradeable=False
```

Reason: MultipleReasons

Message: Cluster should not be upgraded between minor versions for multiple reasons:
AdminAckRequired,ResourceDeletesInProgress

* Kubernetes 1.29 and therefore OpenShift 4.16 remove several APIs which require admin consideration. Please see the knowledge article <https://access.redhat.com/articles/7031404> for details and instructions.

* Cluster minor level upgrades are not allowed while resource deletions are in progress;
resources=PrometheusRule "openshift-kube-apiserver/kube-apiserver-recording-rules"

```
ReleaseAccepted=False
```

Reason: PreconditionChecks

Message: Preconditions failed for payload loaded version="4.16.34"
image="quay.io/openshift-release-dev/ocp-release@sha256:41bb08c560f6db5039ccdf242e590e8b23049b5eb31e1c4f6021d1d520b353b8": Precondition "ClusterVersionUpgradeable" failed because of "MultipleReasons": Cluster should not be upgraded between minor versions for multiple reasons:
AdminAckRequired,ResourceDeletesInProgress

* Kubernetes 1.29 and therefore OpenShift 4.16 remove several APIs which require admin consideration. Please see the knowledge article <https://access.redhat.com/articles/7031404> for details and instructions.

* Cluster minor level upgrades are not allowed while resource deletions are in progress;
resources=PrometheusRule "openshift-kube-apiserver/kube-apiserver-recording-rules"

Upstream is unset, so the cluster will use an appropriate default.

Channel: eus-4.16 (available channels: candidate-4.15, candidate-4.16, eus-4.16, fast-4.15, fast-4.16, stable-4.15, stable-4.16)

Recommended updates:

VERSION	IMAGE
4.16.34	quay.io/openshift-release-dev/ocp-release@sha256:41bb08c560f6db5039ccdf242e590e8b23049b5eb31e1c4f6021d1d520b353b8

VERSION	IMAGE
4.16.34	quay.io/openshift-release-dev/ocp-release@sha256:41bb08c560f6db5039ccdf242e590e8b23049b5eb31e1c4f6021d1d520b353b8



NOTE

In this example, a linked Red Hat Knowledgebase article ([Preparing to upgrade to OpenShift Container Platform 4.16](#)) provides more detail about verifying API compatibility between releases.

Verification

- Verify the update by running the following command:

```
$ oc get configmap admin-acks -n openshift-config -o json | jq .data
```

Example output

```
{
  "ack-4.14-kube-1.28-api-removals-in-4.15": "true",
  "ack-4.15-kube-1.29-api-removals-in-4.16": "true"
}
```



NOTE

In this example, the cluster is updated from version 4.14 to 4.15, and then from 4.15 to 4.16 in a Control Plane Only update.

Additional resources

- [Kubernetes API removals](#)
- [Verifying cluster API versions between update versions](#)

17.2.6.2. Starting the cluster update

When updating from one y-stream release to the next, you must ensure that the intermediate z-stream releases are also compatible.



NOTE

You can verify that you are updating to a viable release by running the **oc adm upgrade** command. The **oc adm upgrade** command lists the compatible update releases.

Procedure

- Start the update:

```
$ oc adm upgrade --to=4.15.33
```



IMPORTANT

- Control Plane Only update:** Make sure you point to the interim <y+1> release path
- Y-stream update** - Make sure you use the correct <y.z> release that follows the Kubernetes [version skew policy](#).
- Z-stream update** - Verify that there are no problems moving to that specific release

Example output

-

Requested update to 4.15.33 ①

- ① The **Requested update** value changes depending on your particular update.

Additional resources

- [Selecting the target release](#)

17.2.6.3. Monitoring the cluster update

You should check the cluster health often during the update. Check for the node status, cluster Operators status and failed pods.

Procedure

- Monitor the cluster update. For example, to monitor the cluster update from version 4.14 to 4.15, run the following command:

```
$ watch "oc get clusterversion; echo; oc get co | head -1; oc get co | grep 4.14; oc get co | grep 4.15; echo; oc get no; echo; oc get po -A | grep -E -iv 'running|complete'"
```

Example output

NAME	VERSION	AVAILABLE	PROGRESSING	SINCE	STATUS
version	4.14.34	True	True	4m6s	Working towards 4.15.33: 111 of 873 done (12% complete), waiting on kube-apiserver

NAME MESSAGE	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
authentication	4.14.34	True	False	False	4d22h
baremetal	4.14.34	True	False	False	4d23h
cloud-controller-manager	4.14.34	True	False	False	4d23h
cloud-credential	4.14.34	True	False	False	4d23h
cluster-autoscaler	4.14.34	True	False	False	4d23h
console	4.14.34	True	False	False	4d22h

...

storage	4.14.34	True	False	False	4d23h
config-operator	4.15.33	True	False	False	4d23h
etcd	4.15.33	True	False	False	4d23h

NAME	STATUS	ROLES	AGE	VERSION
ctrl-plane-0	Ready	control-plane,master	4d23h	v1.27.15+6147456
ctrl-plane-1	Ready	control-plane,master	4d23h	v1.27.15+6147456
ctrl-plane-2	Ready	control-plane,master	4d23h	v1.27.15+6147456
worker-0	Ready	mcp-1,worker	4d23h	v1.27.15+6147456
worker-1	Ready	mcp-2,worker	4d23h	v1.27.15+6147456

NAMESPACE	NAME	READY	STATUS	RESTARTS	AGE
openshift-marketplace	redhat-marketplace-rf86t	0/1	ContainerCreating	0	0s

Verification

During the update the **watch** command cycles through one or several of the cluster Operators at a time, providing a status of the Operator update in the **MESSAGE** column.

When the cluster Operators update process is complete, each control plane nodes is rebooted, one at a time.



NOTE

During this part of the update, messages are reported that state cluster Operators are being updated again or are in a degraded state. This is because the control plane node is offline while it reboots nodes.

As soon as the last control plane node reboot is complete, the cluster version is displayed as updated.

When the control plane update is complete a message such as the following is displayed. This example shows an update completed to the intermediate y-stream release.

NAME	VERSION	AVAILABLE	PROGRESSING	SINCE	STATUS	
version	4.15.33	True	False	28m	Cluster version is 4.15.33	
NAME VERSION AVAILABLE PROGRESSING DEGRADED SINCE MESSAGE						
authentication	4.15.33	True	False	False	5d	
baremetal	4.15.33	True	False	False	5d	
cloud-controller-manager	4.15.33	True	False	False	5d1h	
cloud-credential	4.15.33	True	False	False	5d1h	
cluster-autoscaler	4.15.33	True	False	False	5d	
config-operator	4.15.33	True	False	False	5d	
console	4.15.33	True	False	False	5d	
...						
service-ca	4.15.33	True	False	False	5d	
storage	4.15.33	True	False	False	5d	
NAME STATUS ROLES AGE VERSION						
ctrl-plane-0	Ready	control-plane,master	5d	v1.28.13+2ca1a23		
ctrl-plane-1	Ready	control-plane,master	5d	v1.28.13+2ca1a23		
ctrl-plane-2	Ready	control-plane,master	5d	v1.28.13+2ca1a23		
worker-0	Ready	mcp-1,worker	5d	v1.28.13+2ca1a23		
worker-1	Ready	mcp-2,worker	5d	v1.28.13+2ca1a23		

17.2.6.4. Updating the OLM Operators

In telco environments, software needs to be vetted before it is loaded onto a production cluster. Production clusters are also configured in a disconnected network, which means that they are not always directly connected to the internet. Because the clusters are in a disconnected network, the OpenShift Operators are configured for manual update during installation so that new versions can be managed on a cluster-by-cluster basis. Perform the following procedure to move the Operators to the newer versions.

Procedure

1. Check to see which Operators need to be updated:

```
$ oc get installplan -A | grep -E 'APPROVED|false'
```

Example output

NAMESPACE	NAME	CSV	APPROVAL
metallb-system	install-nwjnh	metallb-operator.v4.16.0-202409202304	Manual
false			
openshift-nmstate	install-5r7wr	kubernetes-nmstate-operator.4.16.0-202409251605	
Manual	false		

- Patch the **InstallPlan** resources for those Operators:

```
$ oc patch installplan -n metallb-system install-nwjnh --type merge --patch \
'{"spec": {"approved": true}}'
```

Example output

```
installplan.operators.coreos.com/install-nwjnh patched
```

- Monitor the namespace by running the following command:

```
$ oc get all -n metallb-system
```

Example output

NAME	READY	STATUS	RESTARTS	AGE
pod/metallb-operator-controller-manager-69b5f884c-8bp22	0/1	ContainerCreating	0	4s
pod/metallb-operator-controller-manager-77895bdb46-bqjdx	1/1	Running	0	4m1s
pod/metallb-operator-webhook-server-5d9b968896-vnbhk	0/1	ContainerCreating	0	4s
pod/metallb-operator-webhook-server-d76f9c6c8-57r4w	1/1	Running	0	4m1s
...				
NAME	DESIRED	CURRENT	READY	AGE
replicaset.apps/metallb-operator-controller-manager-69b5f884c	1	1	0	4s
replicaset.apps/metallb-operator-controller-manager-77895bdb46	1	1	1	4m1s
replicaset.apps/metallb-operator-controller-manager-99b76f88	0	0	0	4m40s
replicaset.apps/metallb-operator-webhook-server-5d9b968896	1	1	0	4s
replicaset.apps/metallb-operator-webhook-server-6f7dbfdb88	0	0	0	4m40s
replicaset.apps/metallb-operator-webhook-server-d76f9c6c8	1	1	1	4m1s

When the update is complete, the required pods should be in a **Running** state, and the required **ReplicaSet** resources should be ready:

NAME	READY	STATUS	RESTARTS	AGE
pod/metallb-operator-controller-manager-69b5f884c-8bp22	1/1	Running	0	25s
pod/metallb-operator-webhook-server-5d9b968896-vnbhk	1/1	Running	0	25s

...

NAME	DESIRED	CURRENT	READY	AGE
replicaset.apps/metallb-operator-controller-manager-69b5f884c	1	1	1	25s
replicaset.apps/metallb-operator-controller-manager-77895bdb46	0	0	0	4m22s
replicaset.apps/metallb-operator-webhook-server-5d9b968896	1	1	1	25s
replicaset.apps/metallb-operator-webhook-server-d76f9c6c8	0	0	0	4m22s

Verification

- Verify that the Operators do not need to be updated for a second time:

```
$ oc get installplan -A | grep -E 'APPROVED|false'
```

There should be no output returned.



NOTE

Sometimes you have to approve an update twice because some Operators have interim z-stream release versions that need to be installed before the final version.

Additional resources

- [Updating the worker nodes](#)

17.2.6.4.1. Performing the second y-stream update

After completing the first y-stream update, you must update the y-stream control plane version to the new EUS version.

Procedure

- Verify that the <4.y.z> release that you selected is still listed as a good channel to move to:

```
$ oc adm upgrade
```

Example output

Cluster version is 4.15.33

Upgradeable=False

Reason: AdminAckRequired

Message: Kubernetes 1.29 and therefore OpenShift 4.16 remove several APIs which require admin consideration. Please see the knowledge article <https://access.redhat.com/articles/7031404> for details and instructions.

Upstream is unset, so the cluster will use an appropriate default.

Channel: eus-4.16 (available channels: candidate-4.15, candidate-4.16, eus-4.16, fast-4.15, fast-4.16, stable-4.15, stable-4.16)

Recommended updates:

VERSION	IMAGE
4.16.14	quay.io/openshift-release-dev/ocp-release@sha256:0521a0f1acd2d1b77f76259cb9bae9c743c60c37d9903806a3372c1414253658
4.16.13	quay.io/openshift-release-dev/ocp-release@sha256:6078cb4ae197b5b0c526910363b8aff540343bfa62ecb1ead9e068d541da27b
4.15.34	quay.io/openshift-release-dev/ocp-release@sha256:f2e0c593f6ed81250c11d0bac94dbaf63656223477b7e8693a652f933056af6e

**NOTE**

If you update soon after the initial GA of a new Y-stream release, you might not see new y-stream releases available when you run the **oc adm upgrade** command.

2. Optional: View the potential update releases that are not recommended. Run the following command:

```
$ oc adm upgrade --include-not-recommended
```

Example output

Cluster version is 4.15.33

Upgradeable=False

Reason: AdminAckRequired

Message: Kubernetes 1.29 and therefore OpenShift 4.16 remove several APIs which require admin consideration. Please see the knowledge article <https://access.redhat.com/articles/7031404> for details and instructions.

Upstream is unset, so the cluster will use an appropriate default. Channel: eus-4.16 (available channels: candidate-4.15, candidate-4.16, eus-4.16, fast-4.15, fast-4.16, stable-4.15, stable-4.16)

Recommended updates:

VERSION	IMAGE
4.16.14	quay.io/openshift-release-dev/ocp-release@sha256:0521a0f1acd2d1b77f76259cb9bae9c743c60c37d9903806a3372c1414253658
4.16.13	quay.io/openshift-release-dev/ocp-release@sha256:6078cb4ae197b5b0c526910363b8aff540343bfa62ecb1ead9e068d541da27b
4.15.34	quay.io/openshift-release-dev/ocp-release@sha256:f2e0c593f6ed81250c11d0bac94dbaf63656223477b7e8693a652f933056af6e

Supported but not recommended updates:

Version: 4.16.15

Image: quay.io/openshift-release-dev/ocp-release@sha256:671bc35e

Recommended: Unknown
 Reason: EvaluationFailed
 Message: Exposure to AzureRegistryImagePreservation is unknown due to an evaluation failure: invalid PromQL result length must be one, but is 0
 In Azure clusters, the in-cluster image registry may fail to preserve images on update.
<https://issues.redhat.com/browse/IR-461>

**NOTE**

The example shows a potential error that can affect clusters hosted in Microsoft Azure. It does not show risks for bare-metal clusters.

17.2.6.4.2. Acknowledging the y-stream release update

When moving between y-stream releases, you must run a patch command to explicitly acknowledge the update. In the output of the **oc adm upgrade** command, a URL is provided that shows the specific command to run.

**IMPORTANT**

Before you acknowledge the update, verify that you are not using any of the Kubernetes APIs that are removed from the version you are updating to. For example, in OpenShift Container Platform 4.17, there are no API removals. See "Kubernetes API removals" for more information.

Prerequisites

- You have verified that APIs for all of the applications running on your cluster are compatible with the next Y-stream release of OpenShift Container Platform. For more details about compatibility, see "Verifying cluster API versions between update versions".

Procedure

- Complete the administrative acknowledgment to start the cluster update by running the following command:

```
$ oc adm upgrade
```

If the cluster update does not complete successfully, more details about the update failure are provided in the **Reason** and **Message** sections.

Example output

Cluster version is 4.15.45

Upgradeable=False

Reason: MultipleReasons

Message: Cluster should not be upgraded between minor versions for multiple reasons:
 AdminAckRequired,ResourceDeletesInProgress

* Kubernetes 1.29 and therefore OpenShift 4.16 remove several APIs which require admin consideration. Please see the knowledge article <https://access.redhat.com/articles/7031404> for details and instructions.

* Cluster minor level upgrades are not allowed while resource deletions are in progress;

```
resources=PrometheusRule "openshift-kube-apiserver/kube-apiserver-recording-rules"
ReleaseAccepted=False
Reason: PreconditionChecks
Message: Preconditions failed for payload loaded version="4.16.34"
image="quay.io/openshift-release-dev/ocp-
release@sha256:41bb08c560f6db5039ccdf242e590e8b23049b5eb31e1c4f6021d1d520b353b
8": Precondition "ClusterVersionUpgradeable" failed because of "MultipleReasons": Cluster
should not be upgraded between minor versions for multiple reasons:
AdminAckRequired,ResourceDeletesInProgress
* Kubernetes 1.29 and therefore OpenShift 4.16 remove several APIs which require admin
consideration. Please see the knowledge article https://access.redhat.com/articles/7031404
for details and instructions.
* Cluster minor level upgrades are not allowed while resource deletions are in progress;
resources=PrometheusRule "openshift-kube-apiserver/kube-apiserver-recording-rules"
```

Upstream is unset, so the cluster will use an appropriate default.

Channel: eus-4.16 (available channels: candidate-4.15, candidate-4.16, eus-4.16, fast-4.15,
fast-4.16, stable-4.15, stable-4.16)

Recommended updates:

VERSION	IMAGE
4.16.34	quay.io/openshift-release-dev/ocp- release@sha256:41bb08c560f6db5039ccdf242e590e8b23049b5eb31e1c4f6021d1d520b353b 8



NOTE

In this example, a linked Red Hat Knowledgebase article ([Preparing to upgrade to OpenShift Container Platform 4.16](#)) provides more detail about verifying API compatibility between releases.

Verification

- Verify the update by running the following command:

```
$ oc get configmap admin-acks -n openshift-config -o json | jq .data
```

Example output

```
{
  "ack-4.14-kube-1.28-api-removals-in-4.15": "true",
  "ack-4.15-kube-1.29-api-removals-in-4.16": "true"
}
```



NOTE

In this example, the cluster is updated from version 4.14 to 4.15, and then from 4.15 to 4.16 in a Control Plane Only update.

Additional resources

- Preparing to update to OpenShift Container Platform 4.18
- Verifying cluster API versions between update versions

17.2.6.5. Starting the y-stream control plane update

After you have determined the full new release that you are moving to, you can run the **oc adm upgrade --to=x.y.z** command.

Procedure

- Start the y-stream control plane update. For example, run the following command:

```
$ oc adm upgrade --to=4.16.14
```

Example output

```
Requested update to 4.16.14
```

You might move to a z-stream release that has potential issues with platforms other than the one you are running on. The following example shows a potential problem for cluster updates on Microsoft Azure:

```
$ oc adm upgrade --to=4.16.15
```

Example output

```
error: the update 4.16.15 is not one of the recommended updates, but is available as a conditional update. To accept the Recommended=Unknown risk and to proceed with update use --allow-not-recommended.
```

```
Reason: EvaluationFailed
```

```
Message: Exposure to AzureRegistryImagePreservation is unknown due to an evaluation failure: invalid PromQL result length must be one, but is 0
```

```
In Azure clusters, the in-cluster image registry may fail to preserve images on update.  
https://issues.redhat.com/browse/IR-461
```



NOTE

The example shows a potential error that can affect clusters hosted in Microsoft Azure. It does not show risks for bare-metal clusters.

```
$ oc adm upgrade --to=4.16.15 --allow-not-recommended
```

Example output

```
warning: with --allow-not-recommended you have accepted the risks with 4.14.11 and bypassed Recommended=Unknown EvaluationFailed: Exposure to AzureRegistryImagePreservation is unknown due to an evaluation failure: invalid PromQL result length must be one, but is 0  
In Azure clusters, the in-cluster image registry may fail to preserve images on update.
```

<https://issues.redhat.com/browse/IR-461>

Requested update to 4.16.15

17.2.6.6. Monitoring the second part of a <y+1> cluster update

Monitor the second part of the cluster update to the <y+1> version.

Procedure

- Monitor the progress of the second part of the <y+1> update. For example, to monitor the update from 4.15 to 4.16, run the following command:

```
$ watch "oc get clusterversion; echo; oc get co | head -1; oc get co | grep 4.15; oc get co | grep 4.16; echo; oc get no; echo; oc get po -A | grep -E -iv 'running|complete'"
```

Example output

NAME	VERSION	AVAILABLE	PROGRESSING	SINCE	STATUS
version	4.15.33	True	True	10m	Working towards 4.16.14: 132 of 903 done (14% complete), waiting on kube-controller-manager, kube-scheduler
NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
MESSAGE					
authentication	4.15.33	True	False	False	5d3h
baremetal	4.15.33	True	False	False	5d4h
cloud-controller-manager	4.15.33	True	False	False	5d4h
cloud-credential	4.15.33	True	False	False	5d4h
cluster-autoscaler	4.15.33	True	False	False	5d4h
console	4.15.33	True	False	False	5d3h
...					
config-operator	4.16.14	True	False	False	5d4h
etcd	4.16.14	True	False	False	5d4h
kube-apiserver	4.16.14	True	True	False	5d4h
NodeInstallerProgressing: 1 node is at revision 15; 2 nodes are at revision 17					
NAME	STATUS	ROLES	AGE	VERSION	
ctrl-plane-0	Ready	control-plane,master	5d4h	v1.28.13+2ca1a23	
ctrl-plane-1	Ready	control-plane,master	5d4h	v1.28.13+2ca1a23	
ctrl-plane-2	Ready	control-plane,master	5d4h	v1.28.13+2ca1a23	
worker-0	Ready	mcp-1,worker	5d4h	v1.27.15+6147456	
worker-1	Ready	mcp-2,worker	5d4h	v1.27.15+6147456	
NAMESPACE			NAME		READY
STATUS	RESTARTS	AGE			
openshift-kube-apiserver	0/5	Pending 0 <invalid>		kube-apiserver-ctrl-plane-0	

As soon as the last control plane node is complete, the cluster version is updated to the new EUS release. For example:

```
NAME VERSION AVAILABLE PROGRESSING SINCE STATUS
version 4.16.14 True False 123m Cluster version is 4.16.14
```

NAME SINCE MESSAGE	VERSION	AVAILABLE	PROGRESSING	DEGRADED
authentication	4.16.14	True	False	False 5d6h
baremetal	4.16.14	True	False	False 5d7h
cloud-controller-manager	4.16.14	True	False	False 5d7h
cloud-credential	4.16.14	True	False	False 5d7h
cluster-autoscaler	4.16.14	True	False	False 5d7h
config-operator	4.16.14	True	False	False 5d7h
console	4.16.14	True	False	False 5d6h
#...				
operator-lifecycle-manager-packageserver	4.16.14	True	False	False 5d7h
service-ca	4.16.14	True	False	False 5d7h
storage	4.16.14	True	False	False 5d7h
NAME	STATUS	ROLES	AGE	VERSION
ctrl-plane-0	Ready	control-plane,master	5d7h	v1.29.8+f10c92d
ctrl-plane-1	Ready	control-plane,master	5d7h	v1.29.8+f10c92d
ctrl-plane-2	Ready	control-plane,master	5d7h	v1.29.8+f10c92d
worker-0	Ready	mcp-1,worker	5d7h	v1.27.15+6147456
worker-1	Ready	mcp-2,worker	5d7h	v1.27.15+6147456

Additional resources

- [Monitoring the cluster update](#)

17.2.6.7. Updating all the OLM Operators

In the second phase of a multi-version upgrade, you must approve all of the Operators and additionally add installations plans for any other Operators that you want to upgrade.

Follow the same procedure as outlined in "Updating the OLM Operators". Ensure that you also update any non-OLM Operators as required.

Procedure

1. Monitor the cluster update. For example, to monitor the cluster update from version 4.14 to 4.15, run the following command:

```
$ watch "oc get clusterversion; echo; oc get co | head -1; oc get co | grep 4.14; oc get co | grep 4.15; echo; oc get no; echo; oc get po -A | grep -E 'running|complete'"
```

2. Check to see which Operators need to be updated:

```
$ oc get installplan -A | grep -E 'APPROVED|false'
```

3. Patch the **InstallPlan** resources for those Operators:

```
$ oc patch installplan -n metallb-system install-nwjnh --type merge --patch \
'{"spec":{"approved":true}}'
```

4. Monitor the namespace by running the following command:

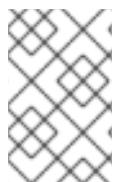
```
$ oc get all -n metallb-system
```

When the update is complete, the required pods should be in a **Running** state, and the required **ReplicaSet** resources should be ready.

Verification

During the update the **watch** command cycles through one or several of the cluster Operators at a time, providing a status of the Operator update in the **MESSAGE** column.

When the cluster Operators update process is complete, each control plane nodes is rebooted, one at a time.



NOTE

During this part of the update, messages are reported that state cluster Operators are being updated again or are in a degraded state. This is because the control plane node is offline while it reboots nodes.

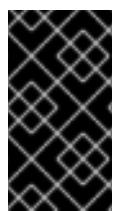
Additional resources

- [Monitoring the cluster update](#)
- [Updating the OLM Operators](#)

17.2.6.8. Updating the worker nodes

You upgrade the worker nodes after you have updated the control plane by unpausing the relevant **mcp** groups you created. Unpausing the **mcp** group starts the upgrade process for the worker nodes in that group. Each of the worker nodes in the cluster reboot to upgrade to the new EUS, y-stream or z-stream version as required.

In the case of Control Plane Only upgrades note that when a worker node is updated it will only require one reboot and will jump <y+2>-release versions. This is a feature that was added to decrease the amount of time that it takes to upgrade large bare-metal clusters.



IMPORTANT

This is a potential holding point. You can have a cluster version that is fully supported to run in production with the control plane that is updated to a new EUS release while the worker nodes are at a <y-2>-release. This allows large clusters to upgrade in steps across several maintenance windows.

1. You can check how many nodes are managed in an **mcp** group. Run the following command to get the list of **mcp** groups:

```
$ oc get mcp
```

Example output

NAME	CONFIG	UPDATED	UPDATING	DEGRADED
MACHINECOUNT	READYMACHINECOUNT	UPDATEDMACHINECOUNT	DEGRADEDMACHINECOUNT	AGE
master	rendered-master-c9a52144456dbff9c9af9c5a37d1b614	True	False	False
3	3	0	36d	
mcp-1	rendered-mcp-1-07fe50b9ad51fae43ed212e84e1dcc8e	False	False	False

1	0	0	0	47h			
mcp-2	rendered-mcp-2-07fe50b9ad51fae43ed212e84e1dcc8e			False	False	False	
1	0	0	0	47h			
worker	rendered-worker-f1ab7b9a768e1b0ac9290a18817f60f0			True	False	False	
0	0	0	0	36d			



NOTE

You decide how many **mcp** groups to upgrade at a time. This depends on how many CNF pods can be taken down at a time and how your pod disruption budget and anti-affinity settings are configured.

- Get the list of nodes in the cluster:

```
$ oc get nodes
```

Example output

NAME	STATUS	ROLES	AGE	VERSION
ctrl-plane-0	Ready	control-plane,master	5d8h	v1.29.8+f10c92d
ctrl-plane-1	Ready	control-plane,master	5d8h	v1.29.8+f10c92d
ctrl-plane-2	Ready	control-plane,master	5d8h	v1.29.8+f10c92d
worker-0	Ready	mcp-1,worker	5d8h	v1.27.15+6147456
worker-1	Ready	mcp-2,worker	5d8h	v1.27.15+6147456

- Confirm the **MachineConfigPool** groups that are paused:

```
$ oc get mcp -o json | jq -r '["MCP","Paused"], [---,-----], (.items[] | [(.metadata.name), (.spec.paused)])' | @tsv' | grep -v worker
```

Example output

```
MCP Paused
---
master false
mcp-1 true
mcp-2 true
```



NOTE

Each **MachineConfigPool** can be unpause independently. Therefore, if a maintenance window runs out of time other MCPs do not need to be unpause immediately. The cluster is supported to run with some worker nodes still at <y>-2>-release version.

- Unpause the required **mcp** group to begin the upgrade:

```
$ oc patch mcp/mcp-1 --type merge --patch '{"spec":{"paused":false}}'
```

Example output

machineconfigpool.machineconfiguration.openshift.io/mcp-1 patched

5. Confirm that the required **mcp** group is unpause:

```
$ oc get mcp -o json | jq -r '["MCP","Paused"], [---,-----], (.items[] | [(.metadata.name), (.spec.paused)])' | @tsv' | grep -v worker
```

Example output

```
MCP Paused
--- -----
master false
mcp-1 false
mcp-2 true
```

6. As each **mcp** group is upgraded, continue to unpause and upgrade the remaining nodes.

```
$ oc get nodes
```

Example output

NAME	STATUS	ROLES	AGE	VERSION
ctrl-plane-0	Ready	control-plane,master	5d8h	v1.29.8+f10c92d
ctrl-plane-1	Ready	control-plane,master	5d8h	v1.29.8+f10c92d
ctrl-plane-2	Ready	control-plane,master	5d8h	v1.29.8+f10c92d
worker-0	Ready	mcp-1,worker	5d8h	v1.29.8+f10c92d
worker-1	NotReady,SchedulingDisabled	mcp-2,worker	5d8h	v1.27.15+6147456

17.2.6.9. Verifying the health of the newly updated cluster

Run the following commands after updating the cluster to verify that the cluster is back up and running.

Procedure

1. Check the cluster version by running the following command:

```
$ oc get clusterversion
```

Example output

NAME	VERSION	AVAILABLE	PROGRESSING	SINCE	STATUS
version	4.16.14	True	False	4h38m	Cluster version is 4.16.14

This should return the new cluster version and the **PROGRESSING** column should return **False**.

2. Check that all nodes are ready:

```
$ oc get nodes
```

Example output

NAME	STATUS	ROLES	AGE	VERSION
ctrl-plane-0	Ready	control-plane,master	5d9h	v1.29.8+f10c92d
ctrl-plane-1	Ready	control-plane,master	5d9h	v1.29.8+f10c92d
ctrl-plane-2	Ready	control-plane,master	5d9h	v1.29.8+f10c92d
worker-0	Ready	mcp-1,worker	5d9h	v1.29.8+f10c92d
worker-1	Ready	mcp-2,worker	5d9h	v1.29.8+f10c92d

All nodes in the cluster should be in a **Ready** status and running the same version.

- Check that there are no paused **mcp** resources in the cluster:

```
$ oc get mcp -o json | jq -r '[{"MCP": "Paused"}, [{"---", "-----"}, (.items[] | [(.metadata.name), (.spec.paused)])] | @tsv' | grep -v worker
```

Example output

```
MCP    Paused
---  -----
master  false
mcp-1   false
mcp-2   false
```

- Check that all cluster Operators are available:

```
$ oc get co
```

Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED
SINCE	MESSAGE			
authentication	4.16.14	True	False	False
baremetal	4.16.14	True	False	False
cloud-controller-manager	4.16.14	True	False	False
cloud-credential	4.16.14	True	False	False
cluster-autoscaler	4.16.14	True	False	False
config-operator	4.16.14	True	False	False
console	4.16.14	True	False	False
control-plane-machine-set	4.16.14	True	False	False
csi-snapshot-controller	4.16.14	True	False	False
dns	4.16.14	True	False	False
etcd	4.16.14	True	False	False
image-registry	4.16.14	True	False	False
ingress	4.16.14	True	False	False
insights	4.16.14	True	False	False
kube-apiserver	4.16.14	True	False	False
kube-controller-manager	4.16.14	True	False	False
kube-scheduler	4.16.14	True	False	False
kube-storage-version-migrator	4.16.14	True	False	False
machine-api	4.16.14	True	False	False
machine approver	4.16.14	True	False	False
machine-config	4.16.14	True	False	False
marketplace	4.16.14	True	False	False
monitoring	4.16.14	True	False	False
network	4.16.14	True	False	False

node-tuning	4.16.14	True	False	False	5d7h
openshift-apiserver	4.16.14	True	False	False	5d9h
openshift-controller-manager	4.16.14	True	False	False	5d9h
openshift-samples	4.16.14	True	False	False	5h24m
operator-lifecycle-manager	4.16.14	True	False	False	5d9h
operator-lifecycle-manager-catalog	4.16.14	True	False	False	5d9h
operator-lifecycle-manager-packageserver	4.16.14	True	False	False	5d9h
service-ca	4.16.14	True	False	False	5d9h
storage	4.16.14	True	False	False	5d9h

All cluster Operators should report **True** in the **AVAILABLE** column.

- Check that all pods are healthy:

```
$ oc get po -A | grep -E -iv 'complete|running'
```

This should not return any pods.



NOTE

You might see a few pods still moving after the update. Watch this for a while to make sure all pods are cleared.

17.2.7. Completing the y-stream cluster update

Follow these steps to perform the y-stream cluster update and monitor the update through to completion. Completing a y-stream update is more straightforward than a Control Plane Only update.

17.2.7.1. Acknowledging the Control Plane Only or y-stream update

When you update to all versions from 4.11 and later, you must manually acknowledge that the update can continue.



IMPORTANT

Before you acknowledge the update, verify that you are not using any of the Kubernetes APIs that are removed from the version you are updating to. For example, in OpenShift Container Platform 4.17, there are no API removals. See "Kubernetes API removals" for more information.

Prerequisites

- You have verified that APIs for all of the applications running on your cluster are compatible with the next Y-stream release of OpenShift Container Platform. For more details about compatibility, see "Verifying cluster API versions between update versions".

Procedure

- Complete the administrative acknowledgment to start the cluster update by running the following command:

```
$ oc adm upgrade
```

If the cluster update does not complete successfully, more details about the update failure are provided in the **Reason** and **Message** sections.

Example output

```
Cluster version is 4.15.45
```

```
Upgradeable=False
```

Reason: MultipleReasons

Message: Cluster should not be upgraded between minor versions for multiple reasons:
AdminAckRequired,ResourceDeletesInProgress

* Kubernetes 1.29 and therefore OpenShift 4.16 remove several APIs which require admin consideration. Please see the knowledge article <https://access.redhat.com/articles/7031404> for details and instructions.

* Cluster minor level upgrades are not allowed while resource deletions are in progress;
resources=PrometheusRule "openshift-kube-apiserver/kube-apiserver-recording-rules"

```
ReleaseAccepted=False
```

Reason: PreconditionChecks

Message: Preconditions failed for payload loaded version="4.16.34"
image="quay.io/openshift-release-dev/ocp-release@sha256:41bb08c560f6db5039ccdf242e590e8b23049b5eb31e1c4f6021d1d520b353b
8": Precondition "ClusterVersionUpgradeable" failed because of "MultipleReasons": Cluster
should not be upgraded between minor versions for multiple reasons:
AdminAckRequired,ResourceDeletesInProgress

* Kubernetes 1.29 and therefore OpenShift 4.16 remove several APIs which require admin consideration. Please see the knowledge article <https://access.redhat.com/articles/7031404> for details and instructions.

* Cluster minor level upgrades are not allowed while resource deletions are in progress;
resources=PrometheusRule "openshift-kube-apiserver/kube-apiserver-recording-rules"

Upstream is unset, so the cluster will use an appropriate default.

Channel: eus-4.16 (available channels: candidate-4.15, candidate-4.16, eus-4.16, fast-4.15,
fast-4.16, stable-4.15, stable-4.16)

Recommended updates:

VERSION	IMAGE
4.16.34	quay.io/openshift-release-dev/ocp-release@sha256:41bb08c560f6db5039ccdf242e590e8b23049b5eb31e1c4f6021d1d520b353b 8

VERSION	IMAGE
4.16.34	quay.io/openshift-release-dev/ocp-release@sha256:41bb08c560f6db5039ccdf242e590e8b23049b5eb31e1c4f6021d1d520b353b 8



NOTE

In this example, a linked Red Hat Knowledgebase article ([Preparing to upgrade to OpenShift Container Platform 4.16](#)) provides more detail about verifying API compatibility between releases.

Verification

- Verify the update by running the following command:

```
$ oc get configmap admin-acks -n openshift-config -o json | jq .data
```

Example output

```
{
  "ack-4.14-kube-1.28-api-removals-in-4.15": "true",
  "ack-4.15-kube-1.29-api-removals-in-4.16": "true"
}
```



NOTE

In this example, the cluster is updated from version 4.14 to 4.15, and then from 4.15 to 4.16 in a Control Plane Only update.

Additional resources

- [Kubernetes API removals](#)
- [Verifying cluster API versions between update versions](#)

17.2.7.2. Starting the cluster update

When updating from one y-stream release to the next, you must ensure that the intermediate z-stream releases are also compatible.



NOTE

You can verify that you are updating to a viable release by running the **oc adm upgrade** command. The **oc adm upgrade** command lists the compatible update releases.

Procedure

1. Start the update:

```
$ oc adm upgrade --to=4.15.33
```



IMPORTANT

- **Control Plane Only update:** Make sure you point to the interim <y+1> release path
- **Y-stream update** - Make sure you use the correct <y.z> release that follows the Kubernetes [version skew policy](#).
- **Z-stream update** - Verify that there are no problems moving to that specific release

Example output

```
Requested update to 4.15.33 ①
```

- ① The **Requested update** value changes depending on your particular update.

Additional resources

- [Selecting the target release](#)

17.2.7.3. Monitoring the cluster update

You should check the cluster health often during the update. Check for the node status, cluster Operators status and failed pods.

Procedure

- Monitor the cluster update. For example, to monitor the cluster update from version 4.14 to 4.15, run the following command:

```
$ watch "oc get clusterversion; echo; oc get co | head -1; oc get co | grep 4.14; oc get co | grep 4.15; echo; oc get no; echo; oc get po -A | grep -E -iv 'running|complete'"
```

Example output

NAME	VERSION	AVAILABLE	PROGRESSING	SINCE	STATUS
version	4.14.34	True	True	4m6s	Working towards 4.15.33: 111 of 873 done (12% complete), waiting on kube-apiserver
NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE
MESSAGE					
authentication	4.14.34	True	False	False	4d22h
baremetal	4.14.34	True	False	False	4d23h
cloud-controller-manager	4.14.34	True	False	False	4d23h
cloud-credential	4.14.34	True	False	False	4d23h
cluster-autoscaler	4.14.34	True	False	False	4d23h
console	4.14.34	True	False	False	4d22h
...					
storage	4.14.34	True	False	False	4d23h
config-operator	4.15.33	True	False	False	4d23h
etcd	4.15.33	True	False	False	4d23h
NAME	STATUS	ROLES	AGE	VERSION	
ctrl-plane-0	Ready	control-plane,master	4d23h	v1.27.15+6147456	
ctrl-plane-1	Ready	control-plane,master	4d23h	v1.27.15+6147456	
ctrl-plane-2	Ready	control-plane,master	4d23h	v1.27.15+6147456	
worker-0	Ready	mcp-1,worker	4d23h	v1.27.15+6147456	
worker-1	Ready	mcp-2,worker	4d23h	v1.27.15+6147456	
NAMESPACE	NAME	READY	STATUS	RESTARTS	AGE
openshift-marketplace	redhat-marketplace-rf86t	0/1	ContainerCreating	0	0s

Verification

During the update the **watch** command cycles through one or several of the cluster Operators at a time, providing a status of the Operator update in the **MESSAGE** column.

When the cluster Operators update process is complete, each control plane nodes is rebooted, one at a time.

**NOTE**

During this part of the update, messages are reported that state cluster Operators are being updated again or are in a degraded state. This is because the control plane node is offline while it reboots nodes.

As soon as the last control plane node reboot is complete, the cluster version is displayed as updated.

When the control plane update is complete a message such as the following is displayed. This example shows an update completed to the intermediate y-stream release.

NAME	VERSION	AVAILABLE	PROGRESSING	SINCE	STATUS
version	4.15.33	True	False	28m	Cluster version is 4.15.33
<hr/>					
NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED	SINCE MESSAGE
authentication	4.15.33	True	False	False	5d
baremetal	4.15.33	True	False	False	5d
cloud-controller-manager	4.15.33	True	False	False	5d1h
cloud-credential	4.15.33	True	False	False	5d1h
cluster-autoscaler	4.15.33	True	False	False	5d
config-operator	4.15.33	True	False	False	5d
console	4.15.33	True	False	False	5d
<hr/>					
...					
service-ca	4.15.33	True	False	False	5d
storage	4.15.33	True	False	False	5d
<hr/>					
NAME	STATUS	ROLES	AGE	VERSION	
ctrl-plane-0	Ready	control-plane,master	5d	v1.28.13+2ca1a23	
ctrl-plane-1	Ready	control-plane,master	5d	v1.28.13+2ca1a23	
ctrl-plane-2	Ready	control-plane,master	5d	v1.28.13+2ca1a23	
worker-0	Ready	mcp-1,worker	5d	v1.28.13+2ca1a23	
worker-1	Ready	mcp-2,worker	5d	v1.28.13+2ca1a23	

17.2.7.4. Updating the OLM Operators

In telco environments, software needs to be vetted before it is loaded onto a production cluster. Production clusters are also configured in a disconnected network, which means that they are not always directly connected to the internet. Because the clusters are in a disconnected network, the OpenShift Operators are configured for manual update during installation so that new versions can be managed on a cluster-by-cluster basis. Perform the following procedure to move the Operators to the newer versions.

Procedure

- Check to see which Operators need to be updated:

```
$ oc get installplan -A | grep -E 'APPROVED|false'
```

Example output

NAMESPACE	NAME	CSV	APPROVAL
APPROVED			

```

metallb-system    install-nwjnh metallb-operator.v4.16.0-202409202304        Manual
false
openshift-nmstate install-5r7wr kubernetes-nmstate-operator.4.16.0-202409251605
Manual false

```

- Patch the **InstallPlan** resources for those Operators:

```
$ oc patch installplan -n metallb-system install-nwjnh --type merge --patch \
'{"spec":{"approved":true}}'
```

Example output

```
installplanoperators.coreos.com/install-nwjnh patched
```

- Monitor the namespace by running the following command:

```
$ oc get all -n metallb-system
```

Example output

NAME	READY	STATUS	RESTARTS	AGE
pod/metallb-operator-controller-manager-69b5f884c-8bp22	0/1	ContainerCreating	0	4s
pod/metallb-operator-controller-manager-77895bdb46-bqjdx	1/1	Running	0	4m1s
pod/metallb-operator-webhook-server-5d9b968896-vnbhk	0/1	ContainerCreating	0	4s
pod/metallb-operator-webhook-server-d76f9c6c8-57r4w	1/1	Running	0	4m1s
...				
NAME	DESIRED	CURRENT	READY	AGE
replicaset.apps/metallb-operator-controller-manager-69b5f884c	1	1	0	4s
replicaset.apps/metallb-operator-controller-manager-77895bdb46	1	1	1	4m1s
replicaset.apps/metallb-operator-controller-manager-99b76f88	0	0	0	4m40s
replicaset.apps/metallb-operator-webhook-server-5d9b968896	1	1	0	4s
replicaset.apps/metallb-operator-webhook-server-6f7dbfdb88	0	0	0	4m40s
replicaset.apps/metallb-operator-webhook-server-d76f9c6c8	1	1	1	4m1s

When the update is complete, the required pods should be in a **Running** state, and the required **ReplicaSet** resources should be ready:

NAME	READY	STATUS	RESTARTS	AGE
pod/metallb-operator-controller-manager-69b5f884c-8bp22	1/1	Running	0	25s
pod/metallb-operator-webhook-server-5d9b968896-vnbhk	1/1	Running	0	25s
...				
NAME	DESIRED	CURRENT	READY	AGE
replicaset.apps/metallb-operator-controller-manager-69b5f884c	1	1	1	25s

replicaset.apps/metallb-operator-controller-manager-77895bdb46	0	0	0	4m22s
replicaset.apps/metallb-operator-webhook-server-5d9b968896	1	1	1	25s
replicaset.apps/metallb-operator-webhook-server-d76f9c6c8	0	0	0	4m22s

Verification

- Verify that the Operators do not need to be updated for a second time:

```
$ oc get installplan -A | grep -E 'APPROVED|false'
```

There should be no output returned.



NOTE

Sometimes you have to approve an update twice because some Operators have interim z-stream release versions that need to be installed before the final version.

Additional resources

- [Updating the worker nodes](#)

17.2.7.5. Updating the worker nodes

You upgrade the worker nodes after you have updated the control plane by unpausing the relevant **mcp** groups you created. Unpausing the **mcp** group starts the upgrade process for the worker nodes in that group. Each of the worker nodes in the cluster reboot to upgrade to the new EUS, y-stream or z-stream version as required.

In the case of Control Plane Only upgrades note that when a worker node is updated it will only require one reboot and will jump <y+2>-release versions. This is a feature that was added to decrease the amount of time that it takes to upgrade large bare-metal clusters.



IMPORTANT

This is a potential holding point. You can have a cluster version that is fully supported to run in production with the control plane that is updated to a new EUS release while the worker nodes are at a <y-2>-release. This allows large clusters to upgrade in steps across several maintenance windows.

- You can check how many nodes are managed in an **mcp** group. Run the following command to get the list of **mcp** groups:

```
$ oc get mcp
```

Example output

NAME	CONFIG	UPDATED	UPDATING	DEGRADED
MACHINECOUNT	READYMACHINECOUNT	UPDATEDMACHINECOUNT		
DEGRADEDMACHINECOUNT	AGE			
master	rendered-master-c9a52144456dbff9c9af9c5a37d1b614	True	False	False
3	3	0	36d	
mcp-1	rendered-mcp-1-07fe50b9ad51fae43ed212e84e1dcc8e	False	False	False

1	0	0	0	47h			
mcp-2	rendered-mcp-2-07fe50b9ad51fae43ed212e84e1dcc8e			False	False	False	
1	0	0	0	47h			
worker	rendered-worker-f1ab7b9a768e1b0ac9290a18817f60f0			True	False	False	
0	0	0	0	36d			



NOTE

You decide how many **mcp** groups to upgrade at a time. This depends on how many CNF pods can be taken down at a time and how your pod disruption budget and anti-affinity settings are configured.

- Get the list of nodes in the cluster:

```
$ oc get nodes
```

Example output

NAME	STATUS	ROLES	AGE	VERSION
ctrl-plane-0	Ready	control-plane,master	5d8h	v1.29.8+f10c92d
ctrl-plane-1	Ready	control-plane,master	5d8h	v1.29.8+f10c92d
ctrl-plane-2	Ready	control-plane,master	5d8h	v1.29.8+f10c92d
worker-0	Ready	mcp-1,worker	5d8h	v1.27.15+6147456
worker-1	Ready	mcp-2,worker	5d8h	v1.27.15+6147456

- Confirm the **MachineConfigPool** groups that are paused:

```
$ oc get mcp -o json | jq -r '["MCP","Paused"], [---,-----], (.items[] | [( .metadata.name), (.spec.paused)])' | @tsv' | grep -v worker
```

Example output

```
MCP Paused
---
master false
mcp-1 true
mcp-2 true
```



NOTE

Each **MachineConfigPool** can be unpause independently. Therefore, if a maintenance window runs out of time other MCPs do not need to be unpause immediately. The cluster is supported to run with some worker nodes still at <y>-2>-release version.

- Unpause the required **mcp** group to begin the upgrade:

```
$ oc patch mcp/mcp-1 --type merge --patch '{"spec":{"paused":false}}'
```

Example output

machineconfigpool.machineconfiguration.openshift.io/mcp-1 patched

5. Confirm that the required **mcp** group is unpause:

```
$ oc get mcp -o json | jq -r '["MCP","Paused"], [---,-----], (.items[] | [(.metadata.name), (.spec.paused)])' | @tsv' | grep -v worker
```

Example output

```
MCP Paused
--- -----
master false
mcp-1 false
mcp-2 true
```

6. As each **mcp** group is upgraded, continue to unpause and upgrade the remaining nodes.

```
$ oc get nodes
```

Example output

NAME	STATUS	ROLES	AGE	VERSION
ctrl-plane-0	Ready	control-plane,master	5d8h	v1.29.8+f10c92d
ctrl-plane-1	Ready	control-plane,master	5d8h	v1.29.8+f10c92d
ctrl-plane-2	Ready	control-plane,master	5d8h	v1.29.8+f10c92d
worker-0	Ready	mcp-1,worker	5d8h	v1.29.8+f10c92d
worker-1	NotReady,SchedulingDisabled	mcp-2,worker	5d8h	v1.27.15+6147456

17.2.7.6. Verifying the health of the newly updated cluster

Run the following commands after updating the cluster to verify that the cluster is back up and running.

Procedure

1. Check the cluster version by running the following command:

```
$ oc get clusterversion
```

Example output

NAME	VERSION	AVAILABLE	PROGRESSING	SINCE	STATUS
version	4.16.14	True	False	4h38m	Cluster version is 4.16.14

This should return the new cluster version and the **PROGRESSING** column should return **False**.

2. Check that all nodes are ready:

```
$ oc get nodes
```

Example output

NAME	STATUS	ROLES	AGE	VERSION
ctrl-plane-0	Ready	control-plane,master	5d9h	v1.29.8+f10c92d
ctrl-plane-1	Ready	control-plane,master	5d9h	v1.29.8+f10c92d
ctrl-plane-2	Ready	control-plane,master	5d9h	v1.29.8+f10c92d
worker-0	Ready	mcp-1,worker	5d9h	v1.29.8+f10c92d
worker-1	Ready	mcp-2,worker	5d9h	v1.29.8+f10c92d

All nodes in the cluster should be in a **Ready** status and running the same version.

- Check that there are no paused **mcp** resources in the cluster:

```
$ oc get mcp -o json | jq -r '[{"MCP": "Paused"}, [{"---", "-----"}, (.items[] | [(.metadata.name), (.spec.paused)])] | @tsv' | grep -v worker
```

Example output

```
MCP    Paused
---  -----
master  false
mcp-1   false
mcp-2   false
```

- Check that all cluster Operators are available:

```
$ oc get co
```

Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED
SINCE	MESSAGE			
authentication	4.16.14	True	False	False
baremetal	4.16.14	True	False	False
cloud-controller-manager	4.16.14	True	False	False
cloud-credential	4.16.14	True	False	False
cluster-autoscaler	4.16.14	True	False	False
config-operator	4.16.14	True	False	False
console	4.16.14	True	False	False
control-plane-machine-set	4.16.14	True	False	False
csi-snapshot-controller	4.16.14	True	False	False
dns	4.16.14	True	False	False
etcd	4.16.14	True	False	False
image-registry	4.16.14	True	False	False
ingress	4.16.14	True	False	False
insights	4.16.14	True	False	False
kube-apiserver	4.16.14	True	False	False
kube-controller-manager	4.16.14	True	False	False
kube-scheduler	4.16.14	True	False	False
kube-storage-version-migrator	4.16.14	True	False	False
machine-api	4.16.14	True	False	False
machine approver	4.16.14	True	False	False
machine-config	4.16.14	True	False	False
marketplace	4.16.14	True	False	False
monitoring	4.16.14	True	False	False
network	4.16.14	True	False	False

node-tuning	4.16.14	True	False	False	5d7h
openshift-apiserver	4.16.14	True	False	False	5d9h
openshift-controller-manager	4.16.14	True	False	False	5d9h
openshift-samples	4.16.14	True	False	False	5h24m
operator-lifecycle-manager	4.16.14	True	False	False	5d9h
operator-lifecycle-manager-catalog	4.16.14	True	False	False	5d9h
operator-lifecycle-manager-packageserver	4.16.14	True	False	False	5d9h
service-ca	4.16.14	True	False	False	5d9h
storage	4.16.14	True	False	False	5d9h

All cluster Operators should report **True** in the **AVAILABLE** column.

- Check that all pods are healthy:

```
$ oc get po -A | grep -E -iv 'complete|running'
```

This should not return any pods.



NOTE

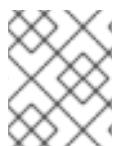
You might see a few pods still moving after the update. Watch this for a while to make sure all pods are cleared.

17.2.8. Completing the z-stream cluster update

Follow these steps to perform the z-stream cluster update and monitor the update through to completion. Completing a z-stream update is more straightforward than a Control Plane Only or y-stream update.

17.2.8.1. Starting the cluster update

When updating from one y-stream release to the next, you must ensure that the intermediate z-stream releases are also compatible.



NOTE

You can verify that you are updating to a viable release by running the **oc adm upgrade** command. The **oc adm upgrade** command lists the compatible update releases.

Procedure

- Start the update:

```
$ oc adm upgrade --to=4.15.33
```



IMPORTANT

- **Control Plane Only update:** Make sure you point to the interim <y+1> release path
- **Y-stream update** - Make sure you use the correct <y.z> release that follows the Kubernetes [version skew policy](#).
- **Z-stream update** - Verify that there are no problems moving to that specific release

Example output

Requested update to 4.15.33 ①

- ① The **Requested update** value changes depending on your particular update.

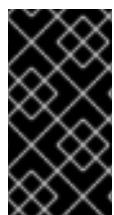
Additional resources

- [Selecting the target release](#)

17.2.8.2. Updating the worker nodes

You upgrade the worker nodes after you have updated the control plane by unpauseing the relevant **mcp** groups you created. Unpausing the **mcp** group starts the upgrade process for the worker nodes in that group. Each of the worker nodes in the cluster reboot to upgrade to the new EUS, y-stream or z-stream version as required.

In the case of Control Plane Only upgrades note that when a worker node is updated it will only require one reboot and will jump <y+2>-release versions. This is a feature that was added to decrease the amount of time that it takes to upgrade large bare-metal clusters.



IMPORTANT

This is a potential holding point. You can have a cluster version that is fully supported to run in production with the control plane that is updated to a new EUS release while the worker nodes are at a <y-2>-release. This allows large clusters to upgrade in steps across several maintenance windows.

1. You can check how many nodes are managed in an **mcp** group. Run the following command to get the list of **mcp** groups:

```
$ oc get mcp
```

Example output

NAME	CONFIG	MACHINECOUNT	READYMACHINECOUNT	UPDATED	UPDATING	DEGRADED
DEGRADED	MACHINECOUNT	AGE				
master	rendered-master-c9a52144456dbff9c9af9c5a37d1b614	3	3	0	36d	True False False
mcp-1	rendered-mcp-1-07fe50b9ad51fae43ed212e84e1dcc8e	3	3	0	36d	False False False

1	0	0	0	47h			
mcp-2	rendered-mcp-2-07fe50b9ad51fae43ed212e84e1dcc8e			False	False	False	
1	0	0	0	47h			
worker	rendered-worker-f1ab7b9a768e1b0ac9290a18817f60f0			True	False	False	
0	0	0	0	36d			

**NOTE**

You decide how many **mcp** groups to upgrade at a time. This depends on how many CNF pods can be taken down at a time and how your pod disruption budget and anti-affinity settings are configured.

- Get the list of nodes in the cluster:

```
$ oc get nodes
```

Example output

NAME	STATUS	ROLES	AGE	VERSION
ctrl-plane-0	Ready	control-plane,master	5d8h	v1.29.8+f10c92d
ctrl-plane-1	Ready	control-plane,master	5d8h	v1.29.8+f10c92d
ctrl-plane-2	Ready	control-plane,master	5d8h	v1.29.8+f10c92d
worker-0	Ready	mcp-1,worker	5d8h	v1.27.15+6147456
worker-1	Ready	mcp-2,worker	5d8h	v1.27.15+6147456

- Confirm the **MachineConfigPool** groups that are paused:

```
$ oc get mcp -o json | jq -r '["MCP","Paused"], [---,-----], (.items[] | [(.metadata.name), (.spec.paused)])' | @tsv' | grep -v worker
```

Example output

```
MCP Paused
---
master false
mcp-1 true
mcp-2 true
```

**NOTE**

Each **MachineConfigPool** can be unpause independently. Therefore, if a maintenance window runs out of time other MCPs do not need to be unpause immediately. The cluster is supported to run with some worker nodes still at <y>-2>-release version.

- Unpause the required **mcp** group to begin the upgrade:

```
$ oc patch mcp/mcp-1 --type merge --patch '{"spec":{"paused":false}}'
```

Example output

machineconfigpool.machineconfiguration.openshift.io/mcp-1 patched

5. Confirm that the required **mcp** group is unpause:

```
$ oc get mcp -o json | jq -r '["MCP","Paused"], [---,-----], (.items[] | [(.metadata.name), (.spec.paused)])' | @tsv' | grep -v worker
```

Example output

```
MCP Paused
--- -----
master false
mcp-1 false
mcp-2 true
```

6. As each **mcp** group is upgraded, continue to unpause and upgrade the remaining nodes.

```
$ oc get nodes
```

Example output

NAME	STATUS	ROLES	AGE	VERSION
ctrl-plane-0	Ready	control-plane,master	5d8h	v1.29.8+f10c92d
ctrl-plane-1	Ready	control-plane,master	5d8h	v1.29.8+f10c92d
ctrl-plane-2	Ready	control-plane,master	5d8h	v1.29.8+f10c92d
worker-0	Ready	mcp-1,worker	5d8h	v1.29.8+f10c92d
worker-1	NotReady,SchedulingDisabled	mcp-2,worker	5d8h	v1.27.15+6147456

17.2.8.3. Verifying the health of the newly updated cluster

Run the following commands after updating the cluster to verify that the cluster is back up and running.

Procedure

1. Check the cluster version by running the following command:

```
$ oc get clusterversion
```

Example output

NAME	VERSION	AVAILABLE	PROGRESSING	SINCE	STATUS
version	4.16.14	True	False	4h38m	Cluster version is 4.16.14

This should return the new cluster version and the **PROGRESSING** column should return **False**.

2. Check that all nodes are ready:

```
$ oc get nodes
```

Example output

NAME	STATUS	ROLES	AGE	VERSION
ctrl-plane-0	Ready	control-plane,master	5d9h	v1.29.8+f10c92d
ctrl-plane-1	Ready	control-plane,master	5d9h	v1.29.8+f10c92d
ctrl-plane-2	Ready	control-plane,master	5d9h	v1.29.8+f10c92d
worker-0	Ready	mcp-1,worker	5d9h	v1.29.8+f10c92d
worker-1	Ready	mcp-2,worker	5d9h	v1.29.8+f10c92d

All nodes in the cluster should be in a **Ready** status and running the same version.

- Check that there are no paused **mcp** resources in the cluster:

```
$ oc get mcp -o json | jq -r '[{"MCP": "Paused"}, [{"---", "-----"}, (.items[]) | [(.metadata.name), (.spec.paused)])] | @tsv' | grep -v worker
```

Example output

```
MCP    Paused
---  -----
master  false
mcp-1   false
mcp-2   false
```

- Check that all cluster Operators are available:

```
$ oc get co
```

Example output

NAME	VERSION	AVAILABLE	PROGRESSING	DEGRADED
SINCE	MESSAGE			
authentication	4.16.14	True	False	False
baremetal	4.16.14	True	False	False
cloud-controller-manager	4.16.14	True	False	False
cloud-credential	4.16.14	True	False	False
cluster-autoscaler	4.16.14	True	False	False
config-operator	4.16.14	True	False	False
console	4.16.14	True	False	False
control-plane-machine-set	4.16.14	True	False	False
csi-snapshot-controller	4.16.14	True	False	False
dns	4.16.14	True	False	False
etcd	4.16.14	True	False	False
image-registry	4.16.14	True	False	False
ingress	4.16.14	True	False	False
insights	4.16.14	True	False	False
kube-apiserver	4.16.14	True	False	False
kube-controller-manager	4.16.14	True	False	False
kube-scheduler	4.16.14	True	False	False
kube-storage-version-migrator	4.16.14	True	False	False
machine-api	4.16.14	True	False	False
machine approver	4.16.14	True	False	False
machine-config	4.16.14	True	False	False
marketplace	4.16.14	True	False	False
monitoring	4.16.14	True	False	False
network	4.16.14	True	False	False

node-tuning	4.16.14	True	False	False	5d7h
openshift-apiserver	4.16.14	True	False	False	5d9h
openshift-controller-manager	4.16.14	True	False	False	5d9h
openshift-samples	4.16.14	True	False	False	5h24m
operator-lifecycle-manager	4.16.14	True	False	False	5d9h
operator-lifecycle-manager-catalog	4.16.14	True	False	False	5d9h
operator-lifecycle-manager-packageserver	4.16.14	True	False	False	5d9h
service-ca	4.16.14	True	False	False	5d9h
storage	4.16.14	True	False	False	5d9h

All cluster Operators should report **True** in the **AVAILABLE** column.

- Check that all pods are healthy:

```
$ oc get po -A | grep -E -iv 'complete|running'
```

This should not return any pods.



NOTE

You might see a few pods still moving after the update. Watch this for a while to make sure all pods are cleared.

17.3. TROUBLESHOOTING AND MAINTAINING TELCO CORE CNF CLUSTERS

17.3.1. Troubleshooting and maintaining telco core CNF clusters

Troubleshooting and maintenance are weekly tasks that can be a challenge if you do not have the tools to reach your goal, whether you want to update a component or investigate an issue. Part of the challenge is knowing where and how to search for tools and answers.

To maintain and troubleshoot a bare-metal environment where high-bandwidth network throughput is required, see the following procedures.



IMPORTANT

This troubleshooting information is not a reference for configuring OpenShift Container Platform or developing Cloud-native Network Function (CNF) applications.

For information about developing CNF applications for telco, see [Red Hat Best Practices for Kubernetes](#).

17.3.1.1. Cloud-native Network Functions

If you are starting to use OpenShift Container Platform for telecommunications Cloud-native Network Function (CNF) applications, learning about CNFs can help you understand the issues that you might encounter.

To learn more about CNFs and their evolution, see [VNF and CNF, what's the difference?](#).

17.3.1.2. Getting Support

If you experience difficulty with a procedure, visit the [Red Hat Customer Portal](#). From the Customer Portal, you can find help in various ways:

- Search or browse through the Red Hat Knowledgebase of articles and solutions about Red Hat products.
- Submit a support case to Red Hat Support.
- Access other product documentation.

To identify issues with your deployment, you can use the debugging tool or check the health endpoint of your deployment. After you have debugged or obtained health information about your deployment, you can search the Red Hat Knowledgebase for a solution or file a support ticket.

17.3.1.2.1. About the Red Hat Knowledgebase

The [Red Hat Knowledgebase](#) provides rich content aimed at helping you make the most of Red Hat's products and technologies. The Red Hat Knowledgebase consists of articles, product documentation, and videos outlining best practices on installing, configuring, and using Red Hat products. In addition, you can search for solutions to known issues, each providing concise root cause descriptions and remedial steps.

17.3.1.2.2. Searching the Red Hat Knowledgebase

In the event of an OpenShift Container Platform issue, you can perform an initial search to determine if a solution already exists within the Red Hat Knowledgebase.

Prerequisites

- You have a Red Hat Customer Portal account.

Procedure

1. Log in to the [Red Hat Customer Portal](#).
2. Click **Search**.
3. In the search field, input keywords and strings relating to the problem, including:
 - OpenShift Container Platform components (such as **etcd**)
 - Related procedure (such as **installation**)
 - Warnings, error messages, and other outputs related to explicit failures
4. Click the **Enter** key.
5. Optional: Select the **OpenShift Container Platform** product filter.
6. Optional: Select the **Documentation** content type filter.

17.3.1.2.3. Submitting a support case

Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.

- You have installed the OpenShift CLI (**oc**).
- You have a Red Hat Customer Portal account.
- You have a Red Hat Standard or Premium subscription.

Procedure

1. Log in to [the Customer Support page](#) of the Red Hat Customer Portal.
2. Click **Get support**.
3. On the **Cases** tab of the **Customer Support** page:
 - a. Optional: Change the pre-filled account and owner details if needed.
 - b. Select the appropriate category for your issue, such as **Bug or Defect**, and click **Continue**.
4. Enter the following information:
 - a. In the **Summary** field, enter a concise but descriptive problem summary and further details about the symptoms being experienced, as well as your expectations.
 - b. Select **OpenShift Container Platform** from the **Product** drop-down menu.
 - c. Select **4.18** from the **Version** drop-down.
5. Review the list of suggested Red Hat Knowledgebase solutions for a potential match against the problem that is being reported. If the suggested articles do not address the issue, click **Continue**.
6. Review the updated list of suggested Red Hat Knowledgebase solutions for a potential match against the problem that is being reported. The list is refined as you provide more information during the case creation process. If the suggested articles do not address the issue, click **Continue**.
7. Ensure that the account information presented is as expected, and if not, amend accordingly.
8. Check that the autofilled OpenShift Container Platform Cluster ID is correct. If it is not, manually obtain your cluster ID.
 - To manually obtain your cluster ID using the OpenShift Container Platform web console:
 - a. Navigate to **Home** → **Overview**.
 - b. Find the value in the **Cluster ID** field of the **Details** section.
 - Alternatively, it is possible to open a new support case through the OpenShift Container Platform web console and have your cluster ID autofilled.
 - a. From the toolbar, navigate to **(?) Help** → **Open Support Case**.
 - b. The **Cluster ID** value is autofilled.
 - To obtain your cluster ID using the OpenShift CLI (**oc**), run the following command:

```
$ oc get clusterversion -o jsonpath='{.items[].spec.clusterID}{"\n"}'
```

9. Complete the following questions where prompted and then click **Continue**:
 - What are you experiencing? What are you expecting to happen?
 - Define the value or impact to you or the business.
 - Where are you experiencing this behavior? What environment?
 - When does this behavior occur? Frequency? Repeatedly? At certain times?
10. Upload relevant diagnostic data files and click **Continue**. It is recommended to include data gathered using the **oc adm must-gather** command as a starting point, plus any issue specific data that is not collected by that command.
11. Input relevant case management details and click **Continue**.
12. Preview the case details and click **Submit**.

17.3.2. General troubleshooting

When you encounter a problem, the first step is to find the specific area where the issue is happening. To narrow down the potential problematic areas, complete one or more tasks:

- Query your cluster
- Check your pod logs
- Debug a pod
- Review events

17.3.2.1. Querying your cluster

Get information about your cluster so that you can more accurately find potential problems.

Procedure

1. Switch into a project by running the following command:

```
$ oc project <project_name>
```

2. Query your cluster version, cluster Operator, and node within that namespace by running the following command:

```
$ oc get clusterversion,clusteroperator,node
```

Example output

NAME	VERSION	AVAILABLE	PROGRESSING	SINCE
STATUS				
clusterversion.config.openshift.io/version	4.16.11	True	False	62d Cluster
version is 4.16.11				
NAME	VERSION	AVAILABLE		
PROGRESSING	DEGRADED	SINCE	MESSAGE	

clusteroperator.config.openshift.io/authentication	4.16.11	True	False
False 62d			
clusteroperator.config.openshift.io/baremetal	4.16.11	True	False
False 62d			
clusteroperator.config.openshift.io/cloud-controller-manager	4.16.11	True	
False False 62d			
clusteroperator.config.openshift.io/cloud-credential	4.16.11	True	False
False 62d			
clusteroperator.config.openshift.io/cluster-autoscaler	4.16.11	True	False
False 62d			
clusteroperator.config.openshift.io/config-operator	4.16.11	True	False
False 62d			
clusteroperator.config.openshift.io/console	4.16.11	True	False
False 62d			
clusteroperator.config.openshift.io/control-plane-machine-set	4.16.11	True	
False False 62d			
clusteroperator.config.openshift.io/csi-snapshot-controller	4.16.11	True	
False False 62d			
clusteroperator.config.openshift.io/dns	4.16.11	True	False
False 62d			
clusteroperator.config.openshift.io/etcd	4.16.11	True	False
False 62d			
clusteroperator.config.openshift.io/image-registry	4.16.11	True	False
False 55d			
clusteroperator.config.openshift.io/ingress	4.16.11	True	False
False 62d			
clusteroperator.config.openshift.io/insights	4.16.11	True	False
False 62d			
clusteroperator.config.openshift.io/kube-apiserver	4.16.11	True	False
False 62d			
clusteroperator.config.openshift.io/kube-controller-manager	4.16.11	True	
False False 62d			
clusteroperator.config.openshift.io/kube-scheduler	4.16.11	True	False
False 62d			
clusteroperator.config.openshift.io/kube-storage-version-migrator	4.16.11	True	
False False 62d			
clusteroperator.config.openshift.io/machine-api	4.16.11	True	False
False 62d			
clusteroperator.config.openshift.io/machine-approvers	4.16.11	True	
False False 62d			
clusteroperator.config.openshift.io/machine-config	4.16.11	True	False
False 62d			
clusteroperator.config.openshift.io/marketplace	4.16.11	True	False
False 62d			
clusteroperator.config.openshift.io/monitoring	4.16.11	True	False
False 62d			
clusteroperator.config.openshift.io/network	4.16.11	True	False
False 62d			
clusteroperator.config.openshift.io/node-tuning	4.16.11	True	False
False 62d			
clusteroperator.config.openshift.io/openshift-apiserver	4.16.11	True	False
False 62d			
clusteroperator.config.openshift.io/openshift-controller-manager	4.16.11	True	
False False 62d			
clusteroperator.config.openshift.io/openshift-samples	4.16.11	True	
False False 35d			

clusteroperator.config.openshift.io/operator-lifecycle-manager	4.16.11	True		
False False 62d				
clusteroperator.config.openshift.io/operator-lifecycle-manager-catalog	4.16.11	True		
False False 62d				
clusteroperator.config.openshift.io/operator-lifecycle-manager-packageserver	4.16.11	True		
False False 62d				
clusteroperator.config.openshift.io/service-ca	4.16.11	True False		
False 62d				
clusteroperator.config.openshift.io/storage	4.16.11	True False		
False 62d				
NAME	STATUS	ROLES	AGE	VERSION
node/ctrl-plane-0	Ready	control-plane,master,worker	62d	v1.29.7
node/ctrl-plane-1	Ready	control-plane,master,worker	62d	v1.29.7
node/ctrl-plane-2	Ready	control-plane,master,worker	62d	v1.29.7

For more information, see "oc get" and "Reviewing pod status".

Additional resources

- [oc get](#)
- [Reviewing pod status](#)

17.3.2.2. Checking pod logs

Get logs from the pod so that you can review the logs for issues.

Procedure

1. List the pods by running the following command:

```
$ oc get pod
```

Example output

NAME	READY	STATUS	RESTARTS	AGE
busybox-1	1/1	Running	168 (34m ago)	7d
busybox-2	1/1	Running	119 (9m20s ago)	4d23h
busybox-3	1/1	Running	168 (43m ago)	7d
busybox-4	1/1	Running	168 (43m ago)	7d

2. Check pod log files by running the following command:

```
$ oc logs -n <namespace> busybox-1
```

For more information, see "oc logs", "Logging", and "Inspecting pod and container logs".

Additional resources

- [oc logs](#)
- [Logging](#)

- [Inspecting pod and container logs](#)

17.3.2.3. Describing a pod

Describing a pod gives you information about that pod to help with troubleshooting. The **Events** section provides detailed information about the pod and the containers inside of it.

Procedure

- Describe a pod by running the following command:

```
$ oc describe pod -n <namespace> busybox-1
```

Example output

```
Name:      busybox-1
Namespace:  busy
Priority:   0
Service Account: default
Node:      worker-3/192.168.0.0
Start Time: Mon, 27 Nov 2023 14:41:25 -0500
Labels:    app=busybox
           pod-template-hash=<hash>
Annotations: k8s.ovn.org/pod-networks:
...
Events:
  Type  Reason  Age          From     Message
  ----  -----  --          ----     ---
  Normal Pulled  41m (x170 over 7d1h)  kubelet  Container image
  "quay.io/quay/busybox:latest" already present on machine
  Normal Created  41m (x170 over 7d1h)  kubelet  Created container busybox
  Normal Started  41m (x170 over 7d1h)  kubelet  Started container busybox
```

For more information, see "oc describe".

Additional resources

- [oc describe](#)

17.3.2.4. Reviewing events

You can review the events in a given namespace to find potential issues.

Procedure

- 1 Check for events in your namespace by running the following command:

```
$ oc get events -n <namespace> --sort-by=".metadata.creationTimestamp" ①
```

- ① Adding the **--sort-by=".metadata.creationTimestamp"** flag places the most recent events at the end of the output.

- Optional: If the events within your specified namespace do not provide enough information, expand your query to all namespaces by running the following command:

```
$ oc get events -A --sort-by=".metadata.creationTimestamp" ①
```

- ① The **--sort-by=".metadata.creationTimestamp"** flag places the most recent events at the end of the output.

To filter the results of all events from a cluster, you can use the **grep** command. For example, if you are looking for errors, the errors can appear in two different sections of the output: the **TYPE** or **MESSAGE** sections. With the **grep** command, you can search for keywords, such as **error** or **failed**.

- For example, search for a message that contains **warning** or **error** by running the following command:

```
$ oc get events -A | grep -Ei "warning|error"
```

Example output

NAMESPACE	LAST SEEN	TYPE	REASON	OBJECT	MESSAGE
openshift	59s	Warning	FailedMount	pod/openshift-1	MountVolume.SetUp failed for volume "v4-0-config-user-idp-0-file-data" : references non-existent secret key: test

- Optional: To clean up the events and see only recurring events, you can delete the events in the relevant namespace by running the following command:

```
$ oc delete events -n <namespace> --all
```

For more information, see "Watching cluster events".

Additional resources

- [Watching cluster events](#)

17.3.2.5. Connecting to a pod

You can directly connect to a currently running pod with the **oc rsh** command, which provides you with a shell on that pod.



WARNING

In pods that run a low-latency application, latency issues can occur when you run the **oc rsh** command. Use the **oc rsh** command only if you cannot connect to the node by using the **oc debug** command.

Procedure

- Connect to your pod by running the following command:

```
$ oc rsh -n <namespace> busybox-1
```

For more information, see "oc rsh" and "Accessing running pods".

Additional resources

- [oc rsh](#)
- [Accessing running pods](#)

17.3.2.6. Debugging a pod

In certain cases, you do not want to directly interact with your pod that is in production.

To avoid interfering with running traffic, you can use a secondary pod that is a copy of your original pod. The secondary pod uses the same components as that of the original pod but does not have running traffic.

Procedure

1. List the pods by running the following command:

```
$ oc get pod
```

Example output

NAME	READY	STATUS	RESTARTS	AGE
busybox-1	1/1	Running	168 (34m ago)	7d
busybox-2	1/1	Running	119 (9m20s ago)	4d23h
busybox-3	1/1	Running	168 (43m ago)	7d
busybox-4	1/1	Running	168 (43m ago)	7d

2. Debug a pod by running the following command:

```
$ oc debug -n <namespace> busybox-1
```

Example output

```
Starting pod/busybox-1-debug, command was: sleep 3600
Pod IP: 10.133.2.11
```

If you do not see a shell prompt, press Enter.

For more information, see "oc debug" and "Starting debug pods with root access".

Additional resources

- [oc debug](#)
- [Starting debug pods with root access](#)

17.3.2.7. Running a command on a pod

If you want to run a command or set of commands on a pod without directly logging into it, you can use the **oc exec -it** command. You can interact with the pod quickly to get process or output information from the pod. A common use case is to run the **oc exec -it** command inside a script to run the same command on multiple pods in a replica set or deployment.



WARNING

In pods that run a low-latency application, the **oc exec** command can cause latency issues.

Procedure

- To run a command on a pod without logging into it, run the following command:

```
$ oc exec -it <pod> -- <command>
```

For more information, see "oc exec" and "Executing remote commands in containers".

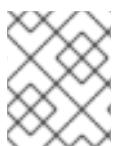
Additional resources

- [oc exec](#)
- [Executing remote commands in containers](#)

17.3.3. Cluster maintenance

In telco networks, you must pay more attention to certain configurations due the nature of bare-metal deployments. You can troubleshoot more effectively by completing these tasks:

- Monitor for failed or failing hardware components
- Periodically check the status of the cluster Operators



NOTE

For hardware monitoring, contact your hardware vendor to find the appropriate logging tool for your specific hardware.

17.3.3.1. Checking cluster Operators

Periodically check the status of your cluster Operators to find issues early.

Procedure

- Check the status of the cluster Operators by running the following command:

```
$ oc get co
```

17.3.3.2. Watching for failed pods

To reduce troubleshooting time, regularly monitor for failed pods in your cluster.

Procedure

- To watch for failed pods, run the following command:

```
$ oc get po -A | grep -Eiv 'complete|running'
```

17.3.4. Security

Implementing a robust cluster security profile is important for building resilient telco networks.

17.3.4.1. Authentication

Determine which identity providers are in your cluster. For more information about supported identity providers, see "Supported identity providers" in *Authentication and authorization*.

After you know which providers are configured, you can inspect the **openshift-authentication** namespace to determine if there are potential issues.

Procedure

1. Check the events in the **openshift-authentication** namespace by running the following command:

```
$ oc get events -n openshift-authentication --sort-by=.metadata.creationTimestamp
```

2. Check the pods in the **openshift-authentication** namespace by running the following command:

```
$ oc get pod -n openshift-authentication
```

3. Optional: If you need more information, check the logs of one of the running pods by running the following command:

```
$ oc logs -n openshift-authentication <pod_name>
```

Additional resources

- [Supported identity providers](#)

17.3.5. Certificate maintenance

Certificate maintenance is required for continuous cluster authentication. As a cluster administrator, you must manually renew certain certificates, while others are automatically renewed by the cluster.

Learn about certificates in OpenShift Container Platform and how to maintain them by using the following resources:

- [Which OpenShift certificates do rotate automatically and which do not in Openshift 4.x?](#)

- [Checking etcd certificate expiry in OpenShift 4](#)

17.3.5.1. Certificates manually managed by the administrator

The following certificates must be renewed by a cluster administrator:

- Proxy certificates
- User-provisioned certificates for the API server

17.3.5.1.1. Managing proxy certificates

Proxy certificates allow users to specify one or more custom certificate authority (CA) certificates that are used by platform components when making egress connections.



NOTE

Certain CAs set expiration dates and you might need to renew these certificates every two years.

If you did not originally set the requested certificates, you can determine the certificate expiration in several ways. Most Cloud-native Network Functions (CNFs) use certificates that are not specifically designed for browser-based connectivity. Therefore, you need to pull the certificate from the **ConfigMap** object of your deployment.

Procedure

- To get the expiration date, run the following command against the certificate file:

```
$ openssl x509 -enddate -noout -in <cert_file_name>.pem
```

For more information about determining how and when to renew your proxy certificates, see "Proxy certificates" in *Security and compliance*.

Additional resources

- [Proxy certificates](#)

17.3.5.1.2. User-provisioned API server certificates

The API server is accessible by clients that are external to the cluster at **api.<cluster_name>. <base_domain>**. You might want clients to access the API server at a different hostname or without the need to distribute the cluster-managed certificate authority (CA) certificates to the clients. You must set a custom default certificate to be used by the API server when serving content.

For more information, see "User-provided certificates for the API server" in *Security and compliance*

Additional resources

- [User-provisioned certificates for the API server](#)

17.3.5.2. Certificates managed by the cluster

You only need to check cluster-managed certificates if you detect an issue in the logs. The following certificates are automatically managed by the cluster:

- Service CA certificates
- Node certificates
- Bootstrap certificates
- etcd certificates
- OLM certificates
- Machine Config Operator certificates
- Monitoring and cluster logging Operator component certificates
- Control plane certificates
- Ingress certificates

Additional resources

- [Service CA certificates](#)
- [Node certificates](#)
- [Bootstrap certificates](#)
- [etcd certificates](#)
- [OLM certificates](#)
- [Machine Config Operator certificates](#)
- [Monitoring and cluster logging Operator component certificates](#)
- [Control plane certificates](#)
- [Ingress certificates](#)

17.3.5.2.1. Certificates managed by etcd

The etcd certificates are used for encrypted communication between etcd member peers as well as encrypted client traffic. The certificates are renewed automatically within the cluster provided that communication between all nodes and all services is current. Therefore, if your cluster might lose communication between components during a specific period of time, which is close to the end of the etcd certificate lifetime, it is recommended to renew the certificate in advance. For example, communication can be lost during an upgrade due to nodes rebooting at different times.

- You can manually renew etcd certificates by running the following command:

```
$ for each in $(oc get secret -n openshift-etcd | grep "kubernetes.io/tls" | grep -e \'etcd-peer\'|etcd-serving" | awk '{print $1}'); do oc get secret $each -n openshift-etcd -o jsonpath="{.data.tls\.crt}" | base64 -d | openssl x509 -noout -enddate; done
```

For more information about updating etcd certificates, see [Checking etcd certificate expiry in OpenShift 4](#). For more information about etcd certificates, see "etcd certificates" in [Security and compliance](#).

Additional resources

- [etcd certificates](#)

17.3.5.2.2. Node certificates

Node certificates are self-signed certificates, which means that they are signed by the cluster and they originate from an internal certificate authority (CA) that is generated by the bootstrap process.

After the cluster is installed, the cluster automatically renews the node certificates.

For more information, see "Node certificates" in [Security and compliance](#).

Additional resources

- [Node certificates](#)

17.3.5.2.3. Service CA certificates

The **service-ca** is an Operator that creates a self-signed certificate authority (CA) when an OpenShift Container Platform cluster is deployed. This allows user to add certificates to their deployments without manually creating them. Service CA certificates are self-signed certificates.

For more information, see "Service CA certificates" in [Security and compliance](#).

Additional resources

- [Service CA certificates](#)

17.3.6. Machine Config Operator

The Machine Config Operator provides useful information to cluster administrators and controls what is running directly on the bare-metal host.

The Machine Config Operator differentiates between different groups of nodes in the cluster, allowing control plane nodes and worker nodes to run with different configurations. These groups of nodes run worker or application pods, which are called **MachineConfigPool (mcp)** groups. The same machine config is applied on all nodes or only on one MCP in the cluster.

For more information about how and why to apply MCPs in a telco core cluster, see [Applying MachineConfigPool labels to nodes before the update](#).

For more information about the Machine Config Operator, see [Machine Config Operator](#).

17.3.6.1. Purpose of the Machine Config Operator

The Machine Config Operator (MCO) manages and applies configuration and updates of Red Hat Enterprise Linux CoreOS (RHCOS) and container runtime, including everything between the kernel and kubelet. Managing RHCOS is important since most telecommunications companies run on bare-metal

hardware and use some sort of hardware accelerator or kernel modification. Applying machine configuration to RHCOS manually can cause problems because the MCO monitors each node and what is applied to it.

You must consider these minor components and how the MCO can help you manage your clusters effectively.



IMPORTANT

You must use the MCO to perform all changes on worker or control plane nodes. Do not manually make changes to RHCOS or node files.

17.3.6.2. Applying several machine config files at the same time

When you need to change the machine config for a group of nodes in the cluster, also known as machine config pools (MCPs), sometimes the changes must be applied with several different machine config files. The nodes need to restart for the machine config file to be applied. After each machine config file is applied to the cluster, all nodes restart that are affected by the machine config file.

To prevent the nodes from restarting for each machine config file, you can apply all of the changes at the same time by pausing each MCP that is updated by the new machine config file.

Procedure

1. Pause the affected MCP by running the following command:

```
$ oc patch mcp/<mcp_name> --type merge --patch '{"spec":{"paused":true}}'
```

2. After you apply all machine config changes to the cluster, run the following command:

```
$ oc patch mcp/<mcp_name> --type merge --patch '{"spec":{"paused":false}}'
```

This allows the nodes in your MCP to reboot into the new configurations.

17.3.7. Bare-metal node maintenance

You can connect to a node for general troubleshooting. However, in some cases, you need to perform troubleshooting or maintenance tasks on certain hardware components. This section discusses topics that you need to perform that hardware maintenance.

17.3.7.1. Connecting to a bare-metal node in your cluster

You can connect to bare-metal cluster nodes for general maintenance tasks.



NOTE

Configuring the cluster node from the host operating system is not recommended or supported.

To troubleshoot your nodes, you can do the following tasks:

- Retrieve logs from node

- Use debugging
- Use SSH to connect to the node



IMPORTANT

Use SSH only if you cannot connect to the node with the **oc debug** command.

Procedure

1. Retrieve the logs from a node by running the following command:

```
$ oc adm node-logs <node_name> -u crio
```

2. Use debugging by running the following command:

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

3. Set **/host** as the root directory within the debug shell. The debug pod mounts the host's root file system in **/host** within the pod. By changing the root directory to **/host**, you can run binaries contained in the host's executable paths:

```
# chroot /host
```

Output

```
You are now logged in as root on the node
```

4. Optional: Use SSH to connect to the node by running the following command:

```
$ ssh core@<node_name>
```

17.3.7.2. Moving applications to pods within the cluster

For scheduled hardware maintenance, you need to consider how to move your application pods to other nodes within the cluster without affecting the pod workload.

Procedure

- Mark the node as unschedulable by running the following command:

```
$ oc adm cordon <node_name>
```

When the node is unschedulable, no pods can be scheduled on the node. For more information, see "Working with nodes".



NOTE

When moving CNF applications, you might need to verify ahead of time that there are enough additional worker nodes in the cluster due to anti-affinity and pod disruption budget.

Additional resources

- [Working with nodes](#)

17.3.7.3. DIMM memory replacement

Dual in-line memory module (DIMM) problems sometimes only appear after a server reboots. You can check the log files for these problems.

When you perform a standard reboot and the server does not start, you can see a message in the console that there is a faulty DIMM memory. In that case, you can acknowledge the faulty DIMM and continue rebooting if the remaining memory is sufficient. Then, you can schedule a maintenance window to replace the faulty DIMM.

Sometimes, a message in the event logs indicates a bad memory module. In these cases, you can schedule the memory replacement before the server is rebooted.

Additional resources

- [OpenShift Container Platform storage overview](#)

17.3.7.4. Disk replacement

If you do not have disk redundancy configured on your node through hardware or software redundant array of independent disks (RAID), you need to check the following:

- Does the disk contain running pod images?
- Does the disk contain persistent data for pods?

For more information, see "OpenShift Container Platform storage overview" in *Storage*.

17.3.7.5. Cluster network card replacement

When you replace a network card, the MAC address changes. The MAC address can be part of the DHCP or SR-IOV Operator configuration, router configuration, firewall rules, or application Cloud-native Network Function (CNF) configuration. Before you bring back a node online after replacing a network card, you must verify that these configurations are up-to-date.



IMPORTANT

If you do not have specific procedures for MAC address changes within the network, contact your network administrator or network hardware vendor.

17.4. OBSERVABILITY

17.4.1. Observability in telco core CNF clusters

OpenShift Container Platform generates a large amount of data, such as performance metrics and logs from both the platform and the workloads running on it. As an administrator, you can use various tools to collect and analyze all the data available. What follows is an outline of best practices for system engineers, architects, and administrators configuring the observability stack.

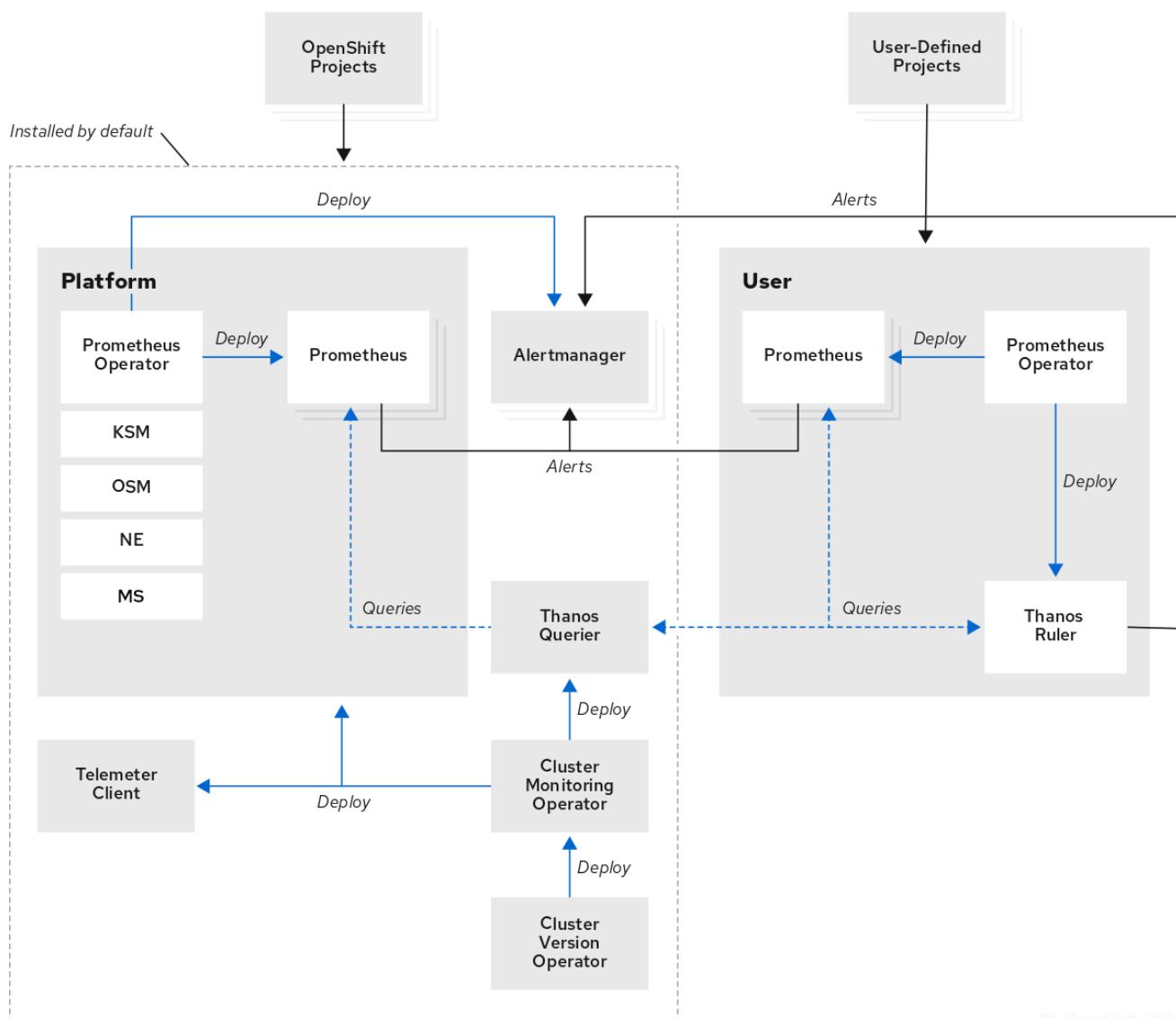
Unless explicitly stated, the material in this document refers to both Edge and Core deployments.

17.4.1.1. Understanding the monitoring stack

The monitoring stack uses the following components:

- Prometheus collects and analyzes metrics from OpenShift Container Platform components and from workloads, if configured to do so.
- Alertmanager is a component of Prometheus that handles routing, grouping, and silencing of alerts.
- Thanos handles long term storage of metrics.

Figure 17.2. OpenShift Container Platform monitoring architecture



118_OpenShift_0920



NOTE

For a single-node OpenShift cluster, you should disable Alertmanager and Thanos because the cluster sends all metrics to the hub cluster for analysis and retention.

Additional resources

- [About OpenShift Container Platform monitoring](#)

- Core platform monitoring first steps

17.4.1.2. Key performance metrics

Depending on your system, there can be hundreds of available measurements.

Here are some key metrics that you should pay attention to:

- **etcd** response times
- API response times
- Pod restarts and scheduling
- Resource usage
- OVN health
- Overall cluster operator health

A good rule to follow is that if you decide that a metric is important, there should be an alert for it.



NOTE

You can check the available metrics by running the following command:

```
$ oc -n openshift-monitoring exec -c prometheus prometheus-k8s-0 -- curl -qsk
http://localhost:9090/api/v1/metadata | jq '.data'
```

17.4.1.2.1. Example queries in PromQL

The following tables show some queries that you can explore in the metrics query browser using the OpenShift Container Platform console.



NOTE

The URL for the console is <https://<OpenShift Console FQDN>/monitoring/query-browser>. You can get the OpenShift Console FQDN by running the following command:

```
$ oc get routes -n openshift-console console -o jsonpath='{.status.ingress[0].host}'
```

Table 17.1. Node memory & CPU usage

Metric	Query
CPU % requests by node	sum by (node) (sum_over_time(kube_pod_container_resource_requests{resource="cpu"}[60m]))/sum by (node) (sum_over_time(kube_node_status_allocatable{resource="cpu"})[60m]) *100

Metric	Query
Overall cluster CPU % utilization	<pre>sum by (managed_cluster) (sum_over_time(kube_pod_container_resource_requests{resource="memory"}[60m])/sum by (managed_cluster) (sum_over_time(kube_node_status_allocatable{resource="cpu"})[60m])) *100</pre>
Memory % requests by node	<pre>sum by (node) (sum_over_time(kube_pod_container_resource_requests{resource="memory"}[60m])/sum by (node) (sum_over_time(kube_node_status_allocatable{resource="memory"})[60m])) *100</pre>
Overall cluster memory % utilization	<pre>(1-(sum by (managed_cluster) (avg_over_time(node_memory_MemAvailable_bytes[60m]))/sum by (managed_cluster) (avg_over_time(kube_node_status_allocatable{resource="memory"})[60m]))) *100</pre>

Table 17.2. API latency by verb

Metric	Query
GET	<pre>histogram_quantile(0.99, sum by (le,managed_cluster) (sum_over_time(apiserver_request_duration_seconds_bucket{apiserver=~"kube-apiserver openshift-apiserver", verb="GET"}[60m])))</pre>
PATCH	<pre>histogram_quantile(0.99, sum by (le,managed_cluster) (sum_over_time(apiserver_request_duration_seconds_bucket{apiserver="kube-apiserver openshift-apiserver", verb="PATCH"})[60m]))</pre>
POST	<pre>histogram_quantile(0.99, sum by (le,managed_cluster) (sum_over_time(apiserver_request_duration_seconds_bucket{apiserver="kube-apiserver openshift-apiserver", verb="POST"})[60m]))</pre>

Metric	Query
LIST	<code>histogram_quantile(0.99, sum by (le,managed_cluster) (sum_over_time(apiserver_request_duration _seconds_bucket{apiserver="kube- apiserver openshift-apiserver", verb="LIST"} [60m])))</code>
PUT	<code>histogram_quantile(0.99, sum by (le,managed_cluster) (sum_over_time(apiserver_request_duration _seconds_bucket{apiserver="kube- apiserver openshift-apiserver", verb="PUT"} [60m])))</code>
DELETE	<code>histogram_quantile(0.99, sum by (le,managed_cluster) (sum_over_time(apiserver_request_duration _seconds_bucket{apiserver="kube- apiserver openshift-apiserver", verb="DELETE"})[60m]))</code>
Combined	<code>histogram_quantile(0.99, sum by (le,managed_cluster) (sum_over_time(apiserver_request_duration _seconds_bucket{apiserver=~"(openshift- apiserver kube-apiserver)", verb!="WATCH"} [60m])))</code>

Table 17.3. etcd

Metric	Query
fsync 99th percentile latency (per instance)	<code>histogram_quantile(0.99, rate(etcd_disk_wal_fsync_duration_seconds _bucket[2m]))</code>
fsync 99th percentile latency (per cluster)	<code>sum by (managed_cluster) (histogram_quantile(0.99, rate(etcd_disk_wal_fsync_duration_seconds _bucket[60m])))</code>
Leader elections	<code>sum(rate(etcd_server_leader_changes_seen _total[1440m]))</code>
Network latency	<code>histogram_quantile(0.99, rate(etcd_network_peer_round_trip_time_se conds_bucket[5m]))</code>

Table 17.4. Operator health

Metric	Query
Degraded operators	<code>sum by (managed_cluster, name) (avg_over_time(cluster_operator_conditions{condition="Degraded", name!="version"} [60m]))</code>
Total degraded operators per cluster	<code>sum by (managed_cluster) (avg_over_time(cluster_operator_conditions{condition="Degraded", name!="version"} [60m]))</code>

17.4.1.2.2. Recommendations for storage of metrics

Out of the box, Prometheus does not back up saved metrics with persistent storage. If you restart the Prometheus pods, all metrics data are lost. You should configure the monitoring stack to use the backend storage that is available on the platform. To meet the high IO demands of Prometheus you should use local storage.

For Telco core clusters, you can use the Local Storage Operator for persistent storage for Prometheus.

Red Hat OpenShift Data Foundation (ODF), which deploys a ceph cluster for block, file, and object storage, is also a suitable candidate for a Telco core cluster.

To keep system resource requirements low on a RAN single-node OpenShift or far edge cluster, you should not provision backend storage for the monitoring stack. Such clusters forward all metrics to the hub cluster where you can provision a third party monitoring platform.

Additional resources

- [Accessing metrics as an administrator](#)
- [Persistent storage using local volumes](#)

17.4.1.3. Monitoring the edge

Single-node OpenShift at the edge keeps the footprint of the platform components to a minimum. The following procedure is an example of how you can configure a single-node OpenShift node with a small monitoring footprint.

Prerequisites

- For environments that use Red Hat Advanced Cluster Management (RHACM), you have enabled the Observability service.
- The hub cluster is running Red Hat OpenShift Data Foundation (ODF).

Procedure

1. Create a **ConfigMap** CR, and save it as **monitoringConfigMap.yaml**, as in the following example:

```

apiVersion: v1
kind: ConfigMap
metadata:
  name: cluster-monitoring-config
  namespace: openshift-monitoring
data:
  config.yaml: |
    alertmanagerMain:
      enabled: false
    telemeterClient:
      enabled: false
    prometheusK8s:
      retention: 24h

```

2. On the single-node OpenShift, apply the **ConfigMap** CR by running the following command:

```
$ oc apply -f monitoringConfigMap.yaml
```

3. Create a **NameSpace** CR, and save it as **monitoringNamespace.yaml**, as in the following example:

```

apiVersion: v1
kind: Namespace
metadata:
  name: open-cluster-management-observability

```

4. On the hub cluster, apply the **Namespace** CR on the hub cluster by running the following command:

```
$ oc apply -f monitoringNamespace.yaml
```

5. Create an **ObjectBucketClaim** CR, and save it as **monitoringObjectBucketClaim.yaml**, as in the following example:

```

apiVersion: objectbucket.io/v1alpha1
kind: ObjectBucketClaim
metadata:
  name: multi-cloud-observability
  namespace: open-cluster-management-observability
spec:
  storageClassName: openshift-storage.noobaa.io
  generateBucketName: acm-multi

```

6. On the hub cluster, apply the **ObjectBucketClaim** CR, by running the following command:

```
$ oc apply -f monitoringObjectBucketClaim.yaml
```

7. Create a **Secret** CR, and save it as **monitoringSecret.yaml**, as in the following example:

```

apiVersion: v1
kind: Secret
metadata:
  name: multicloudhub-operator-pull-secret

```

```

namespace: open-cluster-management-observability
stringData:
  .dockerconfigjson: 'PULL_SECRET'

```

- On the hub cluster, apply the **Secret** CR by running the following command:

```
$ oc apply -f monitoringSecret.yaml
```

- Get the keys for the NooBaa service and the backend bucket name from the hub cluster by running the following commands:

```
$ NOOBAA_ACCESS_KEY=$(oc get secret noobaa-admin -n openshift-storage -o json | jq -r '.data.AWS_ACCESS_KEY_ID|@base64d')
```

```
$ NOOBAA_SECRET_KEY=$(oc get secret noobaa-admin -n openshift-storage -o json | jq -r '.data.AWS_SECRET_ACCESS_KEY|@base64d')
```

```
$ OBJECT_BUCKET=$(oc get objectbucketclaim -n open-cluster-management-observability multi-cloud-observability -o json | jq -r .spec.bucketName)
```

- Create a **Secret** CR for bucket storage and save it as **monitoringBucketSecret.yaml**, as in the following example:

```

apiVersion: v1
kind: Secret
metadata:
  name: thanos-object-storage
  namespace: open-cluster-management-observability
type: Opaque
stringData:
  thanos.yaml: |
    type: s3
    config:
      bucket: ${OBJECT_BUCKET}
      endpoint: s3.openshift-storage.svc
      insecure: true
      access_key: ${NOOBAA_ACCESS_KEY}
      secret_key: ${NOOBAA_SECRET_KEY}

```

- On the hub cluster, apply the **Secret** CR by running the following command:

```
$ oc apply -f monitoringBucketSecret.yaml
```

- Create the **MultiClusterObservability** CR and save it as **monitoringMultiClusterObservability.yaml**, as in the following example:

```

apiVersion: observability.open-cluster-management.io/v1beta2
kind: MultiClusterObservability
metadata:
  name: observability
spec:
  advanced:
    retentionConfig:

```

```

blockDuration: 2h
deleteDelay: 48h
retentionInLocal: 24h
retentionResolutionRaw: 3d
enableDownsampling: false
observabilityAddonSpec:
  enableMetrics: true
  interval: 300
storageConfig:
  alertmanagerStorageSize: 10Gi
  compactStorageSize: 100Gi
  metricObjectStorage:
    key: thanos.yaml
    name: thanos-object-storage
  receiveStorageSize: 25Gi
  ruleStorageSize: 10Gi
  storeStorageSize: 25Gi

```

13. On the hub cluster, apply the **MultiClusterObservability** CR by running the following command:

```
$ oc apply -f monitoringMultiClusterObservability.yaml
```

Verification

1. Check the routes and pods in the namespace to validate that the services have deployed on the hub cluster by running the following command:

```
$ oc get routes,pods -n open-cluster-management-observability
```

Example output

NAME PATH SERVICES	HOST/PORT PORT TERMINATION	WILDCARD
route.route.openshift.io/alertmanager route.route.openshift.io/grafana route.route.openshift.io/observatorium-api route.route.openshift.io/rbac-query-proxy	alertmanager-open-cluster-management-observability.cloud.example.com /api/v2 grafana-open-cluster-management-observability.cloud.example.com observability-observatorium-api rbac-query-proxy-open-cluster-management-observability.cloud.example.com	oauth-proxy oauth-proxy public https
reencrypt/Redirect None reencrypt/Redirect None reencrypt/Redirect None reencrypt/Redirect None	alertmanager grafana observability-observatorium-api rbac-query-proxy	
passthrough/None None		
<...snip...>		

NAME	READY STATUS RESTARTS AGE
pod/observability-alertmanager-0	3/3 Running 0 1d
pod/observability-alertmanager-1	3/3 Running 0 1d
pod/observability-alertmanager-2	3/3 Running 0 1d
pod/observability-grafana-685b47bb47-dq4cw	3/3 Running 0 1d
<...snip...>	

pod/observability-thanos-store-shard-0-0	1/1	Running	0	1d
pod/observability-thanos-store-shard-1-0	1/1	Running	0	1d
pod/observability-thanos-store-shard-2-0	1/1	Running	0	1d

- 1 A dashboard is accessible at the grafana route listed. You can use this to view metrics across all managed clusters.

For more information on observability in Red Hat Advanced Cluster Management, see [Observability](#).

17.4.1.4. Alerting

OpenShift Container Platform includes a large number of alert rules, which can change from release to release.

17.4.1.4.1. Viewing default alerts

Use the following procedure to review all of the alert rules in a cluster.

Procedure

- To review all the alert rules in a cluster, you can run the following command:

```
$ oc get cm -n openshift-monitoring prometheus-k8s-rulefiles-0 -o yaml
```

Rules can include a description and provide a link to additional information and mitigation steps. For example, this is the rule for **etcdHighFsyncDurations**:

```
- alert: etcdHighFsyncDurations
  annotations:
    description: 'etcd cluster "{{ $labels.job }}": 99th percentile fsync durations
      are {{ $value }}s on etcd instance {{ $labels.instance }}.'
    runbook_url: https://github.com/openshift/runbooks/blob/master/alerts/cluster-etcd-
      operator/etcdHighFsyncDurations.md
    summary: etcd cluster 99th percentile fsync durations are too high.
  expr: |
    histogram_quantile(0.99,
      rate(etcd_disk_wal_fsync_duration_seconds_bucket{job=~".*etcd.*"}[5m]))
      > 1
  for: 10m
  labels:
    severity: critical
```

17.4.1.4.2. Alert notifications

You can view alerts in the OpenShift Container Platform console, however an administrator should configure an external receiver to forward the alerts to. OpenShift Container Platform supports the following receiver types:

- PagerDuty: a 3rd party incident response platform
- Webhook: an arbitrary API endpoint that receives an alert via a POST request and can take any necessary action

- Email: sends an email to designated address
- Slack: sends a notification to either a slack channel or an individual user

Additional resources

- [Managing alerts](#)

17.4.1.5. Workload monitoring

By default, OpenShift Container Platform does not collect metrics for application workloads. You can configure a cluster to collect workload metrics.

Prerequisites

- You have defined endpoints to gather workload metrics on the cluster.

Procedure

- 1 Create a **ConfigMap** CR and save it as **monitoringConfigMap.yaml**, as in the following example:

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: cluster-monitoring-config
  namespace: openshift-monitoring
data:
  config.yaml: |
    enableUserWorkload: true 1
```

- 1 Set to **true** to enable workload monitoring.

- 2 Apply the **ConfigMap** CR by running the following command:

```
$ oc apply -f monitoringConfigMap.yaml
```

- 3 Create a **ServiceMonitor** CR, and save it as **monitoringServiceMonitor.yaml**, as in the following example:

```
apiVersion: monitoring.coreos.com/v1
kind: ServiceMonitor
metadata:
  labels:
    app: ui
  name: myapp
  namespace: myns
spec:
  endpoints: 1
  - interval: 30s
    port: ui-http
    scheme: http
    path: /healthz 2
```

```

    selector:
      matchLabels:
        app: ui
  
```

- 1 Use endpoints to define workload metrics.
- 2 Prometheus scrapes the path **/metrics** by default. You can define a custom path here.

4. Apply the **ServiceMonitor** CR by running the following command:

```
$ oc apply -f monitoringServiceMonitor.yaml
```

Prometheus scrapes the path **/metrics** by default, however you can define a custom path. It is up to the vendor of the application to expose this endpoint for scraping, with metrics that they deem relevant.

17.4.1.5.1. Creating a workload alert

You can enable alerts for user workloads on a cluster.

Procedure

1. Create a **ConfigMap** CR, and save it as **monitoringConfigMap.yaml**, as in the following example:

```

apiVersion: v1
kind: ConfigMap
metadata:
  name: cluster-monitoring-config
  namespace: openshift-monitoring
data:
  config.yaml: |
    enableUserWorkload: true 1
# ...
  
```

- 1** Set to **true** to enable workload monitoring.
2. Apply the **ConfigMap** CR by running the following command:

```
$ oc apply -f monitoringConfigMap.yaml
```

3. Create a YAML file for alerting rules, **monitoringAlertRule.yaml**, as in the following example:

```

apiVersion: monitoring.coreos.com/v1
kind: PrometheusRule
metadata:
  name: myapp-alert
  namespace: myns
spec:
  groups:
  - name: example
  rules:
  
```

```

- alert: InternalErrorsAlert
  expr: flask_http_request_total{status="500"} > 0
# ...

```

4. Apply the alert rule by running the following command:

```
$ oc apply -f monitoringAlertRule.yaml
```

Additional resources

- [ServiceMonitor\[monitoring.coreos.com/v1\]](#)
- [Enabling monitoring for user-defined projects](#)
- [Managing alerting rules for user-defined projects](#)

17.5. SECURITY

17.5.1. Security basics

Security is a critical component of telecommunications deployments on OpenShift Container Platform, particularly when running cloud-native network functions (CNFs).

You can enhance security for high-bandwidth network deployments in telecommunications (telco) environments by following key security considerations. By implementing these standards and best practices, you can strengthen security in telco-specific use cases.

17.5.1.1. RBAC overview

Role-based access control (RBAC) objects determine whether a user is allowed to perform a given action within a project.

Cluster administrators can use the cluster roles and bindings to control who has various access levels to the OpenShift Container Platform platform itself and all projects.

Developers can use local roles and bindings to control who has access to their projects. Note that authorization is a separate step from authentication, which is more about determining the identity of who is taking the action.

Authorization is managed using the following authorization objects:

Rules

Are sets of permitted actions on specific objects. For example, a rule can determine whether a user or service account can create pods. Each rule specifies an API resource, the resource within that API, and the allowed action.

Roles

Are collections of rules that define what actions users or groups can perform. You can associate or bind rules to multiple users or groups. A role file can contain one or more rules that specify the actions and resources allowed for that role.

Roles are categorized into the following types:

- Cluster roles: You can define cluster roles at the cluster level. They are not tied to a single namespace. They can apply across all namespaces or specific namespaces when you bind them to users, groups, or service accounts.
- Project roles: You can create project roles within a specific namespace, and they only apply to that namespace. You can assign permissions to specific users to create roles and role bindings within their namespace, ensuring they do not affect other namespaces.

Bindings

Are associations between users and/or groups with a role. You can create a role binding to connect the rules in a role to a specific user ID or group. This brings together the role and the user or group, defining what actions they can perform.



NOTE

You can bind more than one role to a user or group.

For more information on RBAC, see "Using RBAC to define and apply permissions".

Operational RBAC considerations

To reduce operational overhead, it is important to manage access through groups rather than handling individual user IDs across multiple clusters. By managing groups at an organizational level, you can streamline access control and simplify administration across your organization.

Additional resources

- [Using RBAC to define and apply permissions](#)

17.5.1.2. Security accounts overview

A service account is an OpenShift Container Platform account that allows a component to directly access the API. Service accounts are API objects that exist within each project. Service accounts provide a flexible way to control API access without sharing a regular user's credentials.

You can use service accounts to apply role-based access control (RBAC) to pods. By assigning service accounts to workloads, such as pods and deployments, you can grant additional permissions, such as pulling from different registries. This also allows you to assign lower privileges to service accounts, reducing the security footprint of the pods that run under them.

For more information about service accounts, see "Understanding and creating service accounts".

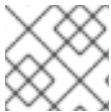
Additional resources

- [Understanding and creating service accounts](#)

17.5.1.3. Identity provider configuration

Configuring an identity provider is the first step in setting up users on the cluster. You can manage groups at the organizational level by using an identity provider.

The identity provider can pull in specific user groups that are maintained at the organizational level, rather than the cluster level. This allows you to add and remove users from groups that follow your organization's established practices.

**NOTE**

You must set up a cron job to run frequently to pull any changes into the cluster.

You can use an identity provider to manage access levels for specific groups within your organization. For example, you can perform the following actions to manage access levels:

- Assign the **cluster-admin** role to teams that require cluster-level privileges.
- Grant application administrators specific privileges to manage only their respective projects.
- Provide operational teams with **view** access across the cluster to enable monitoring without allowing modifications.

For information about configuring an identity provider, see "Understanding identity provider configuration".

Additional resources

- [Understanding identity provider configuration](#)

17.5.1.4. Replacing the kubeadmin user with a cluster-admin user

The **kubeadmin** user with the **cluster-admin** privileges is created on every cluster by default. To enhance the cluster security, you can replace the `kubeadmin` user with a **cluster-admin** user and then disable or remove the **kubeadmin** user.

Prerequisites

- You have created a user with **cluster-admin** privileges.
- You have installed the OpenShift CLI (**oc**).
- You have administrative access to a virtual vault for secure storage.

Procedure

1. Create an emergency **cluster-admin** user by using the **htpasswd** identity provider. For more information, see "About htpasswd authentication".
2. Assign the **cluster-admin** privileges to the new user by running the following command:

```
$ oc adm policy add-cluster-role-to-user cluster-admin <emergency_user>
```
3. Verify the emergency user access:
 - a. Log in to the cluster using the new emergency user.
 - b. Confirm that the user has **cluster-admin** privileges by running the following command:

```
$ oc whoami
```
4. Store the password or authentication key for the emergency user securely in a virtual vault.

**NOTE**

Follow the best practices of your organization for securing sensitive credentials.

5. Disable or remove the **kubeadmin** user to reduce security risks by running the following command:

```
$ oc delete secrets kubeadmin -n kube-system
```

Additional resources

- [About htpasswd authentication](#)

17.5.1.5. Security considerations for telco CNFs

Telco workloads handle vast amounts of sensitive data and demand high reliability. A single security vulnerability can lead to broader cluster-wide compromises. With numerous components running on a single-node OpenShift cluster, each component must be secured to prevent any breach from escalating. Ensuring security across the entire infrastructure, including all components, is essential to maintaining the integrity of the telco network and avoiding vulnerabilities.

The following key security features are essential for telco:

- Security Context Constraints (SCCs): Provide granular control over pod security in the OpenShift clusters.
- Pod Security Admission (PSA): Kubernetes-native pod security controls.
- Encryption: Ensures data confidentiality in high-throughput network environments.

17.5.1.6. Advancement of pod security in Kubernetes and OpenShift Container Platform

Kubernetes initially had limited pod security. When OpenShift Container Platform integrated Kubernetes, Red Hat added pod security through Security Context Constraints (SCCs). In Kubernetes version 1.3, **PodSecurityPolicy** (PSP) was introduced as a similar feature. However, Pod Security Admission (PSA) was introduced in Kubernetes version 1.21, which resulted in the deprecation of PSP in Kubernetes version 1.25.

PSA also became available in OpenShift Container Platform version 4.11. While PSA improves pod security, it lacks some features provided by SCCs that are still necessary for telco use cases. Therefore, OpenShift Container Platform continues to support both PSA and SCCs.

17.5.1.7. Key areas for CNF deployment

The cloud-native network function (CNF) deployment contains the following key areas:

Core

The first deployments of CNFs occurred in the core of the wireless network. Deploying CNFs in the core typically means racks of servers placed in central offices or data centers. These servers are connected to both the internet and the Radio Access Network (RAN), but they are often behind multiple security firewalls or sometimes disconnected from the internet altogether. This type of setup is called an offline or disconnected cluster.

RAN

After CNFs were successfully tested in the core network and found to be effective, they were

considered for deployment in the Radio Access Network (RAN). Deploying CNFs in RAN requires a large number of servers (up to 100,000 in a large deployment). These servers are located near cellular towers and typically run as single-node OpenShift clusters, with the need for high scalability.

17.5.1.8. Telco-specific infrastructure

Hardware requirements

In telco networks, clusters are primarily built on bare-metal hardware. This means that the operating system (op-system-first) is installed directly on the physical machines, without using virtual machines. This reduces network connectivity complexity, minimizes latency, and optimizes CPU usage for applications.

Network requirements

Telco networks require much higher bandwidth compared to standard IT networks. Telco networks commonly use dual-port 25 GB connections or 100 GB Network Interface Cards (NICs) to handle massive data throughput. Security is critical, requiring encrypted connections and secure endpoints to protect sensitive personal data.

17.5.1.9. Lifecycle management

Upgrades are critical for security. When a vulnerability is discovered, it is patched in the latest z-stream release. This fix is then rolled back through each lower y-stream release until all supported versions are patched. Releases that are no longer supported do not receive patches. Therefore, it is important to upgrade OpenShift Container Platform clusters regularly to stay within a supported release and ensure they remain protected against vulnerabilities.

For more information about lifecycle management and upgrades, see "Upgrading a telco core CNF clusters".

Additional resources

[Upgrading a telco core CNF clusters](#)

17.5.1.10. Evolution of Network Functions to CNFs

Network Functions (NFs) began as Physical Network Functions (PNFs), which were purpose-built hardware devices operating independently. Over time, PNFs evolved into Virtual Network Functions (VNFs), which virtualized their capabilities while controlling resources like CPU, memory, storage, and network.

As technology advanced further, VNFs transitioned to cloud-native network functions (CNFs). CNFs run in lightweight, secure, and scalable containers. They enforce stringent restrictions, including non-root execution and minimal host interference, to enhance security and performance.

PNFs had unrestricted root access to operate independently without interference. With the shift to VNFs, resource usage was controlled, but processes could still run as root within their virtual machines. In contrast, CNFs restrict root access and limit container capabilities to prevent interference with other containers or the host operating system.

The main challenges in migrating to CNFs are as follows:

- Breaking down monolithic network functions into smaller, containerized processes.
- Adhering to cloud-native principles, such as non-root execution and isolation, while maintaining telco-grade performance and reliability.

17.5.2. Host security

17.5.2.1. Red Hat Enterprise Linux CoreOS (RHCOS)

Red Hat Enterprise Linux CoreOS (RHCOS) is different from Red Hat Enterprise Linux (RHEL) in key areas. For more information, see "About RHCOS".

From a telco perspective, a major distinction is the control of **rpm-ostree**, which is updated through the Machine Config Operator.

RHCOS follows the same immutable design used for pods in OpenShift Container Platform. This ensures that the operating system remains consistent across the cluster. For information about RHCOS architecture, see "Red Hat Enterprise Linux CoreOS (RHCOS)".

To manage hosts effectively while maintaining security, avoid direct access whenever possible. Instead, you can use the following methods for host management:

- Debug pod
- Direct SSHs
- Console access

Review the following RHCOS security mechanisms that are integral to maintaining host security:

Linux namespaces

Provide isolation for processes and resources. Each container keeps its processes and files within its own namespace. If a user escapes from the container namespace, they could gain access to the host operating system, potentially compromising security.

Security-Enhanced Linux (SELinux)

Enforces mandatory access controls to restrict access to files and directories by processes. It adds an extra layer of security by preventing unauthorized access to files if a process tries to break its confinement.

SELinux follows the security policy of denying everything unless explicitly allowed. If a process attempts to modify or access a file without permission, SELinux denies access. For more information, see [Introduction to SELinux](#).

Linux capabilities

Assign specific privileges to processes at a granular level, minimizing the need for full root permissions. For more information, see "Linux capabilities".

Control groups (cgroups)

Allocate and manage system resources, such as CPU and memory for processes and containers, ensuring efficient usage. As of OpenShift Container Platform 4.16, there are two versions of cgroups. cgroup v2 is now configured by default.

CRI-O

Serves as a lightweight container runtime that enforces security boundaries and manages container workloads.

Additional resources

- [About RHCOS](#)
- [Red Hat Enterprise Linux CoreOS \(RHCOS\)](#) .

- [Linux capabilities](#).

17.5.2.2. Command-line host access

Direct access to a host must be restricted to avoid modifying the host or accessing pods that should not be accessed. For users who need direct access to a host, it is recommended to use an external authenticator, like SSSD with LDAP, to manage access. This helps maintain consistency across the cluster through the Machine Config Operator.



IMPORTANT

Do not configure direct access to the root ID on any OpenShift Container Platform cluster server.

You can connect to a node in the cluster using the following methods:

Using debug pod

This is the recommended method to access a node. To debug or connect to a node, run the following command:

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

After connecting to the node, run the following command to get access to the root file system:

```
# chroot /host
```

This gives you root access within a debug pod on the node. For more information, see "Starting debug pods with root access".

Direct SSH

Avoid using the root user. Instead, use the core user ID (or your own ID). To connect to the node using SSH, run the following command:

```
$ ssh core@<worker_node_name>
```



IMPORTANT

The core user ID is initially given **sudo** privileges within the cluster.

If you cannot connect to a node using SSH, see [How to connect to OpenShift Container Platform 4.x Cluster nodes using SSH bastion pod](#) to add your SSH key to the core user.

After connecting to the node using SSH, run the following command to get access to the root shell:

```
$ sudo -i
```

Console Access

Ensure that consoles are secure. Do not allow direct login with the root ID, instead use individual IDs.



NOTE

Follow the best practices of your organization for securing console access.

Additional resources

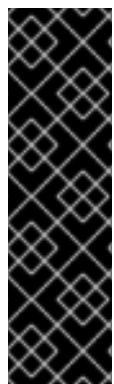
- [Starting debug pods with root access](#).

17.5.2.3. Linux capabilities

Linux capabilities define the actions a process can perform on the host system. By default, pods are granted several capabilities unless security measures are applied. These default capabilities are as follows:

- **CHOWN**
- **DAC_OVERRIDE**
- **FSETID**
- **FOWNER**
- **SETGID**
- **SETUID**
- **SETPCAP**
- **NET_BIND_SERVICE**
- **KILL**

You can modify which capabilities that a pod can receive by configuring Security Context Constraints (SCCs).



IMPORTANT

You must not assign the following capabilities to a pod:

- **SYS_ADMIN**: A powerful capability that grants elevated privileges. Allowing this capability can break security boundaries and pose a significant security risk.
- **NET_ADMIN**: Allows control over networking, like SR-IOV ports, but can be replaced with alternative solutions in modern setups.

For more information about Linux capabilities, see [Linux capabilities](#) man page.

17.5.3. Security context constraints

Similar to the way that RBAC resources control user access, administrators can use security context constraints (SCCs) to control permissions for pods. These permissions determine the actions that a pod can perform and what resources it can access. You can use SCCs to define a set of conditions that a pod must run.

Security context constraints allow an administrator to control the following security constraints:

- Whether a pod can run privileged containers with the **allowPrivilegedContainer** flag
- Whether a pod is constrained with the **allowPrivilegeEscalation** flag
- The capabilities that a container can request
- The use of host directories as volumes
- The SELinux context of the container
- The container user ID
- The use of host namespaces and networking
- The allocation of an **FSGroup** that owns the pod volumes
- The configuration of allowable supplemental groups
- Whether a container requires write access to its root file system
- The usage of volume types
- The configuration of allowable **seccomp** profiles

Default SCCs are created during installation and when you install some Operators or other components. As a cluster administrator, you can also create your own SCCs by using the OpenShift CLI (**oc**).

For information about default security context constraints, see [Default security context constraints](#).



IMPORTANT

Do not modify the default SCCs. Customizing the default SCCs can lead to issues when some of the platform pods deploy or OpenShift Container Platform is upgraded. Additionally, the default SCC values are reset to the defaults during some cluster upgrades, which discards all customizations to those SCCs.

Instead of modifying the default SCCs, create and modify your own SCCs as needed. For detailed steps, see [Creating security context constraints](#).

You can use the following basic SCCs:

- **restricted**
- **restricted-v2**

The **restricted-v2** SCC is the most restrictive SCC provided by a new installation and is used by default for authenticated users. It aligns with Pod Security Admission (PSA) restrictions and improves security, as the original **restricted** SCC is less restrictive. It also helps transition from the original SCCs to v2 across multiple releases. Eventually, the original SCCs get deprecated. Therefore, it is recommended to use the **restricted-v2** SCC.

You can examine the **restricted-v2** SCC by running the following command:

```
$ oc describe scc restricted-v2
```

Example output

```

Name: restricted-v2
Priority: <none>
Access:
Users: <none>
Groups: <none>
Settings:
Allow Privileged: false
Allow Privilege Escalation: false
Default Add Capabilities: <none>
Required Drop Capabilities: ALL
Allowed Capabilities: NET_BIND_SERVICE
Allowed Seccomp Profiles: runtime/default
Allowed Volume Types: configMap,downwardAPI,emptyDir,ephemeral,persistentVolumeClaim,projected,secret
Allowed Flexvolumes: <all>
Allowed Unsafe Sysctls: <none>
Forbidden Sysctls: <none>
Allow Host Network: false
Allow Host Ports: false
Allow Host PID: false
Allow Host IPC: false
Read Only Root Filesystem: false
Run As User Strategy: MustRunAsRange
  UID: <none>
  UID Range Min: <none>
  UID Range Max: <none>
SELinux Context Strategy: MustRunAs
  User: <none>
  Role: <none>
  Type: <none>
  Level: <none>
FSGroup Strategy: MustRunAs
  Ranges: <none>
Supplemental Groups Strategy: RunAsAny
  Ranges: <none>

```

The **restricted-v2** SCC explicitly denies everything except what it explicitly allows. The following settings define the allowed capabilities and security restrictions:

- Default add capabilities: Set to **<none>**. It means that no capabilities are added to a pod by default.
- Required drop capabilities: Set to **ALL**. This drops all the default Linux capabilities of a pod.
- Allowed capabilities: **NET_BIND_SERVICE**. A pod can request this capability, but it is not added by default.
- Allowed **seccomp** profiles: **runtime/default**.

For more information, see [Managing security context constraints](#).