



OpenShift Container Platform 4.15

Edge computing

Configure and deploy OpenShift Container Platform clusters at the network edge

OpenShift Container Platform 4.15 Edge computing

Configure and deploy OpenShift Container Platform clusters at the network edge

Legal Notice

Copyright © 2024 Red Hat, Inc.

The text of and illustrations in this document are licensed by Red Hat under a Creative Commons Attribution–Share Alike 3.0 Unported license ("CC-BY-SA"). An explanation of CC-BY-SA is available at

<http://creativecommons.org/licenses/by-sa/3.0/>

. In accordance with CC-BY-SA, if you distribute this document or an adaptation of it, you must provide the URL for the original version.

Red Hat, as the licensor of this document, waives the right to enforce, and agrees not to assert, Section 4d of CC-BY-SA to the fullest extent permitted by applicable law.

Red Hat, Red Hat Enterprise Linux, the Shadowman logo, the Red Hat logo, JBoss, OpenShift, Fedora, the Infinity logo, and RHCE are trademarks of Red Hat, Inc., registered in the United States and other countries.

Linux[®] is the registered trademark of Linus Torvalds in the United States and other countries.

Java[®] is a registered trademark of Oracle and/or its affiliates.

XFS[®] is a trademark of Silicon Graphics International Corp. or its subsidiaries in the United States and/or other countries.

MySQL[®] is a registered trademark of MySQL AB in the United States, the European Union and other countries.

Node.js[®] is an official trademark of Joyent. Red Hat is not formally related to or endorsed by the official Joyent Node.js open source or commercial project.

The OpenStack[®] Word Mark and OpenStack logo are either registered trademarks/service marks or trademarks/service marks of the OpenStack Foundation, in the United States and other countries and are used with the OpenStack Foundation's permission. We are not affiliated with, endorsed or sponsored by the OpenStack Foundation, or the OpenStack community.

All other trademarks are the property of their respective owners.

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.

Table of Contents

CHAPTER 1. CHALLENGES OF THE NETWORK FAR EDGE	7
1.1. OVERCOMING THE CHALLENGES OF THE NETWORK FAR EDGE	7
1.2. USING GITOPS ZTP TO PROVISION CLUSTERS AT THE NETWORK FAR EDGE	8
1.3. INSTALLING MANAGED CLUSTERS WITH SITECONFIG RESOURCES AND RHACM	9
1.4. CONFIGURING MANAGED CLUSTERS WITH POLICIES AND POLICYGENTEMPLATE RESOURCES	10
CHAPTER 2. PREPARING THE HUB CLUSTER FOR ZTP	13
2.1. TELCO RAN DU 4.15 VALIDATED SOFTWARE COMPONENTS	13
2.2. RECOMMENDED HUB CLUSTER SPECIFICATIONS AND MANAGED CLUSTER LIMITS FOR GITOPS ZTP	14
2.3. INSTALLING GITOPS ZTP IN A DISCONNECTED ENVIRONMENT	15
2.4. ADDING RHCOS ISO AND ROOTFS IMAGES TO THE DISCONNECTED MIRROR HOST	16
2.5. ENABLING THE ASSISTED SERVICE	17
2.6. CONFIGURING THE HUB CLUSTER TO USE A DISCONNECTED MIRROR REGISTRY	18
2.7. CONFIGURING THE HUB CLUSTER TO USE UNAUTHENTICATED REGISTRIES	21
2.8. CONFIGURING THE HUB CLUSTER WITH ARGOCD	22
2.9. PREPARING THE GITOPS ZTP SITE CONFIGURATION REPOSITORY	24
2.9.1. Preparing the GitOps ZTP site configuration repository for version independence	26
CHAPTER 3. UPDATING GITOPS ZTP	29
3.1. OVERVIEW OF THE GITOPS ZTP UPDATE PROCESS	29
3.2. PREPARING FOR THE UPGRADE	29
3.3. LABELING THE EXISTING CLUSTERS	30
3.4. STOPPING THE EXISTING GITOPS ZTP APPLICATIONS	30
3.5. REQUIRED CHANGES TO THE GIT REPOSITORY	31
3.6. INSTALLING THE NEW GITOPS ZTP APPLICATIONS	33
3.7. ROLLING OUT THE GITOPS ZTP CONFIGURATION CHANGES	34
CHAPTER 4. INSTALLING MANAGED CLUSTERS WITH RHACM AND SITECONFIG RESOURCES	36
4.1. GITOPS ZTP AND TOPOLOGY AWARE LIFECYCLE MANAGER	36
4.2. OVERVIEW OF DEPLOYING MANAGED CLUSTERS WITH GITOPS ZTP	37
Overview of the managed site installation process	38
4.3. CREATING THE MANAGED BARE-METAL HOST SECRETS	38
4.4. CONFIGURING DISCOVERY ISO KERNEL ARGUMENTS FOR INSTALLATIONS USING GITOPS ZTP	39
4.5. DEPLOYING A MANAGED CLUSTER WITH SITECONFIG AND GITOPS ZTP	41
4.5.1. Single-node OpenShift SiteConfig CR installation reference	46
4.6. MONITORING MANAGED CLUSTER INSTALLATION PROGRESS	49
4.7. TROUBLESHOOTING GITOPS ZTP BY VALIDATING THE INSTALLATION CRS	49
4.8. TROUBLESHOOTING GITOPS ZTP VIRTUAL MEDIA BOOTING ON SUPERMICRO SERVERS	50
4.9. REMOVING A MANAGED CLUSTER SITE FROM THE GITOPS ZTP PIPELINE	51
4.10. REMOVING OBSOLETE CONTENT FROM THE GITOPS ZTP PIPELINE	51
4.11. TEARING DOWN THE GITOPS ZTP PIPELINE	52
CHAPTER 5. CONFIGURING MANAGED CLUSTERS WITH POLICIES AND POLICYGENTEMPLATE RESOURCES	53
5.1. ABOUT THE POLICYGENTEMPLATE CRD	53
5.2. RECOMMENDATIONS WHEN CUSTOMIZING POLICYGENTEMPLATE CRS	56
5.3. POLICYGENTEMPLATE CRS FOR RAN DEPLOYMENTS	57
5.4. CUSTOMIZING A MANAGED CLUSTER WITH POLICYGENTEMPLATE CRS	58
5.5. MONITORING MANAGED CLUSTER POLICY DEPLOYMENT PROGRESS	60
5.6. VALIDATING THE GENERATION OF CONFIGURATION POLICY CRS	61
5.7. RESTARTING POLICY RECONCILIATION	63

5.8. CHANGING APPLIED MANAGED CLUSTER CRS USING POLICIES	64
5.9. INDICATION OF DONE FOR GITOPS ZTP INSTALLATIONS	66
CHAPTER 6. MANUALLY INSTALLING A SINGLE-NODE OPENSIFT CLUSTER WITH ZTP	67
6.1. GENERATING GITOPS ZTP INSTALLATION AND CONFIGURATION CRS MANUALLY	67
6.2. CREATING THE MANAGED BARE-METAL HOST SECRETS	72
6.3. CONFIGURING DISCOVERY ISO KERNEL ARGUMENTS FOR MANUAL INSTALLATIONS USING GITOPS ZTP	73
6.4. INSTALLING A SINGLE MANAGED CLUSTER	75
6.5. MONITORING THE MANAGED CLUSTER INSTALLATION STATUS	76
6.6. TROUBLESHOOTING THE MANAGED CLUSTER	77
6.7. RHACM GENERATED CLUSTER INSTALLATION CRS REFERENCE	78
CHAPTER 7. RECOMMENDED SINGLE-NODE OPENSIFT CLUSTER CONFIGURATION FOR VDU APPLICATION WORKLOADS	80
7.1. RUNNING LOW LATENCY APPLICATIONS ON OPENSIFT CONTAINER PLATFORM	80
7.2. RECOMMENDED CLUSTER HOST REQUIREMENTS FOR VDU APPLICATION WORKLOADS	80
7.3. CONFIGURING HOST FIRMWARE FOR LOW LATENCY AND HIGH PERFORMANCE	81
7.4. CONNECTIVITY PREREQUISITES FOR MANAGED CLUSTER NETWORKS	82
7.5. WORKLOAD PARTITIONING IN SINGLE-NODE OPENSIFT WITH GITOPS ZTP	83
7.6. RECOMMENDED CLUSTER INSTALL MANIFESTS	83
7.6.1. Workload partitioning	84
7.6.2. Reduced platform management footprint	85
7.6.3. SCTP	87
7.6.4. Setting rcu_normal	88
7.6.5. Automatic kernel crash dumps with kdump	90
7.6.6. Disable automatic CRI-O cache wipe	92
7.6.7. Configuring crun as the default container runtime	93
7.7. RECOMMENDED POSTINSTALLATION CLUSTER CONFIGURATIONS	94
7.7.1. Operators	94
7.7.2. Operator subscriptions	97
7.7.3. Cluster logging and log forwarding	99
7.7.4. Performance profile	100
7.7.5. Configuring cluster time synchronization	102
7.7.6. PTP	103
7.7.7. Extended Tuned profile	112
7.7.8. SR-IOV	113
7.7.9. Console Operator	116
7.7.10. Alertmanager	116
7.7.11. Operator Lifecycle Manager	116
7.7.12. LVM Storage	117
7.7.13. Network diagnostics	118
CHAPTER 8. VALIDATING SINGLE-NODE OPENSIFT CLUSTER TUNING FOR VDU APPLICATION WORKLOADS	119
8.1. RECOMMENDED FIRMWARE CONFIGURATION FOR VDU CLUSTER HOSTS	119
8.2. RECOMMENDED CLUSTER CONFIGURATIONS TO RUN VDU APPLICATIONS	121
8.2.1. Recommended cluster MachineConfig CRs for single-node OpenShift clusters	121
8.2.2. Recommended cluster Operators	122
8.2.3. Recommended cluster kernel configuration	122
8.2.4. Checking the realtime kernel version	123
8.3. CHECKING THAT THE RECOMMENDED CLUSTER CONFIGURATIONS ARE APPLIED	124
CHAPTER 9. ADVANCED MANAGED CLUSTER CONFIGURATION WITH SITECONFIG RESOURCES	134

9.1. CUSTOMIZING EXTRA INSTALLATION MANIFESTS IN THE GITOPS ZTP PIPELINE	134
9.2. FILTERING CUSTOM RESOURCES USING SITECONFIG FILTERS	135
9.3. DELETING A NODE BY USING THE SITECONFIG CR	137
CHAPTER 10. ADVANCED MANAGED CLUSTER CONFIGURATION WITH POLICYGENTEMPLATE RESOURCES	139
10.1. DEPLOYING ADDITIONAL CHANGES TO CLUSTERS	139
10.2. USING POLICYGENTEMPLATE CRS TO OVERRIDE SOURCE CRS CONTENT	139
10.3. ADDING CUSTOM CONTENT TO THE GITOPS ZTP PIPELINE	142
10.4. CONFIGURING POLICY COMPLIANCE EVALUATION TIMEOUTS FOR POLICYGENTEMPLATE CRS	144
10.5. SIGNALLING GITOPS ZTP CLUSTER DEPLOYMENT COMPLETION WITH VALIDATOR INFORM POLICIES	146
10.6. CONFIGURING POWER STATES USING POLICYGENTEMPLATES CRS	147
10.6.1. Configuring performance mode using PolicyGenTemplate CRs	148
10.6.2. Configuring high-performance mode using PolicyGenTemplate CRs	148
10.6.3. Configuring power saving mode using PolicyGenTemplate CRs	149
10.6.4. Maximizing power savings	150
10.7. CONFIGURING LVM STORAGE USING POLICYGENTEMPLATE CRS	151
10.8. CONFIGURING PTP EVENTS WITH POLICYGENTEMPLATE CRS	153
10.8.1. Configuring PTP events that use HTTP transport	153
10.8.2. Configuring PTP events that use AMQP transport	155
10.9. CONFIGURING BARE-METAL EVENTS WITH POLICYGENTEMPLATE CRS	157
10.9.1. Configuring bare-metal events that use HTTP transport	157
10.9.2. Configuring bare-metal events that use AMQP transport	158
10.10. CONFIGURING THE IMAGE REGISTRY OPERATOR FOR LOCAL CACHING OF IMAGES	160
10.10.1. Configuring disk partitioning with SiteConfig	160
10.10.2. Configuring the image registry using PolicyGenTemplate CRs	161
10.11. USING HUB TEMPLATES IN POLICYGENTEMPLATE CRS	164
10.11.1. Example hub templates	165
10.11.2. Specifying group and site configuration in group PolicyGenTemplate CRs with hub templates	166
10.11.3. Syncing new ConfigMap changes to existing PolicyGenTemplate CRs	170
CHAPTER 11. UPDATING MANAGED CLUSTERS WITH THE TOPOLOGY AWARE LIFECYCLE MANAGER	172
11.1. ABOUT THE TOPOLOGY AWARE LIFECYCLE MANAGER CONFIGURATION	172
11.2. ABOUT MANAGED POLICIES USED WITH TOPOLOGY AWARE LIFECYCLE MANAGER	172
11.3. INSTALLING THE TOPOLOGY AWARE LIFECYCLE MANAGER BY USING THE WEB CONSOLE	173
11.4. INSTALLING THE TOPOLOGY AWARE LIFECYCLE MANAGER BY USING THE CLI	173
11.5. ABOUT THE CLUSTERGROUPUPGRADE CR	175
11.5.1. Selecting clusters	176
11.5.2. Validating	178
11.5.3. Pre-caching	178
11.5.4. Creating a backup	179
11.5.5. Updating clusters	179
11.5.6. Update status	181
11.5.7. Blocking ClusterGroupUpgrade CRs	184
11.6. UPDATE POLICIES ON MANAGED CLUSTERS	191
11.6.1. Configuring Operator subscriptions for managed clusters that you install with TALM	192
11.6.2. Applying update policies to managed clusters	193
11.7. CREATING A BACKUP OF CLUSTER RESOURCES BEFORE UPGRADE	200
11.7.1. Creating a ClusterGroupUpgrade CR with backup	200
11.7.2. Recovering a cluster after a failed upgrade	203
11.8. USING THE CONTAINER IMAGE PRE-CACHE FEATURE	205
11.8.1. Using the container image pre-cache filter	206

11.8.2. Creating a ClusterGroupUpgrade CR with pre-caching	207
11.9. TROUBLESHOOTING THE TOPOLOGY AWARE LIFECYCLE MANAGER	209
11.9.1. General troubleshooting	210
11.9.2. Cannot modify the ClusterUpgradeGroup CR	210
11.9.3. Managed policies	211
Checking managed policies on the system	211
Checking remediationAction mode	211
Checking policy compliance state	212
11.9.4. Clusters	212
Checking if managed clusters are present	212
Checking if managed clusters are available	213
Checking clusterLabelSelector	213
Checking if canary clusters are present	214
Checking the pre-caching status on spoke clusters	215
11.9.5. Remediation Strategy	215
Checking if remediationStrategy is present in the ClusterGroupUpgrade CR	215
Checking if maxConcurrency is specified in the ClusterGroupUpgrade CR	215
11.9.6. Topology Aware Lifecycle Manager	215
Checking condition message and status in the ClusterGroupUpgrade CR	215
Checking corresponding copied policies	216
Checking if status.remediationPlan was computed	216
Errors in the TALM manager container	216
Clusters are not compliant to some policies after a ClusterGroupUpgrade CR has completed	217
Auto-created ClusterGroupUpgrade CR in the GitOps ZTP workflow has no managed policies	217
Pre-caching has failed	217
CHAPTER 12. UPDATING MANAGED CLUSTERS IN A DISCONNECTED ENVIRONMENT WITH THE TOPOLOGY AWARE LIFECYCLE MANAGER	219
12.1. UPDATING CLUSTERS IN A DISCONNECTED ENVIRONMENT	219
12.1.1. Setting up the environment	219
12.1.2. Performing a platform update	221
12.1.3. Performing an Operator update	224
12.1.3.1. Troubleshooting missed Operator updates due to out-of-date policy compliance states	229
12.1.4. Performing a platform and an Operator update together	230
12.1.5. Removing Performance Addon Operator subscriptions from deployed clusters	233
12.1.6. Pre-caching user-specified images with TALM on single-node OpenShift clusters	234
12.1.6.1. Creating the custom resources for pre-caching	236
12.2. ABOUT THE AUTO-CREATED CLUSTERGROUPUPGRADE CR FOR GITOPS ZTP	239
CHAPTER 13. EXPANDING SINGLE-NODE OPENSIFT CLUSTERS WITH GITOPS ZTP	242
13.1. APPLYING PROFILES TO THE WORKER NODE	242
13.2. (OPTIONAL) ENSURING PTP AND SR-IOV DAEMON SELECTOR COMPATIBILITY	243
13.3. PTP AND SR-IOV NODE SELECTOR COMPATIBILITY	244
13.4. USING POLICYGENTEMPLATE CRS TO APPLY WORKER NODE POLICIES TO WORKER NODES	244
13.5. ADDING WORKER NODES TO SINGLE-NODE OPENSIFT CLUSTERS WITH GITOPS ZTP	247
CHAPTER 14. PRE-CACHING IMAGES FOR SINGLE-NODE OPENSIFT DEPLOYMENTS	250
14.1. GETTING THE FACTORY-PRE-CACHING-CLI TOOL	250
14.2. BOOTING FROM A LIVE OPERATING SYSTEM IMAGE	251
14.3. PARTITIONING THE DISK	252
14.3.1. Creating the partition	253
14.3.2. Mounting the partition	255
14.4. DOWNLOADING THE IMAGES	255
14.4.1. Downloading with parallel workers	256

14.4.2. Preparing to download the OpenShift Container Platform images	256
14.4.3. Downloading the OpenShift Container Platform images	257
14.4.4. Downloading the Operator images	260
14.4.5. Pre-caching custom images in disconnected environments	261
14.5. PRE-CACHING IMAGES IN GITOPS ZTP	264
14.5.1. Understanding the clusters.ignitionConfigOverride field	267
14.5.2. Understanding the nodes.installerArgs field	268
14.5.3. Understanding the nodes.ignitionConfigOverride field	268
14.6. TROUBLESHOOTING	269
14.6.1. Rendered catalog is invalid	269

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?

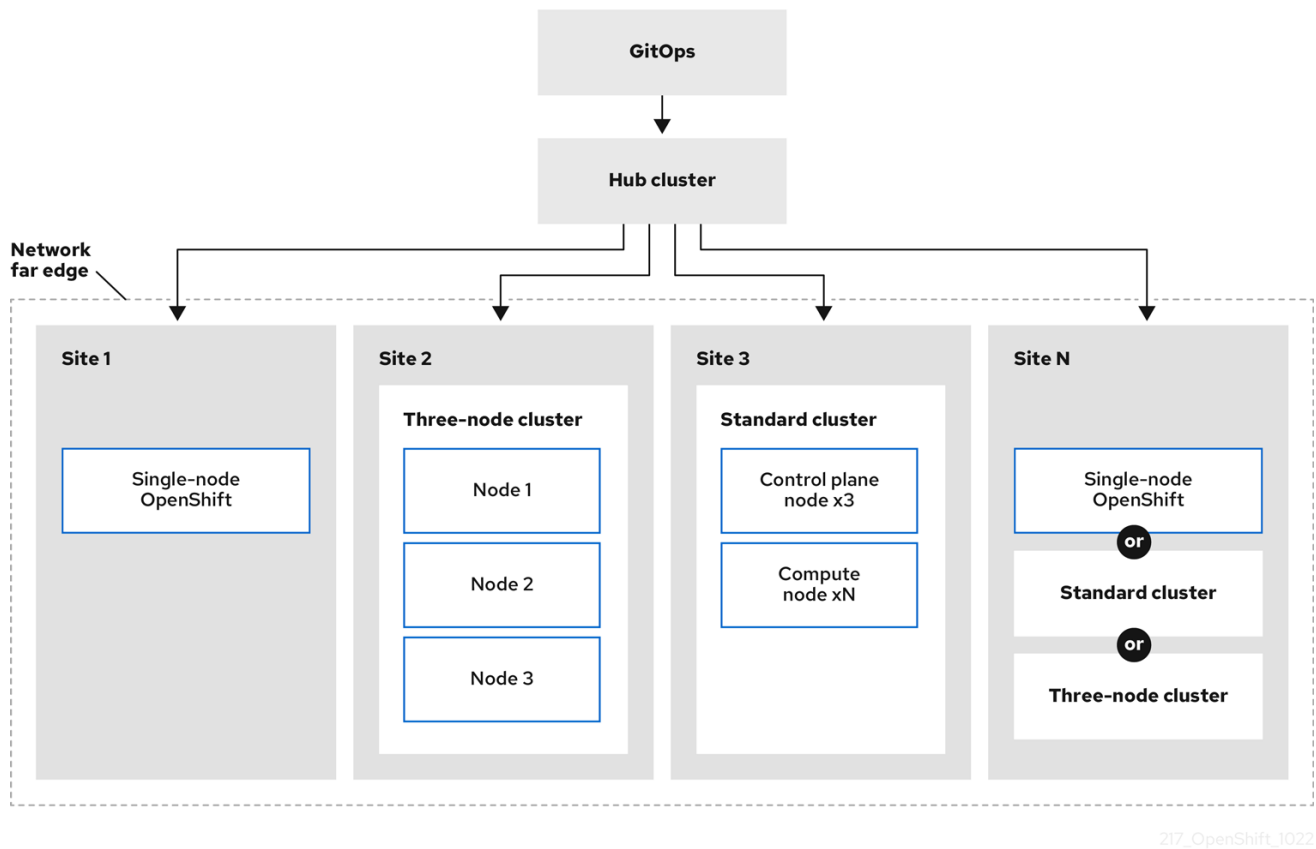
GitOps Zero Touch Provisioning (ZTP) and *GitOps* meets these challenges by allowing you to provision remote edge sites at scale with declarative site definitions and configurations for bare-metal equipment. Template or overlay configurations install OpenShift Container Platform features that are required 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.



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

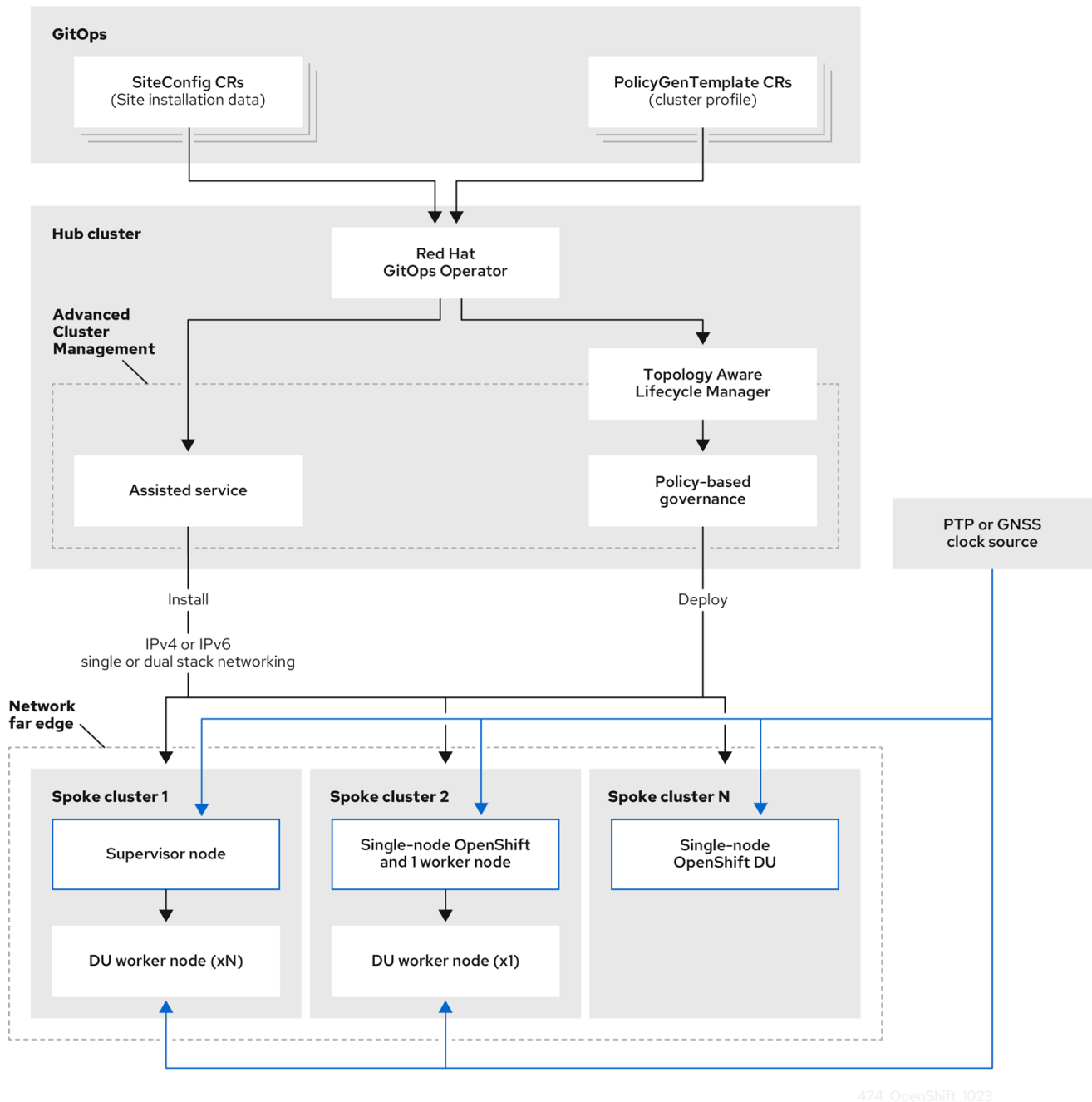
Red Hat Advanced Cluster Management (RHACM) manages clusters in a hub-and-spoke architecture, where a single hub cluster manages many spoke clusters. Hub clusters running RHACM provision and deploy the managed clusters by using GitOps Zero Touch Provisioning (ZTP) and the assisted service that is deployed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



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.

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.

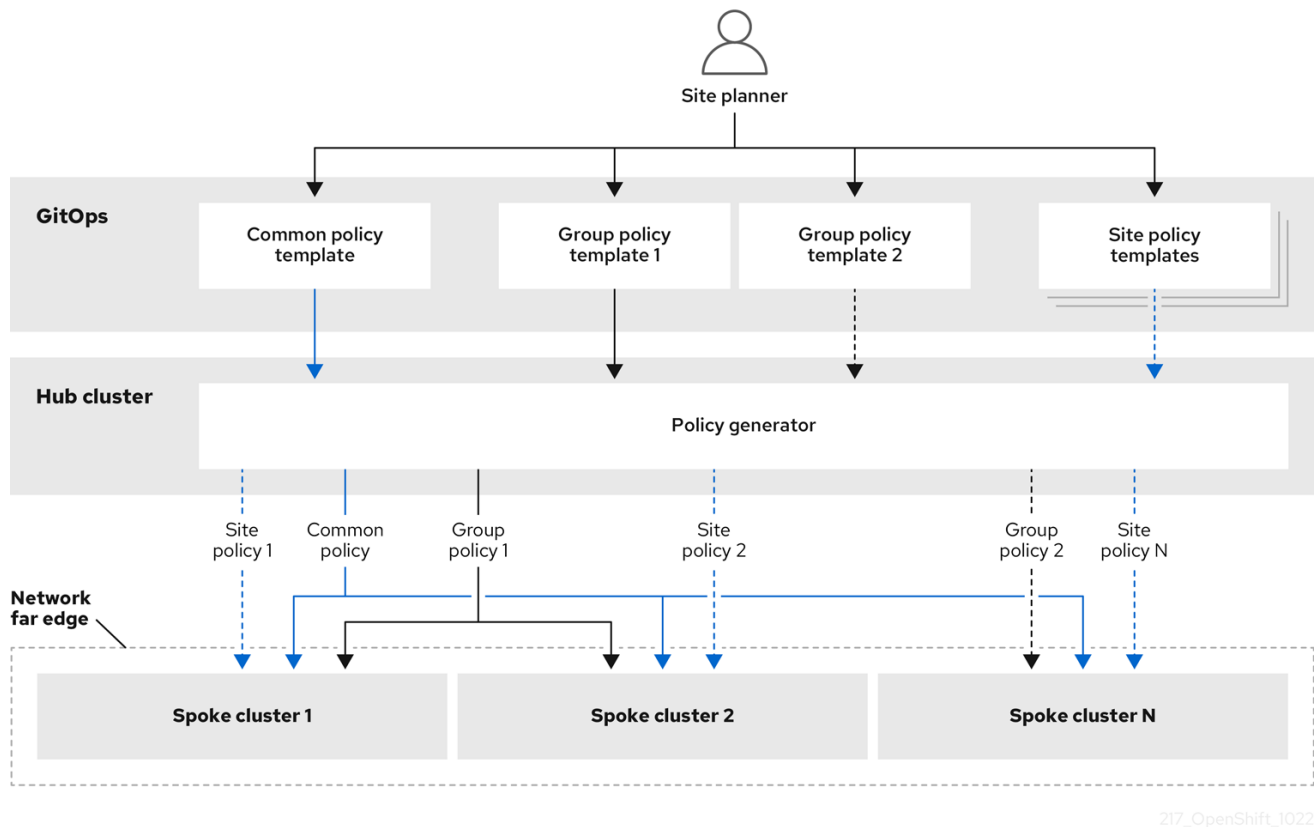


NOTE

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.



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 PolicyGenTemplate 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 PolicyGenTemplate 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.

Additional resources

- For more information about extracting the reference **SiteConfig** and **PolicyGenTemplate** CRs from the **ztp-site-generate** container image, see [Preparing the ZTP Git repository](#).

CHAPTER 2. PREPARING THE HUB CLUSTER FOR 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 4.15 VALIDATED SOFTWARE COMPONENTS

The Red Hat telco RAN DU 4.15 solution has been validated using the following Red Hat software products for OpenShift Container Platform managed clusters and hub clusters.

Table 2.1. Telco RAN DU managed cluster validated software components

Component	Software version
Managed cluster version	4.15
Cluster Logging Operator	5.8
Local Storage Operator	4.15
PTP Operator	4.15
SRIOV Operator	4.15
Node Tuning Operator	4.15
Logging Operator	4.15
SRIOV-FEC Operator	2.8

Table 2.2. Hub cluster validated software components

Component	Software version
Hub cluster version	4.15
GitOps ZTP plugin	4.15
Red Hat Advanced Cluster Management (RHACM)	2.9, 2.10
Red Hat OpenShift GitOps	1.11
Topology Aware Lifecycle Manager (TALM)	4.15

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 2.3. Representative three-node hub cluster machine specifications

Requirement	Description
OpenShift Container Platform	version 4.13
RHACM	version 2.7
Topology Aware Lifecycle Manager (TALM)	version 4.13
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
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 2.4. 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> ❶
```

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

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

❶ ISO image name, for example, **rhcos-4.15.1-x86_64-live.x86_64.iso**

❶ RootFS image name, for example, **rhcos-4.15.1-x86_64-live-rootfs.x86_64.img**

❶ OpenShift Container Platform version, for example, **4.15.1**

- b. Download the required images:

```
$ sudo wget https://mirror.openshift.com/pub/openshift-  
v4/dependencies/rhcos/4.15/${OCP_VERSION}/${ISO_IMAGE_NAME} -O  
/var/www/html/${ISO_IMAGE_NAME}
```

```
$ sudo wget https://mirror.openshift.com/pub/openshift-  
v4/dependencies/rhcos/4.15/${OCP_VERSION}/${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-4.15.1-x86_64-live.x86_64.iso  
rhcos-4.15.1-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. Update the **AgentServiceConfig** CR by running the following command:

```
$ oc edit AgentServiceConfig
```

3. Add the following entry to the **items.spec.osImages** field in the CR:

```
- cpuArchitecture: x86_64
  openshiftVersion: "4.15"
  rootFSUrl: https://<host>/<path>/rhcos-live-rootfs.x86_64.img
  url: https://<mirror-registry>/<path>/rhcos-live.x86_64.iso
```

where:

<host>

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

<path>

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

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) 2.9 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 ❶
  labels:
    app: assisted-service
data:
  ca-bundle.crt: | ❷
    -----BEGIN CERTIFICATE-----
    <certificate_contents>
    -----END CERTIFICATE-----

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

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

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

- ❶ The **ConfigMap** namespace must be set to **multicluster-engine**.
- ❷ The mirror registry's certificate that is used when creating the mirror registry.
- ❸ 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.
- ❹ 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.

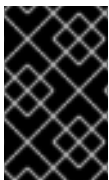
- 5 The registries defined in the **registries.conf** file must be scoped by repository, not by registry. In this example, both the **quay.io/example-repository** and the

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>
      url: <iso_url> 3
```

- 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 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 **PolicyGenTemplate** CRs, respectively.
2. To install the GitOps ZTP plugin, patch the ArgoCD instance in the hub cluster with the relevant multicluster engine (MCE) subscription image. Customize the patch file that you previously extracted into the **out/argocd/deployment/** directory for your environment.
- a. Select the **multicluster-operators-subscription** image that matches your RHACM version.

Table 2.5. **multicluster-operators-subscription** image versions

OpenShift Container Platform version	RHACM version	MCE version	MCE RHEL version	MCE image
4.14, 4.15, 4.16	2.8, 2.9	2.8, 2.9	RHEL 8	registry.redhat.io/rhacm2/multicluster-operators-subscription-rhel8:v2.8 registry.redhat.io/rhacm2/multicluster-operators-subscription-rhel8:v2.9
4.14, 4.15, 4.16	2.10	2.10	RHEL 9	registry.redhat.io/rhacm2/multicluster-operators-subscription-rhel9:v2.10

**IMPORTANT**

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

- b. Add the following configuration to the **out/argocd/deployment/argocd-openshift-gitops-patch.json** file:

```
{
  "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" ❶
  ],
  "command": [
    "/bin/bash"
  ],
  "image": "registry.redhat.io/rhacm2/multicluster-operators-subscription-rhel9:v2.10", ❷
}
```

```

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

```

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 **PolicyGenTemplate** CRs.



NOTE

Keep **SiteConfig** and **PolicyGenTemplate** CRs in separate directories. Both the **SiteConfig** and **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:v4.15
```

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

```
$ podman run --log-driver=none --rm registry.redhat.io/openshift4/ztp-site-generate-rhel8:v4.15 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 **PolicyGenTemplate** 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 **PolicyGenTemplate** files that represent the recommended configuration.
4. Copy the **out/source-crs** folder and contents to the **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/
├── policygentemplates
│   ├── kustomization.yaml
│   └── source-crs/
├── siteconfig
│   ├── extra-manifests
│   └── kustomization.yaml
```

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 **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 **policygentemplate** 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/
├── policygentemplates
│   ├── common-ranGen.yaml
│   ├── example-sno-site.yaml
│   ├── group-du-sno-ranGen.yaml
│   ├── group-du-sno-validator-ranGen.yaml
│   ├── kustomization.yaml
│   ├── source-crs/
│   └── ns.yaml
└── siteconfig
    ├── example-sno.yaml
    ├── extra-manifests/ ❶
    ├── custom-manifests/ ❷
    ├── KlusterletAddonConfigOverride.yaml
    └── kustomization.yaml
```

❶ Contains reference manifests from the **ztp-container**.

❷ Contains custom manifests.

2.9.1. Preparing the GitOps ZTP site configuration repository for version independence

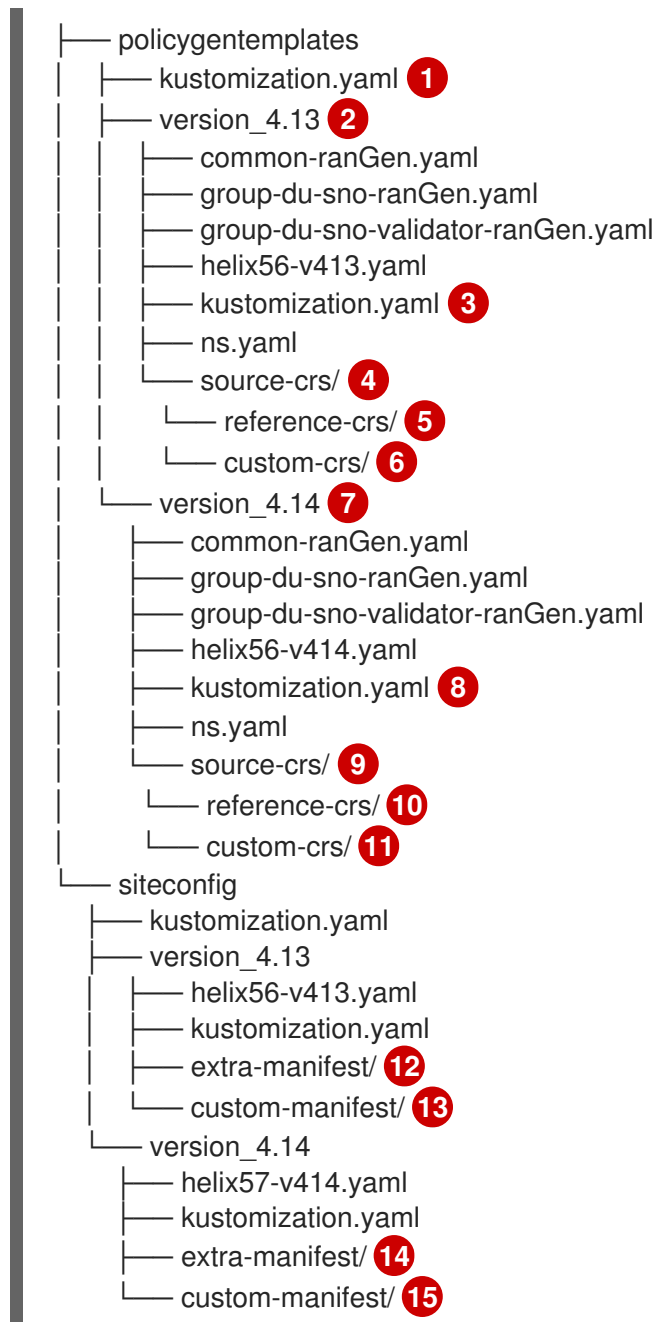
You can use GitOps ZTP to manage source custom resources (CRs) for managed clusters that are running different versions of OpenShift Container Platform. This means that the version of OpenShift Container Platform running on the hub cluster can be independent of the version running on the managed clusters.

Procedure

1. Create a directory structure with separate paths for the **SiteConfig** and **PolicyGenTemplate** CRs.
2. Within the **PolicyGenTemplate** 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.
3. 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 **/policygentemplates** 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.

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.

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. 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:v4.15 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 **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 **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.

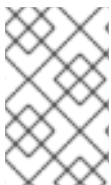


IMPORTANT

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

1. 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'
```

2. 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

1. 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
```

2. 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.

- Make required changes to **PolicyGenTemplate** files:
All **PolicyGenTemplate** 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 **PolicyGenTemplate** CRs must be included in a **kustomization.yaml** file under their respective directory trees. For example:

```

├── policygentemplates
│   ├── 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 **PolicyGenTemplate** 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 **PolicyGenTemplate** kustomization file must contain all **PolicyGenTemplate** YAML files in the **generator** section and **Namespace** CRs in the **resources** section. For example:

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

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

resources:
- common-ns.yaml
- 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 **PolicyGenTemplate** 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 **PolicyGenTemplate** 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 multicluster engine (MCE) subscription image. Customize the patch file that you previously extracted into the **out/argocd/deployment/** directory for your environment.
 - a. Select the **multicluster-operators-subscription** image that matches your RHACM version.

Table 3.1. multicluster-operators-subscription image versions

OpenShift Container Platform version	RHACM version	MCE version	MCE RHEL version	MCE image
4.14, 4.15, 4.16	2.8, 2.9	2.8, 2.9	RHEL 8	registry.redhat.io/rhacm2/multicluster-operators-subscription-rhel8:v2.8 registry.redhat.io/rhacm2/multicluster-operators-subscription-rhel8:v2.9
4.14, 4.15, 4.16	2.10	2.10	RHEL 9	registry.redhat.io/rhacm2/multicluster-operators-subscription-rhel9:v2.10



IMPORTANT

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

- b. Add the following configuration to the **out/argocd/deployment/argocd-openshift-gitops-patch.json** file:

```
{
  "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/multicluster-operators-subscription-rhel9:v2.10",
    "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

```

2. 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

```

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

```

$ oc apply -k out/argocd/deployment

```

3.7. 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 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.

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:

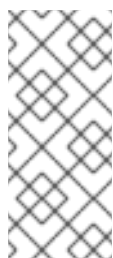
- The **ClusterGroupUpgrade** CR is created and enabled in the **ztp-install** namespace.
- **ClusterGroupUpgrade** CR has the same name as the **ManagedCluster** CR.
- The cluster selector includes only the cluster associated with that **ManagedCluster** CR.
- The set of managed policies includes all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

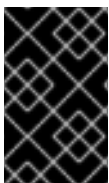
- Installing the host operating system (RHCOS) on a blank server
- Deploying OpenShift Container Platform
- Creating cluster policies and site subscriptions
- Making the necessary network configurations to the server operating system
- Deploying profile Operators and performing any needed software-related 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 ❶
data: ❷
  password: <base64_password>
  username: <base64_username>
type: Opaque
---
apiVersion: v1
kind: Secret
metadata:
  name: pull-secret
  namespace: example-sno ❸
data:
  .dockerconfigjson: <pull_secret> ❹
type: kubernetes.io/dockerconfigjson

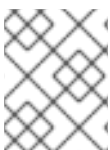
```

- ❶ Must match the namespace configured in the related **SiteConfig** CR
- ❷ Base64-encoded values for **password** and **username**
- ❸ Must match the namespace configured in the related **SiteConfig** CR
- ❹ 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 4.15, 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.

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**.

- a. Export the cluster namespace by running the following command:

```
$ export CLUSTERS=example-sno
```

- b. Create the namespace:

```
$ oc create namespace $CLUSTERS
```

2. 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.

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

- b. 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/v2
kind: SiteConfig
metadata:
  name: "example-sno"
  namespace: "example-sno"
spec:
  baseDomain: "example.com"
  pullSecretRef:
    name: "assisted-deployment-pull-secret"
  clusterImageSetNameRef: "openshift-4.10"
  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 but the marketplace component from 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
      installConfigOverrides: "{\"capabilities\":{\"baselineCapabilitySet\": \"None\",
      \"additionalEnabledCapabilities\": [ \"OperatorLifecycleManager\", \"NodeTuning\" ] }}"
      # 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 UEFISecureBoot to enable secure boot
        bootMode: "UEFI"
        rootDeviceHints:
          wwn: "0x11111000000asd123"
          # example of diskPartition below is used for image registry (check
          # ImageRegistry.md for more details), but it's not limited to this use case
          # diskPartition:
          #   - device: /dev/disk/by-id/wwn-0x11111000000asd123 # match
rootDeviceHints
          # partitions:
          #   - mount_point: /var/imageregistry
          #     size: 102500
          #     start: 344844

    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.

- 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. Single-node OpenShift SiteConfig CR installation reference

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

SiteConfig CR field	Description
spec.cpuPartitioningMode	<p>Configure workload partitioning by setting the value for cpuPartitioningMode to AllNodes. To complete the configuration, specify the isolated and reserved CPUs in the PerformanceProfile CR.</p> <div>  <p>NOTE</p> <p>Configuring workload partitioning by using the cpuPartitioningMode field in the SiteConfig CR is a Tech Preview feature in OpenShift Container Platform 4.13.</p> </div>
metadata.name	<p>Set name to assisted-deployment-pull-secret and create the assisted-deployment-pull-secret CR in the same namespace as the SiteConfig CR.</p>
spec.clusterImageSetNameRef	<p>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 oc get clusterimagesets.</p>

SiteConfig CR field	Description
installConfigOverrides	<p>Set the installConfigOverrides field to enable or disable optional components prior to cluster installation.</p> <div>  <div> <p>IMPORTANT</p> <p>Use the reference configuration as specified in the example SiteConfig CR. Adding additional components back into the system might require additional reserved CPU capacity.</p> </div> </div>
spec.clusters.clusterImageSetNameRef	Specifies the cluster image set used to deploy an individual cluster. If defined, it overrides the spec.clusterImageSetNameRef at site level.
spec.clusters.clusterLabels	Configure cluster labels to correspond to the bindingRules field in the PolicyGenTemplate CRs that you define. For example, policygentemplates/common-ranGen.yaml applies to all clusters with common: true set, policygentemplates/group-du-sno-ranGen.yaml applies to all clusters with group-du-sno: "" set.
spec.clusters.crTemplates.KlusterletAddonConfig	Optional. Set KlusterletAddonConfig to KlusterletAddonConfigOverride.yaml to override the default KlusterletAddonConfig that is created for the cluster.
spec.clusters.nodes.hostName	For single-node deployments, define a single host. For three-node deployments, define three hosts. For standard deployments, define three hosts with role: master and two or more hosts defined with role: worker .
spec.clusters.nodes.nodeLabels	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.
spec.clusters.nodes.automatedCleaningMode	Optional. Uncomment and set the value to metadata to enable the removal of the disk's partitioning table only, without fully wiping the disk. The default value is disabled .
spec.clusters.nodes.bmcAddress	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.

SiteConfig CR field	Description
spec.clusters.nodes.bmcAddress	<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> <div>  <div> <p>NOTE</p> <p>In far edge Telco use cases, only virtual media is supported for use with GitOps ZTP.</p> </div> </div>
spec.clusters.nodes.bmcCredentialsName	Configure the bmh-secret CR that you separately create with the host BMC credentials. When creating the bmh-secret CR, use the same namespace as the SiteConfig CR that provisions the host.
spec.clusters.nodes.bootMode	Set the boot mode for the host to UEFI . The default value is UEFI . Use UEFISecureBoot to enable secure boot on the host.
spec.clusters.nodes.rootDeviceHints	Specifies the device for deployment. Identifiers that are stable across reboots are recommended, for example, wwn: <disk_wwn> or deviceName: /dev/disk/by-path/<device_path> . For a detailed list of stable identifiers, see the "About root device hints section".
spec.clusters.nodes.diskPartition	Optional. The provided example diskPartition is used to configure additional disk partitions.
spec.clusters.nodes.ignitionConfigOverride	Optional. Use this field to assign partitions for persistent storage. Adjust disk ID and size to the specific hardware.
spec.clusters.nodes.cpuset	Configure cpuset to match value that you set in the cluster PerformanceProfile CR spec.cpu.reserved field for workload partitioning.
spec.clusters.nodes.nodeNetwork	Configure the network settings for the node.
spec.clusters.nodes.nodeNetwork.config.interfaces.ipv6	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

- [Customizing extra installation manifests in the GitOps ZTP pipeline](#)
- [Preparing the GitOps ZTP site configuration repository](#)
- [Configuring the hub cluster with ArgoCD](#)

- [Signalling ZTP cluster deployment completion with validator inform policies](#)
- [Creating the managed bare-metal host secrets](#)
- [BMC addressing](#)
- [About root device hints](#)

4.6. 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]'
```

4.7. TROUBLESHOOTING GITOPS ZTP BY VALIDATING THE INSTALLATION CRS

The ArgoCD pipeline uses the **SiteConfig** and **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 describe -n openshift-gitops application clusters
```

- a. Check for the **Status.Conditions** field to view the error logs for the managed cluster. For example, setting an invalid value for **extraManifestPath** in the **SiteConfig** CR raises the following error:

```
Status:
Conditions:
  Last Transition Time: 2021-11-26T17:21:39Z
  Message:          rpc error: code = Unknown desc = `kustomize build
/tmp/https___git.com/ran-sites/siteconfigs/ --enable-alpha-plugins` failed exit status 1:
2021/11/26 17:21:40 Error could not create extra-manifest ranSite1.extra-manifest3 stat
extra-manifest3: no such file or directory 2021/11/26 17:21:40 Error: could not build the
entire SiteConfig defined by /tmp/kust-plugin-config-913473579: stat extra-manifest3: no
such file or directory Error: failure in plugin configured via /tmp/kust-plugin-config-
913473579; exit status 1: exit status 1
  Type: ComparisonError
```

- b. 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
```

4.8. 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.

4.9. 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 **PolicyGenTemplate** files from the **kustomization.yaml** file.
When you run the GitOps ZTP pipeline again, the generated CRs are removed.
2. Optional: If you want to permanently remove a site, you should also remove the **SiteConfig** and site-specific **PolicyGenTemplate** files from the Git repository.
3. Optional: If you want to remove a site temporarily, for example when redeploying a site, you can leave the **SiteConfig** and site-specific **PolicyGenTemplate** CRs in the Git repository.

Additional resources

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

4.10. REMOVING OBSOLETE CONTENT FROM THE GITOPS ZTP PIPELINE

If a change to the **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 **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 **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 **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>
```

4.11. 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. CONFIGURING MANAGED CLUSTERS WITH POLICIES AND 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.

5.1. 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 **bindingRules** section.

Example PolicyGenTemplate CR - common-du-ranGen.yaml

```
---
apiVersion: ran.openshift.io/v1
kind: PolicyGenTemplate
metadata:
  name: "common"
  namespace: "ztp-common"
spec:
  bindingRules:
    common: "true" 1
  sourceFiles: 2
    - fileName: SriovSubscription.yaml
      policyName: "subscriptions-policy"
    - fileName: SriovSubscriptionNS.yaml
      policyName: "subscriptions-policy"
    - fileName: SriovSubscriptionOperGroup.yaml
      policyName: "subscriptions-policy"
    - fileName: SriovOperatorStatus.yaml
      policyName: "subscriptions-policy"
    - fileName: PtpSubscription.yaml
      policyName: "subscriptions-policy"
    - fileName: PtpSubscriptionNS.yaml
      policyName: "subscriptions-policy"
    - fileName: PtpSubscriptionOperGroup.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: ReduceMonitoringFootprint.yaml
  policyName: "config-policy"
- fileName: OperatorHub.yaml ❸
  policyName: "config-policy"
- fileName: DefaultCatsrc.yaml ❹
  policyName: "config-policy" ❺
  metadata:
    name: redhat-operators
  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

```

- ❶ **common: "true"** applies the policies to all clusters with this label.
- ❷ Files listed under **sourceFiles** create the Operator policies for installed clusters.
- ❸ **OperatorHub.yaml** configures the OperatorHub for the disconnected registry.
- ❹ **DefaultCatsrc.yaml** configures the catalog source for the disconnected registry.
- ❺ **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-ntp-slave"
  spec:
    profile:
      - name: "slave"
        interface: "ens5f0"
        ptp4IOpts: "-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-ntp-slave**. The **spec** defined in **PtpConfigSlave.yaml** is placed under **du-ntp-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-ntp-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-ntp-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-ntp-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
    ....

```

5.2. 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 overhead 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.
- **PolicyGenTemplates** 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.

5.3. POLICYGENTEMPLATE CRS FOR RAN DEPLOYMENTS

Use **PolicyGenTemplate** (PGT) custom resources (CRs) to customize the configuration applied to the cluster by using the GitOps Zero Touch Provisioning (ZTP) pipeline. The PGT CR allows you to generate one or more policies to manage the set of configuration CRs on your fleet of clusters. The PGT 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 5.1. 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-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](#)

5.4. 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 **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** **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 desired 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 desired 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 desired 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/policygentemplates/kustomization.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 ZTP cluster deployment completion with validator inform policies](#)

5.5. 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	3h42m
ztp-site.example1-perf-policy	inform	NonCompliant	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 it's 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.

5.6. 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** → **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 <placementRuleName> -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 using the following command:

```
$ oc get ManagedCluster $CLUSTER -o jsonpath='{.metadata.labels}' | jq
```

8. Check to see which policies are compliant 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.

5.7. 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 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](#).

5.8. 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

- 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	REMEDIACTION 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.

5.9. 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 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 transition 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.

CHAPTER 6. MANUALLY INSTALLING A SINGLE-NODE OPENSIFT CLUSTER WITH 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](#).

6.1. 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 **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.

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:v4.15 extract /home/ztp --tar | tar x -C ./out
```

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

Example output

```
out
├── argocd
│   └── example
│       ├── policygentemplates
│       │   ├── common-ranGen.yaml
│       │   ├── example-sno-site.yaml
│       │   └── group-du-sno-ranGen.yaml
```

```

├── group-du-sno-validator-ranGen.yaml
├── kustomization.yaml
├── ns.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/v2
kind: SiteConfig
metadata:
  name: "example-sno"
  namespace: "example-sno"
spec:
  baseDomain: "example.com"
  pullSecretRef:
    name: "assisted-deployment-pull-secret"
  clusterImageSetNameRef: "openshift-4.10"
  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 but the marketplace component from 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
      installConfigOverrides: "{\"capabilities\":{\"baselineCapabilitySet\": \"None\",
      \"additionalEnabledCapabilities\": [ \"OperatorLifecycleManager\", \"NodeTuning\" ] }}"
      # 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 UEFISecureBoot to enable secure boot
    bootMode: "UEFI"
    rootDeviceHints:
      wwn: "0x11111000000asd123"
      # example of diskPartition below is used for image registry (check ImageRegistry.md
for more details), but it's not limited to this use case
      # diskPartition:
      # - device: /dev/disk/by-id/wwn-0x11111000000asd123 # match rootDeviceHints
      # partitions:
      # - mount_point: /var/imageregistry
      # size: 102500
      # start: 344844

    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.

5. 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:v4.15 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:

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

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

- b. 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:v4.15 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 **PolicyGenTemplate** CRs from the previous step. Run the following commands:

- a. Create an output folder for the Day 2 CRs:

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

- b. Generate and export the Day 2 configuration CRs:

```
$ podman run -it --rm -v `pwd`/out/argocd/example/policygentemplates:/resources:Z -v `pwd`/ref:/output:Z,U registry.redhat.io/openshift4/ztp-site-generate-rhel8:v4.15 generator config -N . /output
```

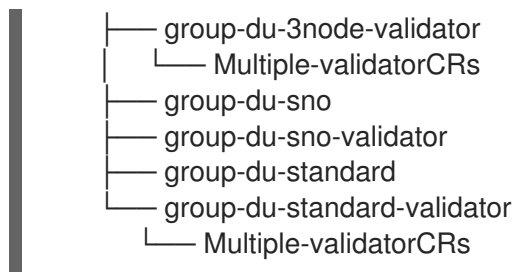
The command generates example group and site-specific **PolicyGenTemplate** CRs for single-node OpenShift, three-node clusters, and standard clusters in the **./ref** folder.

Example output

```

ref
├── customResource
│   ├── common
│   ├── example-multinode-site
│   ├── example-sno
│   └── group-du-3node

```



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](#)

6.2. 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 ❶
data: ❷
  password: <base64_password>
  username: <base64_username>
type: Opaque
---
apiVersion: v1
kind: Secret
metadata:
  name: pull-secret
  namespace: example-sno ❸
data:
  .dockerconfigjson: <pull_secret> ❹
type: kubernetes.io/dockerconfigjson
```

- ❶ Must match the namespace configured in the related **SiteConfig** CR
- ❷ Base64-encoded values for **password** and **username**
- ❸ Must match the namespace configured in the related **SiteConfig** CR
- ❹ 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.

6.3. 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 4.15, 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
```

6.4. 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-4.15.yaml**. A **ClusterImageSet** has the following format:

```
apiVersion: hive.openshift.io/v1
kind: ClusterImageSet
metadata:
  name: openshift-4.15.0 1
spec:
  releaseImage: quay.io/openshift-release-dev/ocp-release:4.15.0-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-4.15.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 PolicyGenTemplate CRs](#)

6.5. 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>
```

4. Check the cluster provisioning status:


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

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

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

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

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

7. 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
```

6.6. TROUBLESHOOTING THE MANAGED CLUSTER

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

Procedure

1. 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.

2. 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.

6.7. 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 6.1. Cluster installation CRs generated by RHACM

CR	Description	Usage
BareMetal Host	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.
ManagedCluster	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.
KlusterletAddonConfig	Contains the list of services provided by the hub to be deployed to the ManagedCluster resource.	Tells the hub which add-on 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 7. 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](#).

7.1. 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.

7.2. 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 7.1. Minimum resource requirements

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

**NOTE**

One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or Hyper-Threading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio:

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

**IMPORTANT**

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

7.3. 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 or Intel Cascade Lake server, 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 7.2. Sample firmware configuration for an Intel Xeon Skylake or Cascade Lake server

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.

7.4. 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**

7.5. WORKLOAD PARTITIONING IN SINGLE-NODE OPENSIFT 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 **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](#).

7.6. 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](#).

7.6.1. 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.



UPGRADING FROM OPENSIFT CONTAINER PLATFORM 4.12 TO 4.13+

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

7.6.2. 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)

```
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,IyEvYmluL2Jhc2gKCmRIYnVnKCKgewogIGVjaG8gJEAgPiYyCn0KCnCvZzYWdlKCkgewogIGVj
aG8gVXNhZ2U6ICQoYmFzZW5hbWUgJDApIFVOSVQgW2VuZmZpbGUgW3Zhcm5hbWVdXQogIGV
jaG8KICBIY2hvIEV4dHJhY3QgdGhlIGNvb3RlbnRzIG9mIHRobSBmaXJzdCBFeGVjU3RhcnQgc3Rhbn
phIHZyb20gdGhlIGdpdmVulHN5c3RibWQgdW5pdCBhbmQgcmlvdXJulGI0HRvIHNOZG91dAogIGVj
aG8KICBIY2hvICJJZiAnZW52ZmlsZScgaXMgcHJjdmlkZWQslHB1dCBpdCBpciB0AGVyZSBpbN0ZW
FklCBhcyBhbiBlbnZpcm9ubVVudCB2YXJpYWJsZSBUeWw1IZCAndmFybmFtZSciCiAgZWNNobyAiRGV
mYXVsdcAndmFybmFtZScgaXMGRVhfMQ1NUQVJUIGlmIG5vdCBzcGVjaWZpZWQiCiAgZXhp dCAx C
n0KCIVOSVQ9JDEKR U5WRklMRT0kMGpWQVJOQU1FPSQzCmImfTb lC16ICRVTKlUIHx8IC RVTKl UI
D09ICltLWhlbHAilHX8ICRVTKlUID09ICItaClg XV07IHR oZW4KICB1c2Fn ZQpm a QpkZW J1 Zy AiRX h0 cm
FjdGl uZYBF eG V j U3 Rh cn Q g Zn J vb S ak V U 5 JV CI K R k I M RT 0 k KH N 5 c 3 Ri b W N 0 b CB j Y X q G J F VO SV Q gf CB
oZW F kl C 1 u IDE p C k Z J TE U 9 J H t GS U x FI 1 w j IH O K a W Y gw 1 sglSaTZ iAkRKIMRSBDXTsgdGhlbgoglGRIY nV
nlCJGYWlsZWQgdG8gZmluZCByb290IGZpbGUgZm9yIHVuaXQgJFVOSVQgKCRGSUXFKSIKIBle
GI0CmZpCmRIYnVnlCJTZXJ2aWNIIGRIZmluaXRpb24gaXMGaW4gJEZJTEUiCkVYRUNTV EFSVD0k
KHNI ZCATbiAtZSA n L15 FeGViU3RhcnQ9Li pcXCQvLC9bXIxcXSQvIHsqcy9eRXhiY1N0YXJ0PS8 vO y Bw
```

```
IH0nIC1IICcvXkV4ZWNTdGFydD0uKlteXFxdJC8geyBzL15FeGVjU3RhcnQ9Ly87IHAgfScgJEZJTEUp
CgppZiBbWyAkRU5WRklMRSBdXTsgdGhlbgogIFZBUk5BTUU9JHtWQVJOQU1FOi1FWEVDU1RBUI
R9CiAgZWNoYAiJHtWQVJOQU1FfT0ke0VYRUNTVEFSVH0iID4gJEVOVkZJTEUKZWxzZQogIGVja
G8gJEVYRUNTVEFSVApmaQo=
```

```
mode: 493
```

```
path: /usr/local/bin/extractExecStart
```

```
- contents:
```

```
source: data:text/plain;charset=utf-
8;base64,IyEvYmluL2Jhc2gKbnNlbnRlciAtLW1vdW50PS9ydW4vY29udGFpbmVyLW1vdW50LW5hbW\
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="OPENSIFT_MAX_HOUSEKEEPING_INTERVAL_DURATION=60s"
    Environment="OPENSIFT_EVICTION_MONITORING_PERIOD_DURATION=30s"
    name: 30-kubelet-interval-tuning.conf
name: kubelet.service

```

7.6.3. 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)

```

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)

```

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:
    - 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
```

7.6.4. Setting rcu_normal

The following **MachineConfig** CR configures the system to set **rcu_normal** to 1 after the system has finished startup. This improves kernel latency for vDU applications.

Recommended configuration for disabling rcu_expedited after the node has finished startup (08-set-rcu-normal-master.yaml)

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: master
  name: 08-set-rcu-normal-master
spec:
  config:
    ignition:
      version: 3.2.0
    storage:
      files:
        - contents:
            source: data:text/plain;charset=utf-
8;base64,IyEvYmluL2Jhc2gKIwojIERpc2FibGUgcmlN1X2V4cGVkaXRIZCBhZnRlciBub2RIIGhhcyBmaWw
5pc2hlZCBib290aW5nCiMKIyBUaGUGZGVmYXVsdlHMgYmVsb3cgY2FuIGJIIG92ZXJyaWRkZW4gdml
hIGVudmlyb25tZW50IHZhcmIhYmxlcwojCgojIERIZmF1bHQgd2FpdCB0aW1lIGlzIDYwMHMGPSAxBG
06Ck1BWEINVU1fV0FJVf9USU1FPSR7TUFYSU1VTv9XQUIUX1RJUU6LTywMH0KCIMGRGvmY
XVsdCBzdGVhZHktc3RhduGdGhyZXNob2xklD0gMiUKlyBBbGxvd2VkIHZhbHVlczoKlyAgNCAGLSBh
YnNvbHVV0ZSBwb2QgY291bnQgKCsvLSskKlyAgNCUgLSBwZXJjZW50IGNoYW5nZSAoKy8tKQojICAt
MSAtIGRpc2FibGUgdGhlIHNoZWFKes1zdGF0ZSBjaGVjavpwTVEVBFRIfU1RBVEVfVeHSRVNIT0xEp
SR7U1RFQURZX1NUQVRFX1RIUkVTSE9MRDotMiv9CgojIERIZmF1bHQgc3RIYWR5LXNoYXRlIHd
pbmRvdyA9IDYwcwojIElmIHRoZSBydW5uaW5nIHVzCBjb3VudCBzdGF5cyB3aXRoaW4gdGhlIGdpd
mVulHRocmVzaG9sZCBmb3ldGhpncyB0aW1lCiMgcGVyaW9kLCByZXRxcm4gQ1BVlHV0aWxpemF0
aW9uIHRvIG5vcmlhbCBiZWZvcmlUgdGhlIG1heGltdW0gd2FpdCB0aW1lIGhhcwwojIGV4cGlyZXMKU1
RFQURZX1NUQVRFX1dJTkrPVz0ke1NURUFEWV9TVEFURV9XSU5ET1c6LTywfwQoKlyBEZWZhd
Wx0IHNoZWFKes1zdGF0ZSBhbGxvd3MgYW55IHVzCBjb3VudCB0byBiZSAic3RIYWR5LXNoYXRlIGo
jIEluY3JlYXNpbmcgdGhpncyB3aWxsIHNoRaXAgYW55IHNoZWFKes1zdGF0ZSBjaGVjavja3MgdW50aWwgd
GhlIGNvdW50IHJpc2VzIGFib3ZlCiMgdGhpncyBudW1iZXlmdG8gYXZvaWQgZmFsc2UgcG9zaXRpdmV
zlGlmIHRoZXXJlIGFyZSBzb21lIHBlcmlyZHMgd2hlcmUgdGhlCiMgY291bnQgZG9lc24ndCBpbmNyZWF
zZSBidXQgd2Uga25vdyB3ZSBjYW4ndCBiZSBhdCBzdGVhZHktc3RhduGueWV0LgpTVEVBFRIfU1RB
VEVftUIOSU1VTT0ke1NURUFEWV9TVEFURV9NSU5JTvvNOio0wfQoKlyMilyMilyMilyMilyMilyMilyMilyMily
```

yMjlyMjlyMjlyMjlyMjlyMjlyMjlyMjlyMjlyMjlyKd2l0aGluKCkgewogIGxvY2FslGxhc3Q9JDEgY3VycmudD0kMiB0aHJlc2hvbGQ9JDMKICBsb2NhbcCBkZWx0YT0wIHBJaGFuZ2UKICBkZWx0YT0kKCggY3VycmVudCAtIGxhc3QgKSskKICBpZiBbWyAkY3VycmVudCAtZXEGJGxhc3QgXV07IHRoZW4KICAgIHBJaGFuZ2U9MAogIGVsawWYGW1sgJGxhc3QgLWVxIDAgaXV07IHRoZW4KICAgIHBJaGFuZ2U9MTAwMDAwMAogIGVsc2UKICAgIHBJaGFuZ2U9JCgolCggliRkZWx0YSIgKiAxMDApLC8gbGFzdCApKQogIGZpCiAgZWNobyAtbiAibGFzdDokbGFzdCBjdXJyZW50OirjdXJyZW50IGRlbHRhOirRkZWx0YSBwY2hhbmddlOir7cGNoyW5nZX0IOiAiCiAgbG9jYWwgYWJzb2x1dGUgbGltaXQKICBjYXNIIICRoahJlc2hvbGQgaW4KICAgIColkKQogICAgICBhYnNvbHV0ZT0ke3BjaGFuZ2Ujly19ICMGYwJzb2x1dGUgdmdFsduWUKICAgICAgbGltaXQ9JHt0aHJlc2hvbGQLJSV9CiAgICAgID57CiAgICAqKQogICAgICBhYnNvbHV0ZT0ke2RlbHRhlyMtfSAjlGFic29sdXRilHZhbHVICiAgICAgICAgGxpblWI0PSR0aHJlc2hvbGQKICAgICAgOzsKICBlc2FjCiAgaWYgW1sgJGFic29sdXRilC1sZSAkbGltaXQgXV07IHRoZW4KICAgIGVjaG8glndpdGhpbiAoKy8tKSR0aHJlc2hvbGQiCiAgICBzYXR1cm4gMAogIGVsc2UKICAgIGVjaG8glm91dHNpZGUgKCsLSkkdGhyZXNob2xklgogICAgcmV0dXJulDEKICBmaQp9CgpzdGVhZHldZGF0ZSGplHsKICBsb2NhbcBsYXN0PSQxlIGN1cnJlbnQ9JDIKICBpZiBbWyAkbgfzdCAtbHQgJFNURUFEFwV9TVEFURV9NSU5JTUVNFIF1dOyb0AGVuCiAgICBIY2hvlICJsYXN0OIRsYXN0IGN1cnJlbnQ6JGN1cnJlbnQgV2FpdGluZyB0byByZWVjaCAKU1RFQURZX1NUQVRFX01JTklnVU0gYmVmY3JlIGNoZWNaW5nlGZvcibZdGVhZHktc3RhduGuiCiAgICBzYXR1cm4gMQogIGZpCiAgd2l0aGluClkbgfzdCIglrijdXJyZW50IaiJFNURUFEFwV9TVEFURV9USFJFU0hPTEQiCn0KCndhaXRGb3JSZWFKesGplHsKICBsb2dnZXIglJIY292ZXJ5OiBXyWl0aW5nlCR7TUfYSU1VTv9XQUiUX1RJTUv9cyBmb3lgdGhlIGluaXRpYWxpemF0aW9ulHRvIGNvbXBsZXRIlgogIGxvY2FslHQ9MCBzPTEwCiAgbG9jYWwgBgfzdENjb3VudD0wlGNjb3VudD0wlHN0ZWFKeVN0YXRIVGltZT0wCiAgd2hpbGUgW1sgJHQGLWx0ICRNQVhtJTVVNx1dBsvrfVeINRSBdXTsgZG8KICAgIHNSZWVwICRzCiAgICAOKHQgKz0gcypkCiAgICAJIERIdGVjdCBzdGVhZHktc3RhduGuCG9kIGNvdW50CiAgICBjY291bnQ9JChjcmljdGwgcHMGMj4vZGV2L251bGwgfCB3YyAtbCkKICAgIGlmIfbICRjY291bnQGldWd0IDAgaXV0giYgc3RIYWR5c3RhduGliRsYXN0Q2NvdW50IaiJGNjb3VudCI7IHRoZW4KIcAgICAgKChzdGVhZHITdGF0ZVRpbWUGKz0gcypkCiAgICAgIGVjaG8glIN0ZWFKesS1zdGF0ZSBmb3lgJHtzdGVhZHITdGF0ZVRpbWV9cy8ke1NURUFEFwV9TVEFURV9XSU5ET1d9cylKICAgICAgawWYGW1sgJHN0ZWFKeVN0YXRIVGltZSAIZ2UgJFNURUFEFwV9TVEFURV9XSU5ET1cgXV07IHRoZW4KICAgICAgICBsb2dnZXIglJIY292ZXJ5OiBTdGVhZHktc3RhduGUgKCsLSAKU1RFQURZX1NUQVRFX1RIUkVTSE9MRCKgzM9ylCR7U1RFQURZX1NUQVRFX1dJTrPV31ZOiBEb25llgogICAgICAgIHJldHVybiAwCiAgICAgIGZpCiAgICBlbHNICiAgICAgIGlmIfbICRzdGVhZHITdGF0ZVRpbWUGldWd0IDAgaXV07IHRoZW4KICAgICAgICBIY2hvlICJSZXNldHRpbmcgc3RIYWR5LXN0YXRilHRpbWVylgogICAgICAgIHNOZWFKeVN0YXRIVGltZT0wCiAgICAgIGZpCiAgICBlmaQogICAgbGFzdENjb3VudD0ky2NvdW50CiAgZG9uZQogIGxvZ2dlciAiUmVjb3Zlcnk6lFIY292ZXJ5IENvbXBsZXRIIFRpbWVvdXQiCn0KCnNldFJjdU5vcmlhbCgplHsKICBIY2hvlICJTZR0aW5nlHJJdv9ub3JtYWwgDG8gMSIKICBIY2hvlIEgPiAvC3lzL2tlcm5ltC9yY3Vfbm9ybWFsCn0KCm1haW4oKSB7CiAgd2FpdEZvclJIYWR5CiAgZWNobyAiV2FpdGluZyBmb3lgc3RIYWR5IHNOYXRilHRbv2s6lCQoYXdrICd7chJpbnpQgaW50KCQxLzM2MDApImgiLCBpbnpQoKCQxJTM2MDApLzYwKSJtliwaW50KCQxJTYwKSJzIn0nC9wcm9JL3VwdGltZSKiCiAgc2V0UmN1Tm9ybWFsCn0KCmImIfbIClke0JBu0hfU09VUkNFWzBdfSlgPSAiJHswfSlgXV07IHRoZW4KICBtYWUlclike0B9lgogIGV4aXQgJD8KZmkK

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

units:

[Unit]

[Service]

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

Environment=MAXIMUM WAIT TIME=600

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

```

7.6.5. 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 MachineConfig CR to remove ice driver from control plane kdump logs (05-kdump-config-master.yaml)

```

apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: master
  name: 05-kdump-config-master
spec:
  config:
    ignition:
      version: 3.2.0
    systemd:
      units:
        - enabled: true
          name: kdump-remove-ice-module.service
          contents: |
            [Unit]
            Description=Remove ice module when doing kdump
            Before=kdump.service
            [Service]
            Type=oneshot
            RemainAfterExit=true
            ExecStart=/usr/local/bin/kdump-remove-ice-module.sh
            [Install]
            WantedBy=multi-user.target

```



```
storage:
  files:
    - contents:
        source: data:text/plain;charset=utf-
base64,IyEvdXNyL2Jpbi9lbnYgYmFzaAoKlyBUaGlzIHNjcmlwdCBYZW1vdmVzIHRoZSBpY2UgbW9k
WxlIGZyb20ga2R1bXAgdG8gcHJldmVudCBZHVtcCBmYWlsdXJlcyBvbiBjZXJ0YWluIHNIcnZlcnMuCi
gVGhpcyBpcyBhIHRlbXBvcmlFyeSB3b3JrYXJvdW5kIGZvciBSSEVMUEXBTi0xMzgyMzYgYW5kIGNh
iZSByZW1vdmVklHdoZW4gdGhhdCBpc3N1ZSBpcwojIGZpeGVkLGoKc2V0IC14CgpTRUQ9li91c3lv
mluL3NIZCIKR1JFUD0iL3Vzci9iaW4vZ3JlcCIKCiMgb3ZlcnJpZGUgZm9yIHRLc3RpbmcgcHVycG9zZX
KS0RVTVBfQ09ORj0iJHsxOi0vZXRjL3N5c2NvbmlZpZy9rZHVtcH0iCiJFTU9WRV9JQ0VfU1RSPSJtb
R1bGVfYmxhY2tsaXN0PWljZSIKCiMgZXhpdCBpZiBmaWxllIGRvZXNuJ3QgZXhpc3QKWyAhIC1mIC
7S0RVTVBfQ09ORn0gXSAmJiBleGl0IDAKCiMgZXhpdCBpZiBmaWxllIGFscmlVhZlHkdXBkYXRlZAAok
0dSRVB9IC1GcSAke1JFTU9WRV9JQ0VfU1RSfSAke0tEVU1QX0NPTkZ9ICYmIGV4aXQgMAoKlyB
YXJnZXQgbGluZSBsb29rcyBzb21ldGhpbmcbGlrZSB0aGlzOgojEtEVU1QX0NPTU1BTkrRMSU5FX
FQUEVORD0iaXJxcG9sbCBucj9jCHVzPTEgLi4uIGhlc3RfZGlzYWJsZSIKlyBVc2Ugc2VkIHRLc3RfZG
olGV2ZXJ5dGhpbmcbG9mV0d2VlbiB0aGUgcXVvdGVzIGFuZCBhcHBmcbG9dGhllFJFTU9WRV9JQ0
VfU1RSIHRLc3RfZG9iR7U0VEfSAtaSAncy9eS0RVTVBfQ09NTUFORExJTkVfQVBQRU5EPSJbXiJdKi8m
Ccke1JFTU9WRV9JQ0VfU1RSfScvJyAke0tEVU1QX0NPTkZ9IHx8IGV4aXQgMAo=
      mode: 448
      path: /usr/local/bin/kdump-remove-ice-module.sh
```

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

```
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 MachineConfig CR to remove ice driver from worker node kdump logs (05-kdump-config-worker.yaml)

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 05-kdump-config-worker
spec:
  config:
    ignition:
      version: 3.2.0
    systemd:
      units:
```

```

- enabled: true
  name: kdump-remove-ice-module.service
  contents: |
    [Unit]
    Description=Remove ice module when doing kdump
    Before=kdump.service
    [Service]
    Type=oneshot
    RemainAfterExit=true
    ExecStart=/usr/local/bin/kdump-remove-ice-module.sh
    [Install]
    WantedBy=multi-user.target
storage:
  files:
    - contents:
        source: data:text/plain;charset=utf-
8;base64,IyEvdXNyL2Jpbi9lbnYgYmFzaAoKlyBUaGlzIHJncmlwdCBYZW1vdmVzIHRoZSBpY2UgbW9k
dWxllGZyb20ga2R1bXAgaG8gcHJldmVudCBvZHVtcCBmYWlsdXJlcyBvbiBjZXJ0YWluIHNIcnZlcnMuCi
MgVGhpcyBpcyBhIHRlbXBvcnFyeSB3b3JrYXJvdW5klGZvciBSSEVMUEExBTi0xMzgyMzYgYW5klGNh
iBiZSByZW1vdmVklHdoZW4gdGhhdCBpc3N1ZSBpcwojIGZpeGVkLgoKc2V0IC14CgpTRUQ9li91c3lv
YmluL3NlZCikR1JFUD0iL3Vzci9iaW4vZ3JlcCIkCiMgb3ZlcnJpZGUgZm9yIHRlc3RpbmcgcHVycG9zZX
MKS0RVTVBfQ09ORj0iJHsxOi0vZXRjL3N5c2NvbmZpZy9rZHVtcH0iCiJFTU9WRV9JQ0VfU1RSPSJtb
2R1bGVfYmxhY2tsaXN0PWljZSIKCiMgZXhpdCBpZiBmaWxllGRvZXNuJ3QgZXhpc3QKWYAhIC1mIC
R7S0RVTVBfQ09ORn0gXSAkJiBleGl0IDAKCiMgZXhpdCBpZiBmaWxllGFscmVhZHkgdXBkYXRIZAoK
e0dSRVB9IC1GcSAke1JFTU9WRV9JQ0VfU1RSfSAke0tEVU1QX0NPTkZ9ICYmIGV4aXQgMAoKlyB
UYXJnZXQgbGluZSBsb29rcyBzb21ldGhpbmcgbGlZSB0aGlzOgojIEtEVU1QX0NPTU1BTkRMSU5FX
0FQUEVORD0iaXJxcG9sbCBucj9jcHVzPTEgLi4uIGhlc3RfZGZlYWJsZSIKlyBVc2Ugc2VklHRvIG1hdG
NoIGV2ZXJ5dGhpbmcgYmV0d2VlbiB0aGUgcXVvdGVzIGFuZCBhcHBmQgdGhlfJFTU9WRV9JQ0
VfU1RSIHRvIGl0CiR7U0VEfSAaSAncy9eS0RVTVBfQ09NTUFORExJTkVfQVBQRU5EPSJbXiJdKi8m
ICcke1JFTU9WRV9JQ0VfU1RSfScvJyAke0tEVU1QX0NPTkZ9IHx8IGV4aXQgMAo=
      mode: 448
      path: /usr/local/bin/kdump-remove-ice-module.sh

```

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

```

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

```

7.6.6. 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`)

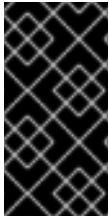
```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: master
  name: 99-crio-disable-wipe-master
spec:
  config:
    ignition:
      version: 3.2.0
    storage:
      files:
        - contents:
            source: data:text/plain;charset=utf-
8;base64,W2NyaW9dCmNsZWFuX3NodXRkb3duX2ZpbGUgPSAilgo=
            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`)

```
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,W2NyaW9dCmNsZWFuX3NodXRkb3duX2ZpbGUgPSAilgo=
            mode: 420
          path: /etc/crio/crio.conf.d/99-crio-disable-wipe.toml
```

7.6.7. 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
```

7.7. 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](#).

7.7.1. 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

```

7.7.2. 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"
  name: cluster-logging
  source: redhat-operators-disconnected
  sourceNamespace: openshift-marketplace
  installPlanApproval: Manual
status:
state: AtLatestKnown
```

7.7.3. Cluster logging and log forwarding

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

Recommended cluster logging configuration (`ClusterLogging.yaml`)

```
apiVersion: logging.openshift.io/v1
kind: ClusterLogging
metadata:
  name: instance
  namespace: openshift-logging
  annotations: {}
spec:
  managementState: "Managed"
  collection:
    logs:
      type: "vector"
```

Recommended log forwarding configuration (`ClusterLogForwarder.yaml`)

```
apiVersion: "logging.openshift.io/v1"
kind: ClusterLogForwarder
metadata:
  name: instance
  namespace: openshift-logging
  annotations: {}
spec:
  outputs: $outputs
  pipelines: $pipelines
```

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

7.7.4. 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 7.3. 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
spec.additionalKernelArgs	"efi=runtime" Configures UEFI secure boot for the cluster host.
spec.cpu.isolated	<p>Set the isolated CPUs. Ensure all of the Hyper-Threading pairs match.</p> <div>  <div> <p>IMPORTANT</p> <p>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.</p> </div> </div>
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)

PerformanceProfile CR field	Description
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.

7.7.5. 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**)

```

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.service
            [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**)

```

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.service
        [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

```

7.7.6. 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: slave
  namespace: openshift-ptp
  annotations: {}
spec:
  profile:
    - name: "slave"
      # The interface name is hardware-specific
      interface: $interface
      ptp4lOpts: "-2 -s"
      phc2sysOpts: "-a -r -n 24"
      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
recommend:
- profile: "slave"
  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"
      ptp4lOpts: "-2"
      phc2sysOpts: "-a -r -n 24"

```

```

ptpSchedulingPolicy: SCHED_FIFO
ptpSchedulingPriority: 10
ptpSettings:
  logReduce: "true"
ptp4lConf: |
# 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)

```

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 -O -37 -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: 100
      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
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:
    enableEventPublisher: true
    transportHost: "http://ptp-event-publisher-service-NODE_NAME.openshift-
    ptp.svc.cluster.local:9043"
```

7.7.7. 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
        [sysctl]
        kernel.timer_migration=1
        [scheduler]
        group.ice-ptp=0:f:10*:ice-ptp.*
        group.ice-gnss=0:f:10*:ice-gnss.*
        [service]
        service.stalld=start,enable
        service.chrond=stop,disable
      recommend:
```

```
- machineConfigLabels:
  machineconfiguration.openshift.io/role: "$mcp"
  priority: 19
  profile: performance-patch
```

Table 7.4. Tuned CR options for single-node OpenShift clusters

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}. When using the non-realtime kernel, remove the timer_migration_override line from the [sysctl] section.

7.7.8. 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: true
enableOperatorWebhook: true
logLevel: 0
```

Table 7.5. 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 7.6. **SriovNetwork** CR options for single-node OpenShift clusters

SriovNetwork CR field	Description
spec.vlan	Configure vlan with the VLAN for the midhaul network.

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 7.7. **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**)

```

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

```

7.7.9. 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\"}}"
```

7.7.10. 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
    telemetryClient:
      enabled: false
    prometheusK8s:
      retention: 24h

```

7.7.11. 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)

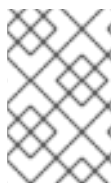
```

apiVersion: v1
kind: ConfigMap
metadata:
  name: collect-profiles-config
  namespace: openshift-operator-lifecycle-manager
data:
  pprof-config.yaml: |
    disabled: True

```

7.7.12. 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: odf-lvmcluster
  namespace: openshift-storage
spec:
  storage:
    deviceClasses:
      - name: vg1
        deviceSelector:
          paths:
            - /usr/disk/by-path/pci-0000:11:00.0-nvme-1
    thinPoolConfig:
      name: thin-pool-1
      overprovisionRatio: 10
      sizePercent: 90

```

Table 7.8. LVMCluster CR options for single-node OpenShift clusters

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.

7.7.13. 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 8. 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](#)

8.1. 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 4.15.



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 8.1. 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.

8.2. 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 4.15 clusters.

8.2.1. 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 8.2. Recommended GitOps ZTP MachineConfig CRs

MachineConfig CR	Description
01-container-mount-ns-and-kubelet-conf-master.yaml 01-container-mount-ns-and-kubelet-conf-worker.yaml	Configures the container mount namespace and kubelet configuration.
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.
05-kdump-config-master.yaml 05-kdump-config-worker.yaml 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.

MachineConfig CR	Description
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.
enable-crun-master.yaml enable-crun-worker.yaml	Enables the crun OCI container runtime.
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](#)

8.2.2. 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

8.2.3. 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:

```
spec:
  additionalKernelArgs:
    - "rcupdate.rcu_normal_after_boot=0"
```

```
- "efi=runtime"
- "module_blacklist=irdma"
```

2. 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:

```
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
      [sysctl]
      kernel.timer_migration=1
      [scheduler]
      group.ice-ptp=0:f:10:*.ice-ptp.*
      group.ice-gnss=0:f:10:*.ice-gnss.*
      [service]
      service.stalld=start,enable
      service.chrond=stop,disable
```

8.2.4. 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
```

8.3. 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 4.15 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 ❶
redhat-marketplace -- {"effect": "PreferredDuringScheduling"}
redhat-operators -- {"effect": "PreferredDuringScheduling"}
```

- ❶ **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

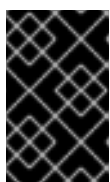
In a properly configured vDU cluster, only a single annotated catalog source is listed.

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
```

6. Check that **chronyd** is disabled on the cluster node by running the following commands:

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

Check the status of **chronyd** 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)

```

7. 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:

- a. 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)
```

- b. 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-ntp rsh -c linuxntp-daemon-container ${PTP_POD_NAME} pmc -u -f
/var/run/ntp4l.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 +0.0000000000
scaledLastGmPhaseChange 0
gmTimeBaseIndicator 0
lastGmPhaseChange 0x0000'0000000000000000.0000
gmPresent          true 2
gmIdentity         3c2c30.fff.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/ntp4l.0.config` is found in the **linuxntp-daemon-container** log:

```
$ oc logs $PTP_POD_NAME -n openshift-ntp -c linuxntp-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}"

```

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}"

```

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

```

9. 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.

10. 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
```

11. Check the **Tuned** performance patch settings by running the following command:

```
$ oc get tuned.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.chrond=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.

12. 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
```


13. 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
OPENSIFT_MAX_HOUSEKEEPING_INTERVAL_DURATION
```

Example output

```
Environment="OPENSIFT_MAX_HOUSEKEEPING_INTERVAL_DURATION=60s"
```

14. 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
```

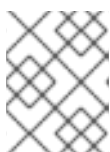
Both queries should return **Error from server (NotFound)** messages.

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 9. 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.

9.1. CUSTOMIZING EXTRA INSTALLATION MANIFESTS IN THE GITOPS 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.

9.2. 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-4.15"
  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>" ❶
  extraManifests:
    filter:
      inclusionDefault: exclude ❷
      include:
        - custom-sctp-machine-config-worker.yaml
```

❶ Replace **<custom_manifest_folder>** with the name of the folder that contains the custom installation CRs, for example, **user-custom-manifest/**.

❷ 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

```

9.3. 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:

```

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. 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
# ...
```

3. 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 10. ADVANCED MANAGED CLUSTER CONFIGURATION WITH POLICYGENTEMPLATE RESOURCES

You can use **PolicyGenTemplate** CRs to deploy custom functionality in your managed clusters.

10.1. 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](#)

10.2. 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-sno-ranGen.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:v4.15.1 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-sno-ranGen.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.

10.3. 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: ClusterLogOperatorGroup.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: StorageOperatorGroup.yaml
      remediationAction: inform
      policyName: "group-dev-lso-operator-group"
    - fileName: StorageSubscription.yaml
      remediationAction: inform
      policyName: "group-dev-lso-sub"
    #These are custom local polices 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: <image_URL_here>
    - fileName: PaoSubscription.yaml
      remediationAction: inform
      policyName: "group-dev-pao-sub"
    #Elasticsearch Operator
    - fileName: elasticsearch/ElasticsearchNS.yaml ❶
      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 ❷
      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.
4. Commit the **PolicyGenTemplate** 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 **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
```

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
```

10.4. 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, add **evaluationInterval** to the **spec** field, and then set the appropriate **compliant** and **noncompliant** values. For example:

```
spec:
  evaluationInterval:
    compliant: 30m
    noncompliant: 20s
```

2. To configure the evaluation interval for the **spec.sourceFiles** object in a **PolicyGenTemplate** CR, add **evaluationInterval** to the **sourceFiles** field, 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 (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"}
```

10.5. 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" ❶
  namespace: "ztp-group" ❷
spec:
  bindingRules:
    group-du-sno: "" ❸
  bindingExcludedRules:
    ztp-done: "" ❹
  mcp: "master" ❺
  sourceFiles:
    - fileName: validatorCRs/informDuValidator.yaml
      remediationAction: inform ❻
      policyName: "du-policy" ❼
```

- ❶ The name of **PolicyGenTemplates** 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 **PolicyGenTemplates**.
- 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](#)

10.6. CONFIGURING POWER STATES USING POLICYGENTEMPLATES 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](#)

10.6.1. 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
```

2. Commit the **PolicyGenTemplate** change in Git, and then push to the Git repository being monitored by the GitOps ZTP Argo CD application.

10.6.2. 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

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 high-performance mode.

```
- fileName: PerformanceProfile.yaml
  policyName: "config-policy"
  metadata:
    [...]
  spec:
    [...]
  workloadHints:
    realTime: true
    highPowerConsumption: true
    perPodPowerManagement: false
```

2. Commit the **PolicyGenTemplate** change in Git, and then push to the Git repository being monitored by the GitOps ZTP Argo CD application.

10.6.3. 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](#)

10.6.4. 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.

2. Commit the **PolicyGenTemplate** change in Git, and then push to the Git repository being monitored by the GitOps ZTP Argo CD application.

10.7. 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

1. 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-4.15
    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 4.15, 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" ❶
spec:
  storage:
    deviceClasses:
      - name: vg1
    thinPoolConfig:
      name: thin-pool-1
      sizePercent: 90
      overprovisionRatio: 10

```

- ❶ 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.

10.8. CONFIGURING PTP EVENTS WITH POLICYGENTEMPLATE CRS

You can use the GitOps ZTP pipeline to configure PTP events that use HTTP or AMQP transport.



NOTE

HTTP transport is the default transport for PTP and bare-metal events. Use HTTP transport instead of AMQP for PTP and bare-metal events where possible. AMQ Interconnect is EOL from 30 June 2024. Extended life cycle support (ELS) for AMQ Interconnect ends 29 November 2029. For more information see, [Red Hat AMQ Interconnect support status](#).

10.8.1. 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 **.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 stanza into **.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 #secs
        maxOffsetThreshold: 100 #nano secs
        minOffsetThreshold: -100 #nano secs
```

- 1 Can be one of **PtpConfigMaster.yaml**, **PtpConfigSlave.yaml**, or **PtpConfigSlaveCvl.yaml** depending on your requirements. **PtpConfigSlaveCvl.yaml** configures **linuxptp** services for an Intel E810 Columbiaville NIC. 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](#)

10.8.2. Configuring PTP events that use AMQP transport

You can configure PTP events that use AMQP transport on managed clusters that you deploy with the GitOps Zero Touch Provisioning (ZTP) pipeline.



NOTE

HTTP transport is the default transport for PTP and bare-metal events. Use HTTP transport instead of AMQP for PTP and bare-metal events where possible. AMQ Interconnect is EOL from 30 June 2024. Extended life cycle support (ELS) for AMQ Interconnect ends 29 November 2029. For more information see, [Red Hat AMQ Interconnect support status](#).

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. Add the following YAML into **.spec.sourceFiles** in the **common-ranGen.yaml** file to configure the AMQP Operator:

```
#AMQ interconnect operator for fast events
- fileName: AmqSubscriptionNS.yaml
  policyName: "subscriptions-policy"
- fileName: AmqSubscriptionOperGroup.yaml
  policyName: "subscriptions-policy"
- fileName: AmqSubscription.yaml
  policyName: "subscriptions-policy"
```

2. 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 **.sourceFiles**, add the **PtpOperatorConfig** CR file that configures the AMQ transport host to the **config-policy**:

```
- fileName: PtpOperatorConfigForEvent.yaml
  policyName: "config-policy"
```

```
spec:
  daemonNodeSelector: {}
  ptpEventConfig:
    enableEventPublisher: true
    transportHost: "amqp://amq-router.amq-router.svc.cluster.local"
```

- b. Configure the **linuxptp** and **phc2sys** for the PTP clock type and interface. For example, add the following stanza into **.sourceFiles**:

```
- fileName: PtpConfigSlave.yaml ❶
  policyName: "config-policy"
  metadata:
    name: "du-ptp-slave"
  spec:
    profile:
      - name: "slave"
        interface: "ens5f1" ❷
        ptp4lOpts: "-2 -s --summary_interval -4" ❸
        phc2sysOpts: "-a -r -m -n 24 -N 8 -R 16" ❹
        ptpClockThreshold: ❺
        holdOverTimeout: 30 #secs
        maxOffsetThreshold: 100 #nano secs
        minOffsetThreshold: -100 #nano secs
```

- ❶ Can be one **PtpConfigMaster.yaml**, **PtpConfigSlave.yaml**, or **PtpConfigSlaveCvl.yaml** depending on your requirements. **PtpConfigSlaveCvl.yaml** configures **linuxptp** services for an Intel E810 Columbiaville NIC. For configurations based on **group-du-sno-ranGen.yaml** or **group-du-3node-ranGen.yaml**, use **PtpConfigSlave.yaml**.
- ❷ Device specific interface name.
- ❸ You must append the **--summary_interval -4** value to **ptp4lOpts** in **.spec.sourceFiles.spec.profile** to enable PTP fast events.
- ❹ Required **phc2sysOpts** values. **-m** prints messages to **stdout**. The **linuxptp-daemon DaemonSet** parses the logs and generates Prometheus metrics.
- ❺ 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**.

3. Apply the following **PolicyGenTemplate** changes to your specific site YAML files, for example, **example-sno-site.yaml**:

- a. In **.sourceFiles**, add the **Interconnect** CR file that configures the AMQ router to the **config-policy**:

■


```
- fileName: AmqInstance.yaml
  policyName: "config-policy"
```

4. Merge any other required changes and files with your custom site repository.
5. Push the changes to your site configuration repository to deploy PTP fast events to new sites using GitOps ZTP.

Additional resources

- [Installing the AMQ messaging bus](#)
- For more information about container image registries, see [OpenShift image registry overview](#).

10.9. CONFIGURING BARE-METAL EVENTS WITH POLICYGENTEMPLATE CRS

You can use the GitOps ZTP pipeline to configure bare-metal events that use HTTP or AMQP transport.



NOTE

HTTP transport is the default transport for PTP and bare-metal events. Use HTTP transport instead of AMQP for PTP and bare-metal events where possible. AMQ Interconnect is EOL from 30 June 2024. Extended life cycle support (ELS) for AMQ Interconnect ends 29 November 2029. For more information see, [Red Hat AMQ Interconnect support status](#).

10.9.1. Configuring bare-metal events that use HTTP transport

You can configure bare-metal 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. Configure the Bare Metal Event Relay Operator by adding the following YAML to **spec.sourceFiles** in the **common-ranGen.yaml** file:

```
# Bare Metal Event Relay operator
- fileName: BareMetalEventRelaySubscriptionNS.yaml
  policyName: "subscriptions-policy"
- fileName: BareMetalEventRelaySubscriptionOperGroup.yaml
  policyName: "subscriptions-policy"
- fileName: BareMetalEventRelaySubscription.yaml
  policyName: "subscriptions-policy"
```

2. Add the **HardwareEvent** CR to **spec.sourceFiles** in your specific group configuration file, for example, in the **group-du-sno-ranGen.yaml** file:

```
- fileName: HardwareEvent.yaml 1
  policyName: "config-policy"
  spec:
    nodeSelector: {}
    transportHost: "http://hw-event-publisher-service.openshift-bare-metal-
events.svc.cluster.local:9043"
    logLevel: "info"
```

- ¹ Each baseboard management controller (BMC) requires a single **HardwareEvent** CR only.



NOTE

In OpenShift Container Platform 4.13 or later, you do not need to set the **transportHost** field in the **HardwareEvent** custom resource (CR) when you use HTTP transport with bare-metal events.

3. Merge any other required changes and files with your custom site repository.
4. Push the changes to your site configuration repository to deploy bare-metal events to new sites with GitOps ZTP.
5. Create the Redfish Secret by running the following command:

```
$ oc -n openshift-bare-metal-events create secret generic redfish-basic-auth \
--from-literal=username=<bmc_username> --from-literal=password=<bmc_password> \
--from-literal=hostaddr="<bmc_host_ip_addr>"
```

Additional resources

- [Installing the Bare Metal Event Relay using the CLI](#)
- [Creating the bare-metal event and Secret CRs](#)

10.9.2. Configuring bare-metal events that use AMQP transport

You can configure bare-metal events that use AMQP transport on managed clusters that you deploy with the GitOps Zero Touch Provisioning (ZTP) pipeline.



NOTE

HTTP transport is the default transport for PTP and bare-metal events. Use HTTP transport instead of AMQP for PTP and bare-metal events where possible. AMQ Interconnect is EOL from 30 June 2024. Extended life cycle support (ELS) for AMQ Interconnect ends 29 November 2029. For more information see, [Red Hat AMQ Interconnect support status](#).

Prerequisites

- You have installed the OpenShift CLI (**oc**).

4. Commit the **PolicyGenTemplate** change in Git, and then push the changes to your site configuration repository to deploy bare-metal events monitoring to new sites using GitOps ZTP.
5. Create the Redfish Secret by running the following command:

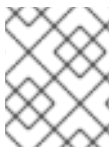
```
$ oc -n openshift-bare-metal-events create secret generic redfish-basic-auth \
--from-literal=username=<bmc_username> --from-literal=password=<bmc_password> \
--from-literal=hostaddr="<bmc_host_ip_addr>"
```

10.10. 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

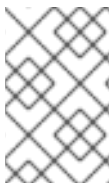
The local image registry can only be used for user application images and cannot be used for the OpenShift Container Platform or Operator Lifecycle Manager operator images.

Additional resources

- [OpenShift Container Platform registry overview](#).

10.10.1. 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.



NOTE

Use persistent naming for devices to avoid device names such as **/dev/sda** and **/dev/sdb** being switched at every reboot. You can use **rootDeviceHints** to choose the bootable device and then use same device for further partitioning.

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 for use with GitOps Zero Touch Provisioning (ZTP).

Procedure

1. Add the following YAML that describes the host disk partitioning to the **SiteConfig** CR that you use to install the managed cluster:

```
nodes:
  rootDeviceHints:
    wwn: "0x62cea7f05c98c2002708a0a22ff480ea"
  diskPartition:
    - device: /dev/disk/by-id/wwn-0x62cea7f05c98c2002708a0a22ff480ea 1
      partitions:
        - mount_point: /var/imageregistry
          size: 102500 2
          start: 344844 3
```

- 1** This setting depends on the hardware. The setting can be a serial number or device name. The value must match the value set for **rootDeviceHints**.
- 2** The minimum value for **size** is 102500 MiB.
- 3** The minimum value for **start** is 25000 MiB. The total value of **size** and **start** must not exceed the disk size, or the installation will fail.

2. Save the **SiteConfig** CR and push it to the site configuration repo.

The GitOps ZTP pipeline provisions the cluster using the **SiteConfig** CR and configures the disk partition.

10.10.2. 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

1. 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**:

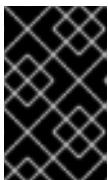
```
sourceFiles:
```

```

# 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"

```

- 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 **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.

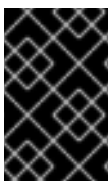
Additional resources

- [Accessing the registry](#)

10.11. USING HUB TEMPLATES IN POLICYGENTEMPLATE CRS

Topology Aware Lifecycle Manager supports partial 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 that you must create the objects referenced in the hub template in the same namespace where the policy is created.

The following supported hub template functions are available for use in GitOps ZTP with TALM:

- **fromConfigmap** returns the value of the provided data key in the named **ConfigMap** resource.



NOTE

There is a [1 MiB size limit](#) for **ConfigMap** CRs. The effective size for **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
```

- **base64enc** returns the base64-encoded value of the input string
- **base64dec** returns the decoded value of the base64-encoded input string
- **indent** returns the input string with added indent spaces
- **autoindent** returns the input string with added indent spaces based on the spacing used in the parent template
- **toInt** casts and returns the integer value of the input value
- **toBool** converts the input string into a boolean value, and returns the boolean

Various [Open source community functions](#) are also available for use with GitOps ZTP.

Additional resources

- [RHACM support for hub cluster templates in configuration policies](#)

10.11.1. Example hub templates

The following code examples are valid hub templates. Each of these templates return values from the **ConfigMap** CR with the name **test-config** in the **default** namespace.

- Returns the value with the key **common-key**:

```
{{hub fromConfigMap "default" "test-config" "common-key" hub}}
```

- Returns a string by using the concatenated value of the **.ManagedClusterName** field and the string **-name**:

```
{{hub fromConfigMap "default" "test-config" (printf "%s-name" .ManagedClusterName) hub}}
```

- Casts and returns a boolean value from the concatenated value of the **.ManagedClusterName** field and the string **-name**:

```
{{hub fromConfigMap "default" "test-config" (printf "%s-name" .ManagedClusterName) | toBool hub}}
```

- Casts and returns an integer value from the concatenated value of the **.ManagedClusterName** field and the string **-name**:

```
{{hub (printf "%s-name" .ManagedClusterName) | fromConfigMap "default" "test-config" | toInt
hub}}
```

10.11.2. Specifying group and site configuration in group PolicyGenTemplate CRs with hub templates

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 **PolicyGenTemplate** (PGT) CRs means that you do not need to create a **PolicyGenTemplate** 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 **PolicyGenTemplate** 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 group **PolicyGenTemplate** CR to apply both site and group configuration to clusters grouped by hardware type and region.



NOTE

When you use the **fromConfigmap** function, the **printf** variable is only available for the template resource **data** key fields. You cannot use it with **name** and **namespace** fields.

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:
  # SriovNetworkNodePolicy.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:
  # SriovNetwork.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 **PolicyGenTemplate** CR.

- Commit the **ConfigMap** CRs in Git, and then push to the Git repository being monitored by the Argo CD application.
- 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. Create a group **PolicyGenTemplate** CR that uses hub templates to obtain the required data from the **ConfigMap** objects. 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
```

```

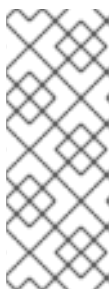
- fileName: SrioVNetwork.yaml # wave 100
  policyName: "group-du-sno-sriov-policy"
  metadata:
    name: sriov-nw-du-fh
  spec:
    resourceName: du_fh
    vlan: '{{hub fromConfigMap "" "site-data-configmap" (printf "%s-sriov-network-vlan-1"
.ManagedClusterName) | toInt hub}}'

- 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

```

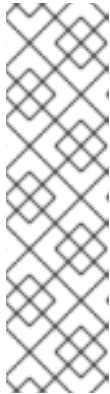


NOTE

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.

- Commit the site **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 **PolicyGenTemplate** CRs. See "Syncing new ConfigMap changes to existing PolicyGenTemplate CRs".

You can use the same **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.

10.11.3. Syncing new ConfigMap changes to existing 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 **PolicyGenTemplate** CR that pulls information from a **ConfigMap** CR using hub cluster templates.

Procedure

- Update the contents of your **ConfigMap** CR, and apply the changes in the hub cluster.
- To sync the contents of the updated **ConfigMap** CR to the deployed policy, do either of the following:
 - Option 1: Delete the existing policy. ArgoCD uses the **PolicyGenTemplate** CR to immediately recreate the deleted policy. For example, run the following command:

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

- 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](#).

- Optional: If it exists, delete the **ClusterGroupUpdate** CR that contains the policy. For example:

```
$ oc delete clustergroupupdate <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 11. 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.

11.1. 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 the following features:

- Create a backup of a deployment before an upgrade
- 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.

11.2. 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 **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.

For more information about the **PolicyGenTemplate** CRD, see the "About the PolicyGenTemplate CRD" section in "Configuring managed clusters with policies and PolicyGenTemplate resources".

11.3. 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.
- Set up a hub cluster with 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.

11.4. 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.
- 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.4.15.x	Topology Aware Lifecycle Manager	4.15.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	cluster-group-upgrades-controller-manager		1/1
1 1 14s			

■

11.5. 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

11.5.1. 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](https://k8s.io/api/machinery/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: ❶
      addClusterLabels:
        upgrade-done: ""
      deleteClusterLabels:
        upgrade-running: ""
      deleteObjects: true
    beforeEnable: ❷
      addClusterLabels:
        upgrade-running: ""
  backup: false
  clusters: ❸
    - spoke1
  enable: false ❹
  managedPolicies: ❺
    - 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: tal-m-policy
      namespace: tal-m-namespace
  managedPoliciesNs:
    tal-m-policy: tal-m-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**.

11.5.2. 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.

11.5.3. 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.

11.5.4. Creating a backup

For single-node OpenShift, TALM can create a backup of a deployment before an update. If the update fails, you can recover the previous version and restore a cluster to a working state without requiring a reprovision of applications. To use the backup feature you first create a **ClusterGroupUpgrade** CR with the **backup** field set to **true**. To ensure that the contents of the backup are up to date, the backup is not taken until you set the **enable** field in the **ClusterGroupUpgrade** CR to **true**.

TALM uses the **BackupSucceeded** condition to report the status and reasons as follows:

- **true**
Backup is completed for all clusters or the backup run has completed but failed for one or more clusters. If backup fails for any cluster, the update fails for that cluster but proceeds for all other clusters.
- **false**
Backup is still in progress for one or more clusters or has failed for all clusters.

For more information, see the "Creating a backup of cluster resources before upgrade" section.

11.5.5. 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 has 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.
- Backup is still in progress.



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: {}
  backup: false
  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.

11.5.6. 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: ❶
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 ❷
  - message: All clusters are compliant with all the managed policies
    reason: Completed
    status: "True"
    type: Succeeded ❸
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'

```

❷

In the **Progressing** fields, the status is **false** as the update has completed; clusters are compliant with all the managed policies.

❸

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: {}
  backup: false
  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.

11.5.7. 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-ntp-sub-policy
  remediationStrategy:
    canaries:
    - spoke1
    maxConcurrency: 2
    timeout: 240
  status:
    conditions:
    - message: The ClusterGroupUpgrade CR is not enabled
      reason: UpgradeNotStarted
      status: "False"
      type: Ready
    copiedPolicies:
    - cgu-a-policy1-common-cluster-version-policy
    - cgu-a-policy2-common-pao-sub-policy
    - cgu-a-policy3-common-ntp-sub-policy
    managedPoliciesForUpgrade:
    - name: policy1-common-cluster-version-policy
      namespace: default
    - name: policy2-common-pao-sub-policy
      namespace: default
    - name: policy3-common-ntp-sub-policy
      namespace: default
    placementBindings:
    - cgu-a-policy1-common-cluster-version-policy
    - cgu-a-policy2-common-pao-sub-policy
    - cgu-a-policy3-common-ntp-sub-policy
    placementRules:
    - cgu-a-policy1-common-cluster-version-policy
    - cgu-a-policy2-common-pao-sub-policy
    - cgu-a-policy3-common-ntp-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: ❶
  - name: cgu-a
    namespace: default
  clusters:
  - spoke4
  - spoke5
  enable: false
  managedPolicies:
  - policy1-common-cluster-version-policy
  - policy2-common-pao-sub-policy
  - policy3-common-ntp-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
  copiedPolicies:
  - cgu-b-policy1-common-cluster-version-policy
  - cgu-b-policy2-common-pao-sub-policy
  - cgu-b-policy3-common-ntp-sub-policy
  - cgu-b-policy4-common-sriov-sub-policy
  managedPoliciesForUpgrade:
  - name: policy1-common-cluster-version-policy
    namespace: default
  - name: policy2-common-pao-sub-policy
    namespace: default
  - name: policy3-common-ntp-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-ntp-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-ntp-sub-policy
  - cgu-b-policy4-common-sriov-sub-policy
  remediationPlan:
  - - spoke4
  - - spoke5
  status: {}

```

❶

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:
  clusters:
  - spoke6
  enable: false
  managedPolicies:
  - policy1-common-cluster-version-policy
  - policy2-common-pao-sub-policy
  - policy3-common-ntp-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
    copiedPolicies:
    - cgu-c-policy1-common-cluster-version-policy
    - cgu-c-policy4-common-sriov-sub-policy
    managedPoliciesCompliantBeforeUpgrade:
    - policy2-common-pao-sub-policy
    - policy3-common-ntp-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**.

2. Create the **ClusterGroupUpgrade** CRs by running the following command for each relevant CR:

```
$ oc apply -f <name>.yaml
```

3. 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-ntp-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
  copiedPolicies:
    - cgu-a-policy1-common-cluster-version-policy
    - cgu-a-policy2-common-pao-sub-policy
    - cgu-a-policy3-common-ntp-sub-policy
  managedPoliciesForUpgrade:
    - name: policy1-common-cluster-version-policy
      namespace: default
    - name: policy2-common-pao-sub-policy
      namespace: default
    - name: policy3-common-ntp-sub-policy
      namespace: default
  placementBindings:
    - cgu-a-policy1-common-cluster-version-policy
    - cgu-a-policy2-common-pao-sub-policy
    - cgu-a-policy3-common-ntp-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
  copiedPolicies:
    - 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
  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-ntp-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-ntp-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-ntp-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
  copiedPolicies:
  - cgu-c-policy1-common-cluster-version-policy
  - cgu-c-policy4-common-sriov-sub-policy
  managedPoliciesCompliantBeforeUpgrade:
  - policy2-common-pao-sub-policy
  - policy3-common-ntp-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.

11.6. UPDATE POLICIES ON MANAGED CLUSTERS

The Topology Aware Lifecycle Manager (TALM) remediates a set of **inform** policies for the clusters specified in the **ClusterGroupUpgrade** CR. TALM remediates **inform** policies by making **enforce** copies of the managed RHACM policies. Each copied 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 copied 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 enforce policies 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-4.4.15.4
  namespace: platform-upgrade
spec:
  disabled: false
  policy-templates:
  - objectDefinition:
      apiVersion: policy.open-cluster-management.io/v1

```

```

kind: ConfigurationPolicy
metadata:
  name: upgrade
spec:
  namespaceselector:
    exclude:
      - kube-*
    include:
      - '*'
  object-templates:
    - complianceType: musthave
      objectDefinition:
        apiVersion: config.openshift.io/v1
        kind: ClusterVersion
        metadata:
          name: version
        spec:
          channel: stable-4.15
          desiredUpdate:
            version: 4.4.15.4
          upstream: https://api.openshift.com/api/upgrades_info/v1/graph
        status:
          history:
            - state: Completed
              version: 4.4.15.4
        remediationAction: inform
        severity: low
        remediationAction: inform

```

For more information about RHACM policies, see [Policy overview](#).

Additional resources

For more information about the **PolicyGenTemplate** CRD, see [About the PolicyGenTemplate CRD](#).

11.6.1. 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.

11.6.2. Applying update policies to managed clusters

You can update your managed clusters by applying your policies.

Prerequisites

- Install the Topology Aware Lifecycle Manager (TALM).
- 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"
    }
  ],
  "copiedPolicies": [
    "cgu-policy1-common-cluster-version-policy",
    "cgu-policy2-common-nto-sub-policy",
    "cgu-policy3-common-ptp-sub-policy",
    "cgu-policy4-common-sriov-sub-policy"
```

```

],
"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"
],
"precaching": {
  "spec": {}
},
"remediationPlan": [
  [
    "spoke1",
    "spoke2"
  ],
  [
    "spoke5",

```

```

    "spoke6"
  ]
},
"status": {}
}

```

- 1 The **spec.enable** field in the **ClusterGroupUpgrade** CR is set to **false**.

- c. Check the status of the policies by running the following command:

```
$ oc get policies -A
```

Example output

NAMESPACE	NAME	COMPLIANCE STATE	AGE	REMEDIATION ACTION
default	cgu-policy1-common-cluster-version-policy	enforce	17m 1	
default	cgu-policy2-common-nto-sub-policy	enforce	17m	
default	cgu-policy3-common-ntp-sub-policy	enforce	17m	
default	cgu-policy4-common-sriov-sub-policy	enforce	17m	
default	policy1-common-cluster-version-policy	inform	15h	NonCompliant
default	policy2-common-nto-sub-policy	inform	15h	NonCompliant
default	policy3-common-ntp-sub-policy	inform	18m	NonCompliant
default	policy4-common-sriov-sub-policy	inform	18m	NonCompliant

- 1 The **spec.remediationAction** field of policies currently applied on the clusters is set to **enforce**. The managed policies in **inform** mode from the **ClusterGroupUpgrade** CR remain in **inform** mode during the update.

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 again 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",
  "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"
}
],
"copiedPolicies": [
  "cgu-policy1-common-cluster-version-policy",
  "cgu-policy2-common-nto-sub-policy",
  "cgu-policy3-common-ptp-sub-policy",
  "cgu-policy4-common-sriov-sub-policy"
],
"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-ntp-sub-policy": "default",
    "policy4-common-sriov-sub-policy": "default"
  },
  "placementBindings": [
    "cgu-policy1-common-cluster-version-policy",
    "cgu-policy2-common-ntp-sub-policy",
    "cgu-policy3-common-ntp-sub-policy",
    "cgu-policy4-common-sriov-sub-policy"
  ],
  "placementRules": [
    "cgu-policy1-common-cluster-version-policy",
    "cgu-policy2-common-ntp-sub-policy",
    "cgu-policy3-common-ntp-sub-policy",
    "cgu-policy4-common-sriov-sub-policy"
  ],
  "precaching": {
    "spec": {}
  },
  "remediationPlan": [
    [
      "spoke1",
      "spoke2"
    ],
    [
      "spoke5",
      "spoke6"
    ]
  ],
  "status": {
    "currentBatch": 1,
    "currentBatchStartedAt": "2022-02-25T15:54:16Z",
    "remediationPlanForBatch": {
      "spoke1": 0,
      "spoke2": 1
    },
    "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. If the policies include Operator subscriptions, you can check the installation progress directly on the single-node cluster.
 - a. 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>
```

- b. 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	cluster-logging	cluster-logging	redhat-
operators stable			

- 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  4.4.15.5  True      True         43s   Working towards 4.4.15.7: 71 of 735 done
(9% complete)
```

- 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:

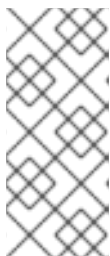
```
$ oc get installplan -n <subscription_namespace>
```

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

11.7. CREATING A BACKUP OF CLUSTER RESOURCES BEFORE UPGRADE

For single-node OpenShift, the Topology Aware Lifecycle Manager (TALM) can create a backup of a deployment before an upgrade. If the upgrade fails, you can recover the previous version and restore a cluster to a working state without requiring a reprovision of applications.

To use the backup feature you first create a **ClusterGroupUpgrade** CR with the **backup** field set to **true**. To ensure that the contents of the backup are up to date, the backup is not taken until you set the **enable** field in the **ClusterGroupUpgrade** CR to **true**.

TALM uses the **BackupSucceeded** condition to report the status and reasons as follows:

- **true**
Backup is completed for all clusters or the backup run has completed but failed for one or more clusters. If backup fails for any cluster, the update does not proceed for that cluster.
- **false**
Backup is still in progress for one or more clusters or has failed for all clusters. The backup process running in the spoke clusters can have the following statuses:
 - **PreparingToStart**
The first reconciliation pass is in progress. The TALM deletes any spoke backup namespace and hub view resources that have been created in a failed upgrade attempt.
 - **Starting**
The backup prerequisites and backup job are being created.
 - **Active**
The backup is in progress.
 - **Succeeded**
The backup succeeded.
 - **BackupTimeout**
Artifact backup is partially done.
 - **UnrecoverableError**
The backup has ended with a non-zero exit code.



NOTE

If the backup of a cluster fails and enters the **BackupTimeout** or **UnrecoverableError** state, the cluster update does not proceed for that cluster. Updates to other clusters are not affected and continue.

11.7.1. Creating a ClusterGroupUpgrade CR with backup

You can create a backup of a deployment before an upgrade on single-node OpenShift clusters. If the upgrade fails you can use the **upgrade-recovery.sh** script generated by Topology Aware Lifecycle Manager (TALM) to return the system to its preupgrade state. The backup consists of the following items:

Cluster backup

A snapshot of **etcd** and static pod manifests.

Content backup

Backups of folders, for example, **/etc**, **/usr/local**, **/var/lib/kubelet**.

Changed files backup

Any files managed by **machine-config** that have been changed.

Deployment

A pinned **ostree** deployment.

Images (Optional)

Any container images that are in use.

Prerequisites

- Install the Topology Aware Lifecycle Manager (TALM).
- Provision one or more managed clusters.
- Log in as a user with **cluster-admin** privileges.
- Install Red Hat Advanced Cluster Management (RHACM).

NOTE

It is highly recommended that you create a recovery partition. The following is an example **SiteConfig** custom resource (CR) for a recovery partition of 50 GB:

```
nodes:
  - hostName: "node-1.example.com"
    role: "master"
    rootDeviceHints:
      hctl: "0:2:0:0"
      deviceName: /dev/disk/by-id/scsi-3600508b400105e210000900000490000
    ...
  #Disk /dev/disk/by-id/scsi-3600508b400105e210000900000490000:
  #893.3 GiB, 959119884288 bytes, 1873281024 sectors
  diskPartition:
    - device: /dev/disk/by-id/scsi-3600508b400105e210000900000490000
      partitions:
        - mount_point: /var/recovery
          size: 51200
          start: 800000
```

Procedure

1. Save the contents of the **ClusterGroupUpgrade** CR with the **backup** and **enable** fields 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
  backup: true
  clusters:
    - cnfdb1
    - cnfdb2
  enable: true
  managedPolicies:
    - du-upgrade-platform-upgrade
  remediationStrategy:
    maxConcurrency: 2
    timeout: 240

```

- To start the update, apply the **ClusterGroupUpgrade** CR by running the following command:

```
$ oc apply -f clustergroupupgrades-group-du.yaml
```

Verification

- Check the status of the upgrade in the hub cluster by running the following command:

```
$ oc get cgu -n ztp-group-du-sno du-upgrade-4918 -o jsonpath='{.status}'
```

Example output

```

{
  "backup": {
    "clusters": [
      "cnfdb2",
      "cnfdb1"
    ],
    "status": {
      "cnfdb1": "Succeeded",
      "cnfdb2": "Failed" ❶
    }
  },
  "computedMaxConcurrency": 1,
  "conditions": [
    {
      "lastTransitionTime": "2022-04-05T10:37:19Z",
      "message": "Backup failed for 1 cluster", ❷
      "reason": "PartiallyDone", ❸
      "status": "True", ❹
      "type": "Succeeded"
    }
  ],
  "precaching": {

```

```
"spec": {}
},
"status": {}
```

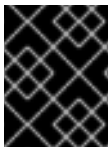
- 1 Backup has failed for one cluster.
- 2 The message confirms that the backup failed for one cluster.
- 3 The backup was partially successful.
- 4 The backup process has finished.

11.7.2. Recovering a cluster after a failed upgrade

If an upgrade of a cluster fails, you can manually log in to the cluster and use the backup to return the cluster to its preupgrade state. There are two stages:

Rollback

If the attempted upgrade included a change to the platform OS deployment, you must roll back to the previous version before running the recovery script.



IMPORTANT

A rollback is only applicable to upgrades from TALM and single-node OpenShift. This process does not apply to rollbacks from any other upgrade type.

Recovery

The recovery shuts down containers and uses files from the backup partition to relaunch containers and restore clusters.

Prerequisites

- Install the Topology Aware Lifecycle Manager (TALM).
- Provision one or more managed clusters.
- Install Red Hat Advanced Cluster Management (RHACM).
- Log in as a user with **cluster-admin** privileges.
- Run an upgrade that is configured for backup.

Procedure

1. Delete the previously created **ClusterGroupUpgrade** custom resource (CR) by running the following command:

```
$ oc delete cgu/du-upgrade-4918 -n ztp-group-du-sno
```

2. Log in to the cluster that you want to recover.
3. Check the status of the platform OS deployment by running the following command:

```
$ ostree admin status
```

Example outputs

```
[root@lab-test-spoke2-node-0 core]# ostree admin status
* rhcos c038a8f08458bbbed83a77ece033ad3c55597e3f64edad66ea12fda18cbdceaf9.0
  Version: 49.84.202202230006-0
  Pinned: yes 1
  origin refs spec:
c038a8f08458bbbed83a77ece033ad3c55597e3f64edad66ea12fda18cbdceaf9
```

- 1 The current deployment is pinned. A platform OS deployment rollback is not necessary.

```
[root@lab-test-spoke2-node-0 core]# ostree admin status
* rhcos f750ff26f2d5550930ccbe17af61af47daafc8018cd9944f2a3a6269af26b0fa.0
  Version: 410.84.202204050541-0
  origin refs spec: f750ff26f2d5550930ccbe17af61af47daafc8018cd9944f2a3a6269af26b0fa
rhcos ad8f159f9dc4ea7e773fd9604c9a16be0fe9b266ae800ac8470f63abc39b52ca.0
(rollback) 1
  Version: 410.84.202203290245-0
  Pinned: yes 2
  origin refs spec:
ad8f159f9dc4ea7e773fd9604c9a16be0fe9b266ae800ac8470f63abc39b52ca
```

- 1 This platform OS deployment is marked for rollback.
- 2 The previous deployment is pinned and can be rolled back.

4. To trigger a rollback of the platform OS deployment, run the following command:

```
$ rpm-ostree rollback -r
```

5. The first phase of the recovery shuts down containers and restores files from the backup partition to the targeted directories. To begin the recovery, run the following command:

```
$ /var/recovery/upgrade-recovery.sh
```

6. When prompted, reboot the cluster by running the following command:

```
$ systemctl reboot
```

7. After the reboot, restart the recovery by running the following command:

```
$ /var/recovery/upgrade-recovery.sh --resume
```



NOTE

If the recovery utility fails, you can retry with the **--restart** option:

```
$ /var/recovery/upgrade-recovery.sh --restart
```


Verification

- To check the status of the recovery run the following command:

```
$ oc get clusterversion,nodes,clusteroperator
```

Example output

```
NAME                                VERSION AVAILABLE PROGRESSING SINCE
STATUS
clusterversion.config.openshift.io/version 4.4.15.23 True False 86d Cluster
version is 4.4.15.23 1

NAME STATUS ROLES AGE VERSION
node/lab-test-spoke1-node-0 Ready master,worker 86d v1.22.3+b93fd35 2

NAME                                VERSION AVAILABLE
PROGRESSING DEGRADED SINCE MESSAGE
clusteroperator.config.openshift.io/authentication 4.4.15.23 True
False False 2d7h 3
clusteroperator.config.openshift.io/baremetal 4.4.15.23 True False
False 86d

.....
```

- 1 The cluster version is available and has the correct version.
- 2 The node status is **Ready**.
- 3 The **ClusterOperator** object's availability is **True**.

11.8. 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.

11.8.1. 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.

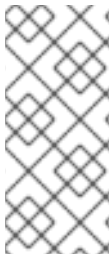
```
apiVersion: v1
```

```
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.

11.8.2. 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": "PrecacheSpecsWellFormed",
      "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.

11.9. 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

11.9.1. 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 11.9.3, "Managed policies"](#)
 - [Section 11.9.4, "Clusters"](#)
 - [Section 11.9.5, "Remediation Strategy"](#)
 - [Section 11.9.6, "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.

11.9.2. 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>
```

11.9.3. 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	5d21h
default	policy3-common-ptp-sub-policy	inform	NonCompliant	5d21h
default	policy4-common-sriov-sub-policy	inform	NonCompliant	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
5d21h			
default	policy3-common-ptp-sub-policy	inform	NonCompliant
5d21h			
default	policy4-common-sriov-sub-policy	inform	NonCompliant
5d21h			

11.9.4. 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
local-cluster	true	https://api.hub.testlab.com:6443	True	Unknown
spoke1	true	https://api.spoke1.testlab.com:6443	True	True
spoke3	true	https://api.spoke3.testlab.com:6443	True	True

- 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	13d
spoke3	true	https://api.spoke3.testlab.com:6443	True True	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
```

11.9.5. 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
```

11.9.6. 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 corresponding copied policies

Issue

You want to check if every policy from **status.managedPoliciesForUpgrade** has a corresponding policy in **status.copiedPolicies**.

Resolution

Run the following command:

```
$ oc get cgu lab-upgrade -oyaml
```

Example output

```
status:  
  ...  
  copiedPolicies:  
  - lab-upgrade-policy3-common-ntp-sub-policy  
  managedPoliciesForUpgrade:  
  - name: policy3-common-ntp-sub-policy  
    namespace: default
```

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 a **ClusterGroupUpgrade** 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 **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 **ztp-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

- For information about troubleshooting, see [OpenShift Container Platform Troubleshooting Operator Issues](#).
- For more information about using Topology Aware Lifecycle Manager in the ZTP workflow, see [Updating managed policies with Topology Aware Lifecycle Manager](#) .
- For more information about the **PolicyGenTemplate** CRD, see [About the PolicyGenTemplate CRD](#)

CHAPTER 12. UPDATING MANAGED CLUSTERS IN A DISCONNECTED ENVIRONMENT WITH THE TOPOLOGY AWARE LIFECYCLE MANAGER

You can use the Topology Aware Lifecycle Manager (TALM) to manage the software lifecycle of OpenShift Container Platform managed clusters. TALM uses Red Hat Advanced Cluster Management (RHACM) policies to perform changes on the target clusters.

Additional resources

- For more information about the Topology Aware Lifecycle Manager, see [About the Topology Aware Lifecycle Manager](#).

12.1. UPDATING CLUSTERS IN A DISCONNECTED ENVIRONMENT

You can upgrade managed clusters and Operators for managed clusters that you have deployed using GitOps Zero Touch Provisioning (ZTP) and Topology Aware Lifecycle Manager (TALM).

12.1.1. Setting up the 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-4.15 -o ~/upgrade-graph_stable-4.15
```

- 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](#).

12.1.2. Performing a platform update

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 contents of the **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} ❷
- fileName: DisconnectedICSP.yaml
  policyName: "platform-upgrade-prep"
  metadata:
    name: disconnected-internal-icsp-for-ocp
  spec:
    repositoryDigestMirrors: ❸
      - 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 ❹
  policyName: "platform-upgrade"
  metadata:
    name: version
  spec:
    channel: "stable-4.15"
    upstream: http://upgrade.example.com/images/upgrade-graph_stable-4.15
    desiredUpdate:
      version: 4.15.4
  status:
    history:
      - version: 4.15.4
        state: "Completed"

```

- ❶ The **ConfigMap** CR contains the signature of the desired release image to update to.
- ❷ 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.
- ❸ 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.
- ❹ 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: ClusterGroupUpdate
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](#).

12.1.3. Performing an Operator update

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

- Update the **PolicyGenTemplate** CR for the Operator update.
 - 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
      spec:
        displayName: Red Hat Operators Catalog
        image: registry.example.com:5000/olm/redhat-operators:v4.15 1
```

```

updateStrategy: ❷
  registryPoll:
    interval: 1h
status:
  connectionState:
    lastObservedState: READY ❸

```

- ❶ 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.
- ❷ 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, you can restore **registryPoll.interval** to the default value once the update is complete.
- ❸ 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** 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**, 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 4.15 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.

- 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.

- a. 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

- For more information about updating GitOps ZTP, see [Upgrading GitOps ZTP](#).
- [Troubleshooting missed Operator updates due to out-of-date policy compliance states](#).

12.1.3.1. Troubleshooting missed Operator updates due to out-of-date policy compliance states

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
  spec:
    displayName: Red Hat Operators Catalog
    image: registry.example.com:5000/olm/redhat-operators:v{product-version}
    updateStrategy:
      registryPoll:
        interval: 1h
  status:
    connectionState:
      lastObservedState: READY
- fileName: DefaultCatsrc.yaml
  remediationAction: inform
  policyName: "operator-catsrc-policy"
  metadata:
```

```

name: redhat-operators-v2 1
spec:
  displayName: Red Hat Operators Catalog v2 2
  image: registry.example.com:5000/olredhat-operators:<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-v2 1
# ...

```

- 1** Enter the name of the additional catalog source configuration that you defined in the **PolicyGenTemplate** resource.

12.1.4. 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 ❶
    - du-upgrade-operator-catsrc-policy ❷
    - common-subscriptions-policy ❸
  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.

12.1.5. Removing Performance Addon Operator subscriptions from deployed clusters

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
```

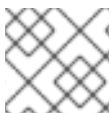
5. Delete the Performance Addon Operator namespace, Operator group and subscription CRs from **.spec.sourceFiles** in the **common-ranGen.yaml** file.
6. Merge the changes with your custom site repository and wait for the ArgoCD application to synchronize the change to the hub cluster. The policy remains compliant.

12.1.6. 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: ❶
    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 ❷
  excludePrecachePatterns: ❸
    - aws
    - vsphere
  additionalImages: ❹
    -
  quay.io/exampleconfig/application1@sha256:3d5800990dee7cd4727d3fe238a97e2d2976d3808fc925
ada29c559a47e2e1ef
    -
  quay.io/exampleconfig/application2@sha256:3d5800123dee7cd4727d3fe238a97e2d2976d3808fc925
ada29c559a47adfaef
    -
  quay.io/exampleconfig/applicationN@sha256:4fe1334adfafadsf987123adfffdaf1243340adfafdedga099
1234afdadfsa09
```

- ❶ 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.
- ❷ 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**.
- ❸ Specifies the images to exclude from pre-caching based on image name matching.
- ❹ 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 ❶
  preCachingConfigRef:
    name: exampleconfig ❷
    namespace: exampleconfig-ns ❸
```

- ❶ The **preCaching** field set to **true** enables the pre-caching job.
- ❷ The **preCachingConfigRef.name** field specifies the **PreCachingConfig** CR that you want to use.
- ❸ The **preCachingConfigRef.namespace** specifies the namespace of the **PreCachingConfig** CR

that you want to use.

12.1.6.1. 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@sha256:4fe1334adfafadsf987123adfffdaf1243340adfafd
- 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

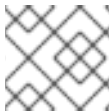
Once you install the images on the cluster, you cannot change or delete them.

- 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@sha256:4fe1334adfafadsf987123adfffdaf1243340adfafd
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: PrecacheSpecsWellFormed
  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/cnfd00.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](#).

12.2. 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 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.

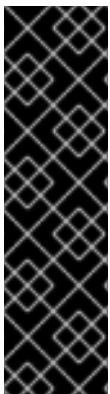


NOTE

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

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 **PolicyGenTemplate** resources. The GitOps ZTP pipeline that is linked to the ArgoCD **policies** application includes the following CRs that

you can find in the **out/argocd/example/policygentemplates** folder when you extract the **ztp-site-generate** container:

- **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. (OPTIONAL) 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 labelled 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 ptpoperatorconfig/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.

2. 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
```

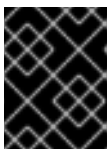
Example output for SR-IOV Operator

```
{"configDaemonNodeSelector":{"node-
role.kubernetes.io/worker":""}, "disableDrain":false, "enableInjector":true, "enableOperatorWebh
ook":true} 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.

3. 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.

4. 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 POLICYGENTEMPLATE CRS TO APPLY WORKER NODE POLICIES TO WORKER NODES

You can create policies for worker nodes.

Procedure

1. Create the following policy template:

```
apiVersion: ran.openshift.io/v1
kind: PolicyGenTemplate
metadata:
  name: "example-sno-workers"
  namespace: "example-sno"
spec:
  bindingRules:
    sites: "example-sno" ❶
  mcp: "worker" ❷
  sourceFiles:
    - fileName: MachineConfigGeneric.yaml ❸
      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,W2NyaW8ucnVudGltZS53b3JrbG9hZHMubWFuYWdlbWVudF0KYWN0aXZhdGlubl
9hbm5vdGF0aW9uID0gInRhcmdldC53b3JrbG9hZC5vcGVuc2hpZnQuaW8vbWFuYWdlbWVu
dCIKYW5ub3RhdGlubl9wcmVmaXggPSAicmVzb3VyY2VzLndvcmtsb2FkLm9wZW5zaGlmdC5
pbylKcmVzb3VyY2VzID0geyAiY3B1c2hhcmVzliA9IDAsICJjcHVzZXQiID0gljAtMylgfQo=
            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,ewogICJtYW5hZ2VtZW50IjogewogICAgImNwdXNldCI6IClwLTMiCiAgfQp9Cg==
            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.chrond=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

```

13.5. ADDING WORKER NODES TO SINGLE-NODE OPENSIFT 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:
 - a. 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
```

- b. 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

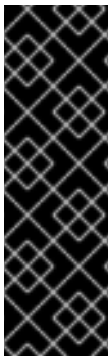
```
example-sno [{"status":"True","type":"Ready"}] {"node-
role.kubernetes.io/master":"","node-role.kubernetes.io/worker":""}
example-node2 [{"status":"True","type":"Ready"}] {"node-role.kubernetes.io/worker":""}
```

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.Ins
ertMedia
```

- 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
```

2. 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
```

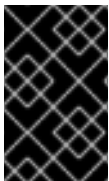


IMPORTANT

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.

1. 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
```

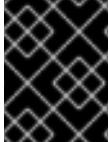
Partitions will be aligned on 2048-sector boundaries

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.

1. 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	

2. Mount the partition:

```
# mount /dev/nvme0n1p1 /mnt/
```

Verification

- Check that the partition is mounted:

```
# lsblk
```

Example output

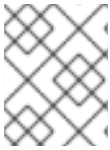
NAME	MAJ:MIN	RM	SIZE	RO	TYPE	MOUNTPOINT
loop0	7:0	0	93.8G	0	loop	/run/ephemeral
loop1	7:1	0	897.3M	1	loop	/sysroot
sr0	11:0	1	999M	0	rom	/run/media/iso
nvme0n1	259:1	0	1.5T	0	disk	
└─nvme0n1p1	259:2	0	250G	0	part	/var/mnt 1

- 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 multicluster-engine
```

Example output

```
multicluster-engine          cluster-group-upgrades-operator.v0.0.3    cluster-
group-upgrades-operator      0.0.3                                     Pending
multicluster-engine          multicluster-engine.v2.1.4                multicluster
engine for Kubernetes        2.1.4                multicluster-engine.v2.0.3
Succeeded
multicluster-engine          openshift-gitops-operator.v1.5.7          Red Hat
OpenShift GitOps            1.5.7                openshift-gitops-operator.v1.5.6-
0.1664915551.p Succeeded
multicluster-engine          openshift-pipelines-operator-rh.v1.6.4    Red Hat
OpenShift Pipelines        1.6.4                openshift-pipelines-operator-rh.v1.6.3
Succeeded
```

2. To access the container registry, copy a valid pull secret on the server to be installed:

- a. Create the **.docker** folder:

```
$ mkdir /root/.docker
```

- b. Copy the valid pull in the **config.json** file to the previously created **.docker/** folder:

```
$ cp config.json /root/.docker/config.json ❶
```

- ❶ **/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 \ ❶
-r 4.15.0 \ ❷
```

```
--acm-version 2.6.3 \ ❸
--mce-version 2.1.4 \ ❹
-f /mnt \ ❺
--img quay.io/custom/repository ❻
```

- ❶ Specifies the downloading function of the factory-precaching-cli tool.
- ❷ Defines the OpenShift Container Platform release version.
- ❸ Defines the RHACM version.
- ❹ Defines the multicluster engine version.
- ❺ Defines the folder where you want to download the images on the disk.
- ❻ 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_16cd7eda26f0fb0fc965a589e1e96ff8577e560fcd14f06b5fda1643036ed6c8
Processing artifact [176/176]: ocp-v4.0-art-
dev@sha256_cf4d862b4a4170d4f611b39d06c31c97658e309724f9788e155999ae51e7188f
...
Summary:

Release:                4.15.0
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_f19dd2e80fb41ef31d62bb8c08b339c50d193fdb10fc39cc15b353cbbfeb9b24.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_f7ba33a6a9db9cfc4b0ab0f368569e19b9fa08f4c01a0d5f6a243d61ab781bd8.tgz

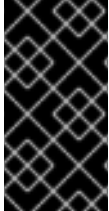
-rw-r--r--. 1 root root 145535253 Oct 31 15:26 ocp-v4.0-art-
dev@sha256_f8f098911d670287826e9499806553f7a1dd3e2b5332abbec740008c36e84de5.t
gz
-rw-r--r--. 1 root root 158048761 Oct 31 15:40 ocp-v4.0-art-
dev@sha256_f914228ddbb99120986262168a705903a9f49724ffa958bb4bf12b2ec1d7fb47.tgz

-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 \ ❶
-r 4.15.0 \ ❷
--acm-version 2.6.3 \ ❸
--mce-version 2.1.4 \ ❹
-f /mnt \ ❺
--img quay.io/custom/repository ❻
--du-profile -s ❼
```

- ❶ Specifies the downloading function of the `factory-precaching-cli` tool.
- ❷ Defines the OpenShift Container Platform release version.
- ❸ Defines the RHACM version.
- ❹ Defines the multicluster engine version.
- ❺ Defines the folder where you want to download the images on the disk.
- ❻ Optional. Defines the repository where you store your additional images. These images are downloaded and pre-cached on the disk.
- ❼ 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_370e47a14c798ca3f8707a38b28cfc28114f492bb35fe1112e55d1eb51022c99
...
Processing artifact [378/379]: ose-local-storage-
operator@sha256_0c81c2b79f79307305e51ce9d3837657cf9ba5866194e464b4d1b299f85034
d0
Processing artifact [379/379]: multicluster-operators-channel-
rhel8@sha256_c10f6bbb84fe36e05816e873a72188018856ad6aac6cc16271a1b3966f73ceb3
...
Summary:

Release:                4.15.0
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 \ ❶
-r 4.15.0 \ ❷
--acm-version 2.6.3 \ ❸
--mce-version 2.1.4 \ ❹
-f /mnt \ ❺
--img quay.io/custom/repository ❻
--du-profile -s \ ❼
--generate-imageset ❽

```

- ❶ Specifies the downloading function of the factory-precaching-cli tool.
- ❷ 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-4.15
        minVersion: 4.15.0 1
        maxVersion: 4.15.0
  additionalImages:
    - name: quay.io/custom/repository
  operators:
    - catalog: registry.redhat.io/redhat/redhat-operator-index:v4.15
      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-4.15'
  - 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:v4.15
  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:v4.15
    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 4.15.0 \ 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 4.15.0 \
--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**

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" ❶
  sshPublicKey: "ssh-rsa ..."
  clusters:
    - clusterName: "sno-worker-0"
      clusterImageSetNameRef: "eko4-img4.11.5-x86-64-appsub" ❷
      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\n[Mount]\nWhat=/dev/disk/by-
partlabel/data\nWhere=/var/mnt\nType=xf\nTimeoutSec=30\n\n[Install]\nRequiredBy=precache-
images.service"}, {"name":"precache-images.service","enabled":true,"contents":"
[Unit]\nDescription=Extracts the precached images in discovery stage\nAfter=var-
mnt.mount\nBefore=agent.service\n\n[Service]\nType=oneshot\nUser=root\nWorkingDirectory=/var/mnt\
nExecStart=bash /usr/local/bin/extract-ai.sh\n#TimeoutStopSec=30\n\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-
%24%28pwd%29%7D%22%0AOCPLIST%3D%22%24%7BOCP_RELEASE_LIST%3A-
ai-
images.txt%7D%22%0ABINARY_FOLDER%3D%2Fvar%2Fmnt%0A%0Apushd%20%24FOLDER%0
A%0Atotal_copies%3D%24%28sort%20-
u%20%24BINARY_FOLDER%2F%24OCP_RELEASE_LIST%20%7C%20wc%20-
l%29%20%20%23%20Required%20to%20keep%20track%20of%20the%20pull%20task%20vs%20tot
al%0Acurrent_copy%3D1%0A%0Awhile%20read%20-
r%20line%3B%0A%0A%20uri%3D%24%28echo%20%22%24line%22%20%7C%20awk%20%
27%7Bprint%241%7D%27%29%0A%20%20%23tar%3D%24%28echo%20%22%24line%22%20%7
C%20awk%20%27%7Bprint%242%7D%27%29%0A%20%20podman%20image%20exists%20%24ur
i%0A%20%20if%20%5B%5B%20%24%3F%20-
eq%200%20%5D%5D%3B%20then%0A%20%20%20%20%20%20echo%20%22Skipping%20existin

```

```

g%20image%20%24tar%22%0A%20%20%20%20%20%20echo%20%22Copying%20%24%7Buri%7
D%20%5B%24%7Bcurrent_copy%7D%2F%24%7Btotal_copies%7D%5D%22%0A%20%20%20%20
%20%20current_copy%3D%24%28%28current_copy%20%2B%201%29%29%0A%20%20%20%20
%20%20continue%0A%20%20fi%0A%20%20tar%3D%24%28echo%20%22%24uri%22%20%7C%2
0%20rev%20%7C%20cut%20-d%20%22%2F%22%20-
f1%20%7C%20rev%20%7C%20tr%20%22%3A%22%20%22_%22%29%0A%20%20tar%20zxf%20
%24%7Btar%7D.tgz%0A%20%20if%20%5B%20%24%3F%20-
eq%200%20%5D%3B%20then%20rm%20-
f%20%24%7Btar%7D.gz%3B%20fi%0A%20%20echo%20%22Copying%20%24%7Buri%7D%20%5B
%24%7Bcurrent_copy%7D%2F%24%7Btotal_copies%7D%5D%22%0A%20%20skopeo%20copy%20
dir%3A%2F%2F%24%28pwd%29%2F%24%7Btar%7D%20containers-
storage%3A%24%7Buri%7D%0A%20%20if%20%5B%20%24%3F%20-
eq%200%20%5D%3B%20then%20rm%20-
rf%20%24%7Btar%7D%3B%20current_copy%3D%24%28%28current_copy%20%2B%201%29%29
%3B%20fi%0A%20done%20%3C%20%24%7BBINARY_FOLDER%7D%2F%24%7BOCP_RELEASE_LI
ST%7D%0A%0A%23%20workaround%20while%20https%3A%2F%2Fgithub.com%2Fopenshift%2F
assisted-service%2Fpull%2F3546%0A%23cp%20%2Fvar%2Fmnt%2Fmodified-rhcos-4.10.3-x86_64-
metal.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%20work
around%20for%20bugzilla%201964591%20where%20symlinks%20inside%20%2Fvar%2Flib%2Fcont
ainers%2F%20get%0A%23%20corrupted%20under%20some%20circumstances.%0A%23%0A%23%
20In%20order%20to%20let%20agent.service%20start%20correctly%20we%20are%20checking%20h
ere%20whether%20the%20requested%0A%23%20container%20image%20exists%20and%20in%20c
ase%20%22podman%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%20correc
tly%2C%20no%20any%20action%20is%20required.%0A%0AIMAGE%3D%24%28echo%20%241%2
0%7C%20sed%20%27s%2F%3A.%2A%2F%2F%27%29%0Apodman%20image%20exists%20%24I
MAGE%20%7C%7C%20echo%20%22already%20loaded%22%20%7C%7C%20echo%20%22need
%20to%20be%20pulled%22%0A%23podman%20images%20%7C%20grep%20%24IMAGE%20%7C
%7C%20podman%20rmi%20--force%20%241%20%7C%7C%20true%20}}}}'
nodes:
- hostName: "snode.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/nvme0n1
  cpuset: "0-1,40-41"
  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\n[Mount]\nWhat=/dev/disk/by-
partlabel/data\nWhere=/var/mnt\nType=xf\n\n[Install]\nRequiredBy=precache-ocp-
images.service"}, {"name":"precache-ocp-images.service","enabled":true,"contents":
"[Unit]\nDescription=Extracts the precached OCP images into containers storage\nAfter=var-
mnt.mount\nBefore=machine-config-daemon-pull.service\n\n[Service]\nType=oneshot\nUser=root\nWorkingDirectory=/var/mnt\nExecStart=k
ash /usr/local/bin/extract-ocp.sh\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-
%24%28pwd%29%7D%22%0AOCF_RELEASE_LIST%3D%22%24%7BOCF_RELEASE_LIST%3A-
ocf-
images.txt%7D%22%0ABINARY_FOLDER%3D%2Fvar%2Fmnt%0A%0Apushd%20%24FOLDER%0
A%0Atotal_copies%3D%24%28sort%20-
u%20%24BINARY_FOLDER%2F%24OCF_RELEASE_LIST%20%7C%20wc%20-
l%29%20%20%23%20Required%20to%20keep%20track%20of%20the%20pull%20task%20vs%20tot
al%0Acurrent_copy%3D1%0A%0Awhile%20read%20-
r%20line%3B%0Ado%0A%20%20uri%3D%24%28echo%20%22%24line%22%20%7C%20awk%20%
27%7Bprint%241%7D%27%29%0A%20%20%23tar%3D%24%28echo%20%22%24line%22%20%7
C%20awk%20%27%7Bprint%242%7D%27%29%0A%20%20podman%20image%20exists%20%24ur
i%0A%20%20if%20%20%5B%5B%20%24%3F%20-
eq%200%20%5D%5D%3B%20then%0A%20%20%20%20%20%20echo%20%22Skipping%20existin
g%20image%20%24tar%22%0A%20%20%20%20%20%20echo%20%22Copying%20%24%7Buri%7
D%20%5B%24%7Bcurrent_copy%7D%2F%24%7Btotal_copies%7D%5D%22%0A%20%20%20%20
%20%20current_copy%3D%24%28%28current_copy%20%2B%201%29%29%0A%20%20%20%20
%20%20continue%0A%20%20fi%0A%20%20tar%3D%24%28echo%20%22%24uri%22%20%7C%2
0%20rev%20%7C%20cut%20-d%20%22%2F%22%20-
f1%20%7C%20rev%20%7C%20tr%20%22%3A%22%20%22_%22%29%0A%20%20tar%20zxvf%20
%24%7Btar%7D.tar.gz%0A%20%20if%20%20%5B%20%24%3F%20-
eq%200%20%5D%5D%3B%20then%20rm%20-
f%20%24%7Btar%7D.tar.gz%3B%20fi%0A%20%20echo%20%22Copying%20%24%7Buri%7D%20%5B
%24%7Bcurrent_copy%7D%2F%24%7Btotal_copies%7D%5D%22%0A%20%20%20%20%20%20skopeo%20copy%20
dir%3A%2F%2F%24%28pwd%29%2F%24%7Btar%7D%20containers-
storage%3A%24%7Buri%7D%0A%20%20%20%20%20%20if%20%20%5B%20%24%3F%20-
eq%200%20%5D%5D%3B%20then%20rm%20-
rf%20%24%7Btar%7D%3B%20current_copy%3D%24%28%28current_copy%20%2B%201%29%29
%3B%20fi%0Adone%20%3C%20%24%7BBINARY_FOLDER%7D%2F%24%7BOCF_RELEASE_LI
ST%7D%0A%0Aexit%200"}]]}]
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

-I, --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 the script finishes successfully, you can use the images locally.

When you upload the **SiteConfig** and the optional **PolicyGenTemplates** custom resources (CRs) to the Git repo, which Argo CD is monitoring, you can start the GitOps ZTP workflow by syncing the CRs with the hub cluster.

14.6. TROUBLESHOOTING

14.6.1. Rendered catalog is invalid

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 4.15.0 --acm-version 2.5.4 \
--mce-version 2.0.4 -f /mnt --img quay.io/custom/repository
--du-profile -s --skip-imageset

```