



# OpenShift Container Platform 4.13

## Virtualization

OpenShift Virtualization installation, usage, and release notes



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## Abstract

This document provides information about how to use OpenShift Virtualization in OpenShift Container Platform.

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# CHAPTER 1. ABOUT OPENSHIFT VIRTUALIZATION

Learn about OpenShift Virtualization's capabilities and support scope.

## 1.1. WHAT YOU CAN DO WITH OPENSHIFT VIRTUALIZATION

OpenShift Virtualization is an add-on to OpenShift Container Platform that allows you to run and manage virtual machine workloads alongside container workloads.

OpenShift Virtualization adds new objects into your OpenShift Container Platform cluster by using Kubernetes custom resources to enable virtualization tasks. These tasks include:

- Creating and managing Linux and Windows virtual machines (VMs)
- Running pod and VM workloads alongside each other in a cluster
- Connecting to virtual machines through a variety of consoles and CLI tools
- Importing and cloning existing virtual machines
- Managing network interface controllers and storage disks attached to virtual machines
- Live migrating virtual machines between nodes

An enhanced web console provides a graphical portal to manage these virtualized resources alongside the OpenShift Container Platform cluster containers and infrastructure.

OpenShift Virtualization is designed and tested to work well with Red Hat OpenShift Data Foundation features.



### IMPORTANT

When you deploy OpenShift Virtualization with OpenShift Data Foundation, you must create a dedicated storage class for Windows virtual machine disks. See [Optimizing ODF PersistentVolumes for Windows VMs](#) for details.

You can use OpenShift Virtualization with the [OVN-Kubernetes](#), [OpenShift SDN](#), or one of the other certified network plugins listed in [Certified OpenShift CNI Plug-ins](#).

You can check your OpenShift Virtualization cluster for compliance issues by installing the [Compliance Operator](#) and running a scan with the **ocp4-moderate** and **ocp4-moderate-node** profiles. The Compliance Operator uses OpenSCAP, a [NIST-certified tool](#), to scan and enforce security policies.

### 1.1.1. OpenShift Virtualization supported cluster version

OpenShift Virtualization 4.13 is supported for use on OpenShift Container Platform 4.13 clusters. To use the latest z-stream release of OpenShift Virtualization, you must first upgrade to the latest version of OpenShift Container Platform.

## 1.2. ABOUT STORAGE VOLUMES FOR VIRTUAL MACHINE DISKS

If you use the storage API with known storage providers, volume and access modes are selected automatically. However, if you use a storage class that does not have a storage profile, you must select the volume and access mode.

For best results, use **accessMode: ReadWriteMany** and **volumeMode: Block**. This is important for the following reasons:

- The ReadWriteMany (RWX) access mode is required for live migration.
- The **Block** volume mode performs significantly better in comparison to the **Filesystem** volume mode. This is because the **Filesystem** volume mode uses more storage layers, including a file system layer and a disk image file. These layers are not necessary for VM disk storage. For example, if you use Red Hat OpenShift Data Foundation, Ceph RBD volumes are preferable to CephFS volumes.



### IMPORTANT

You cannot live migrate virtual machines that use:

- A storage volume with ReadWriteOnce (RWO) access mode
- Passthrough features such as GPUs

Do not set the **evictionStrategy** field to **LiveMigrate** for these virtual machines.

## 1.3. SINGLE-NODE OPENSIFT DIFFERENCES

You can install OpenShift Virtualization on single-node OpenShift.

However, you should be aware that Single-node OpenShift does not support the following features:

- High availability
- Pod disruption
- Live migration
- Virtual machines or templates that have an eviction strategy configured

## 1.4. ADDITIONAL RESOURCES

- [Glossary of common terms for OpenShift Container Platform storage](#)
- [About single-node OpenShift](#)
- [Assisted installer](#)
- [Hostpath Provisioner \(HPP\)](#)
- [OpenShift Container Platform Data Foundation Logical Volume Manager Operator](#)
- [Pod disruption budgets](#)
- [Live migration](#)
- [Eviction strategy](#)
- [Tuning & Scaling Guide](#)

# CHAPTER 2. OPENSHIFT VIRTUALIZATION ARCHITECTURE

Learn about OpenShift Virtualization architecture.

## 2.1. HOW OPENSHIFT VIRTUALIZATION ARCHITECTURE WORKS

After you install OpenShift Virtualization, the Operator Lifecycle Manager (OLM) deploys operator pods for each component of OpenShift Virtualization:

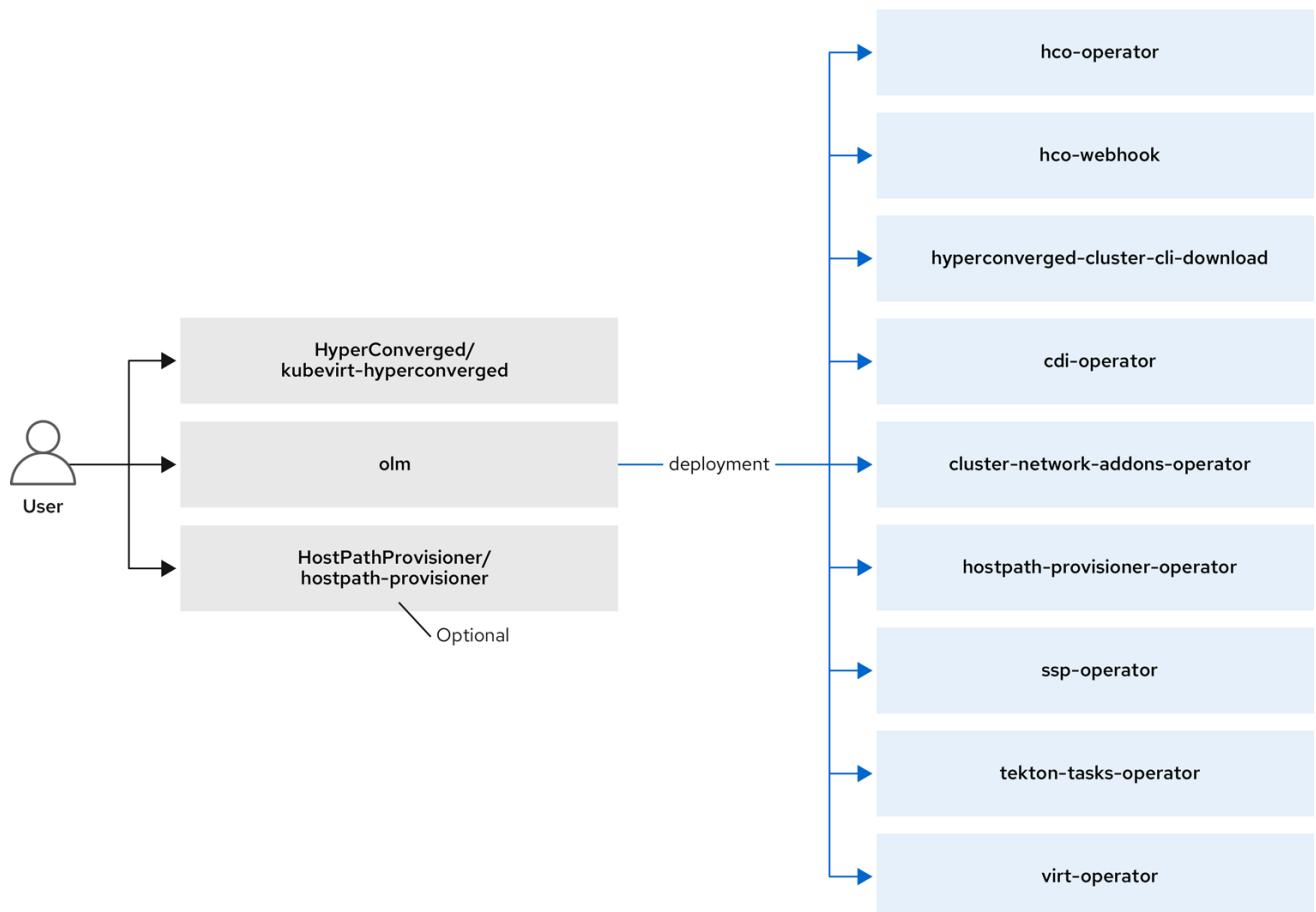
- Compute: **virt-operator**
- Storage: **cdi-operator**
- Network: **cluster-network-addons-operator**
- Scaling: **ssp-operator**
- Templating: **tekton-tasks-operator**

OLM also deploys the **hyperconverged-cluster-operator** pod, which is responsible for the deployment, configuration, and life cycle of other components, and several helper pods: **hco-webhook**, and **hyperconverged-cluster-cli-download**.

After all operator pods are successfully deployed, you should create the **HyperConverged** custom resource (CR). The configurations set in the **HyperConverged** CR serve as the single source of truth and the entrypoint for OpenShift Virtualization, and guide the behavior of the CRs.

The **HyperConverged** CR creates corresponding CRs for the operators of all other components within its reconciliation loop. Each operator then creates resources such as daemon sets, config maps, and additional components for the OpenShift Virtualization control plane. For example, when the **hco-operator** creates the **KubeVirt** CR, the **virt-operator** reconciles it and create additional resources such as **virt-controller**, **virt-handler**, and **virt-api**.

The OLM deploys the **hostpath-provisioner-operator**, but it is not functional until you create a **hostpath provisioner** (HPP) CR.



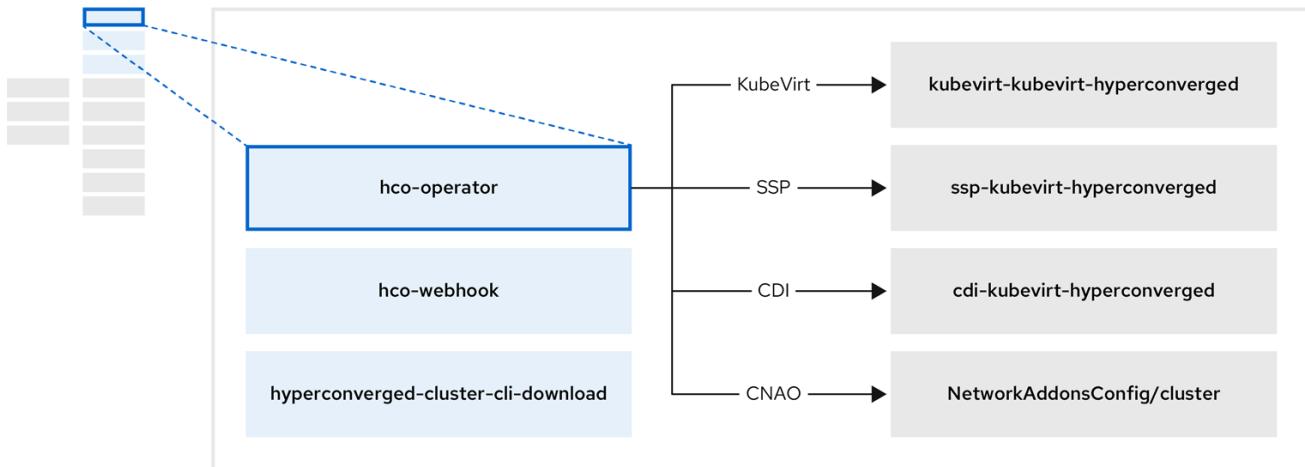
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### Additional resources

- [HyperConverged CR configuration](#)
- [Virtctl client commands](#)

## 2.2. ABOUT THE HCO-OPERATOR

The **hco-operator** (HCO) provides a single entry point for deploying and managing OpenShift Virtualization and several helper operators with opinionated defaults. It also creates custom resources (CRs) for those operators.



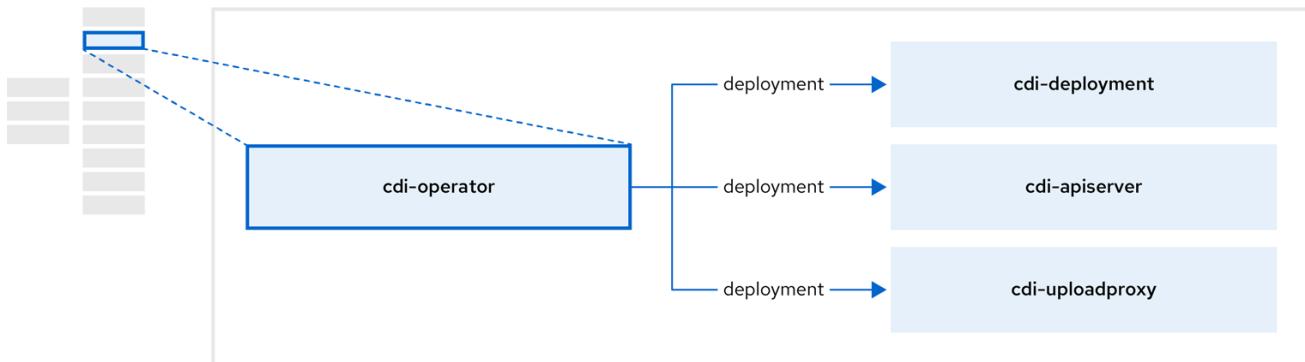
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**Table 2.1. hco-operator components**

Component	Description
<b>deployment/hco-webhook</b>	Validates the <b>HyperConverged</b> custom resource contents.
<b>deployment/hyperconverged-cluster-cli-download</b>	Provides the <b>virtctl</b> tool binaries to the cluster so that you can download them directly from the cluster.
<b>KubeVirt/kubevirt-kubevirt-hyperconverged</b>	Contains all operators, CRs, and objects needed by OpenShift Virtualization.
<b>SSP/ssp-kubevirt-hyperconverged</b>	An SSP CR. This is automatically created by the HCO.
<b>CDI/cdi-kubevirt-hyperconverged</b>	A CDI CR. This is automatically created by the HCO.
<b>NetworkAddonsConfig/cluster</b>	A CR that instructs and is managed by the <b>cluster-network-addons-operator</b> .

## 2.3. ABOUT THE CDI-OPERATOR

The **cdi-operator** manages the Containerized Data Importer (CDI), and its related resources, which imports a virtual machine (VM) image into a persistent volume claim (PVC) by using a data volume.



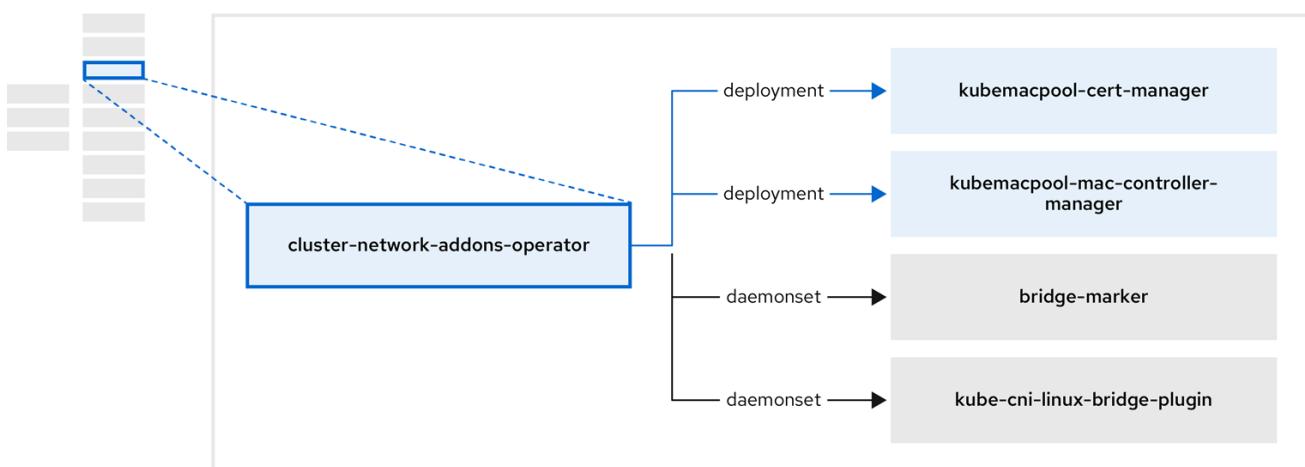
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**Table 2.2. cdi-operator components**

Component	Description
<b>deployment/cdi-apiserver</b>	Manages the authorization to upload VM disks into PVCs by issuing secure upload tokens.
<b>deployment/cdi-uploadproxy</b>	Directs external disk upload traffic to the appropriate upload server pod so that it can be written to the correct PVC. Requires a valid upload token.
<b>pod/cdi-importer</b>	Helper pod that imports a virtual machine image into a PVC when creating a data volume.

## 2.4. ABOUT THE CLUSTER-NETWORK-ADDONS-OPERATOR

The **cluster-network-addons-operator** deploys networking components on a cluster and manages the related resources for extended network functionality.



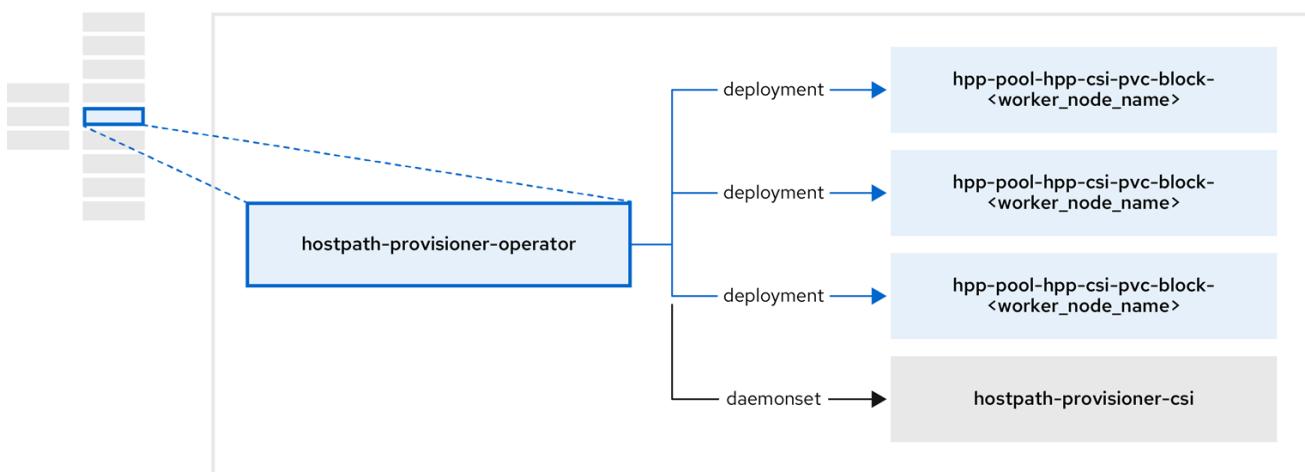
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**Table 2.3. cluster-network-addons-operator components**

Component	Description
<b>deployment/kubemacpool-cert-manager</b>	Manages TLS certificates of Kubemacpool's webhooks.
<b>deployment/kubemacpool-mac-controller-manager</b>	Provides a MAC address pooling service for virtual machine (VM) network interface cards (NICs).
<b>daemonset/bridge-marker</b>	Marks network bridges available on nodes as node resources.
<b>daemonset/kube-cni-linux-bridge-plugin</b>	Installs CNI plugins on cluster nodes, enabling the attachment of VMs to Linux bridges through network attachment definitions.

## 2.5. ABOUT THE HOSTPATH-PROVISIONER-OPERATOR

The **hostpath-provisioner-operator** deploys and manages the multi-node hostpath provisioner (HPP) and related resources.



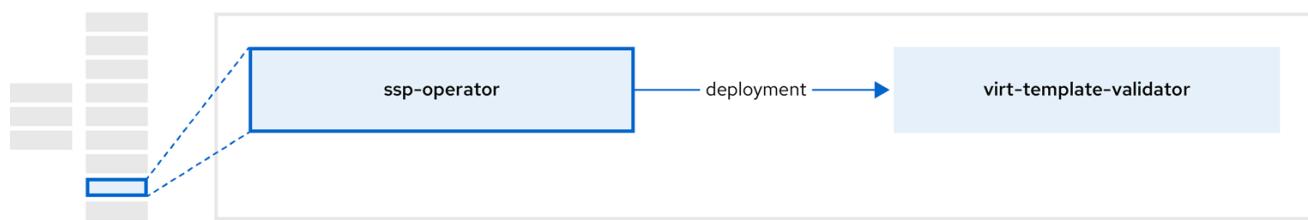
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Table 2.4. hostpath-provisioner-operator components

Component	Description
<b>deployment/hpp-pool-hpp-csi-pvc-block- &lt;worker_node_name&gt;</b>	Provides a worker for each node where the hostpath provisioner (HPP) is designated to run. The pods mount the specified backing storage on the node.
<b>daemonset/hostpath-provisioner-csi</b>	Implements the Container Storage Interface (CSI) driver interface of the HPP.
<b>daemonset/hostpath-provisioner</b>	Implements the legacy driver interface of the HPP.

## 2.6. ABOUT THE SSP-OPERATOR

The **ssp-operator** deploys the common templates, the related default boot sources, and the template validator.



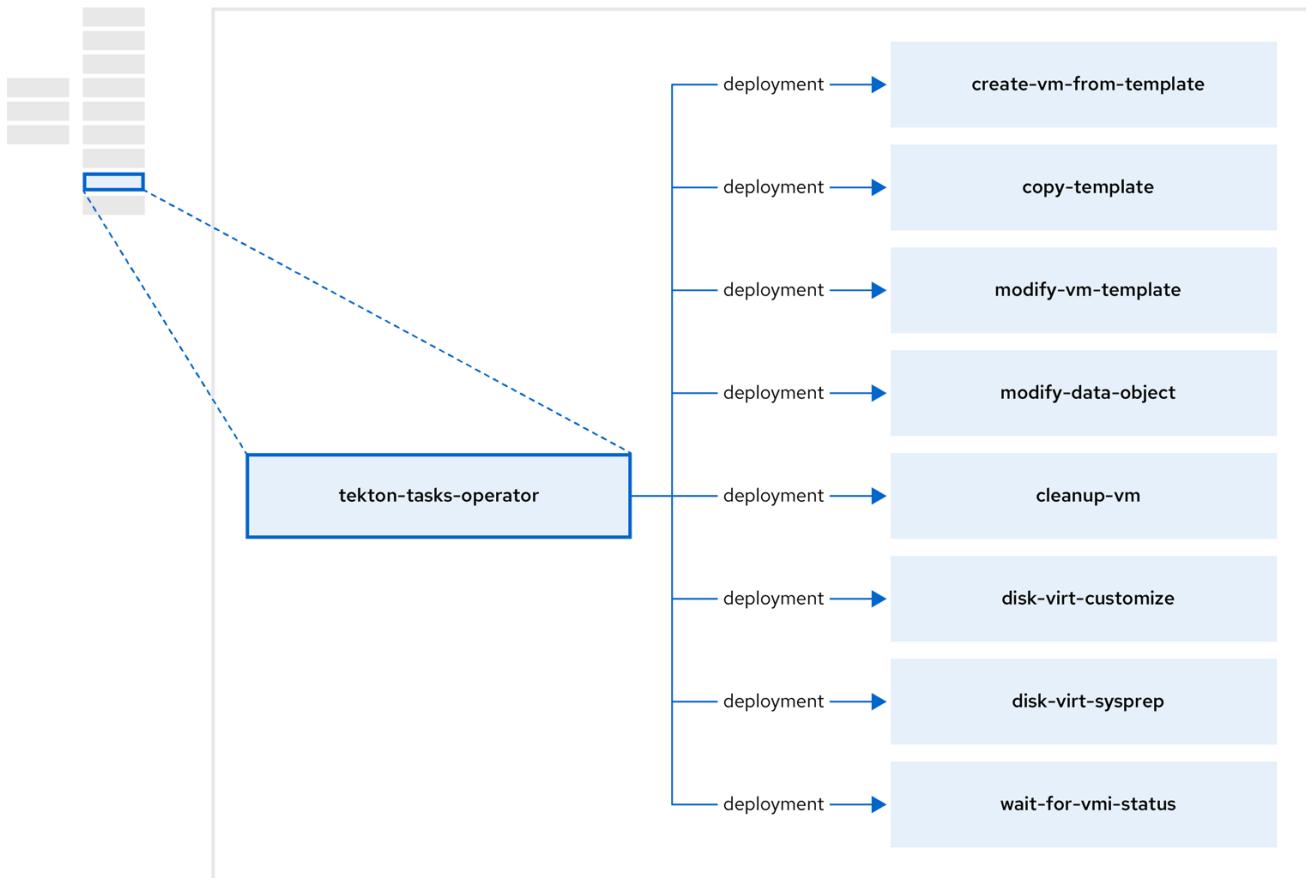
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**Table 2.5. ssp-operator components**

Component	Description
<b>deployment/virt-template-validator</b>	Checks <b>vm.kubevirt.io/validations</b> annotations on virtual machines created from templates, and rejects them if they are invalid.

## 2.7. ABOUT THE TEKTON-TASKS-OPERATOR

The **tekton-tasks-operator** deploys example pipelines showing the usage of OpenShift Pipelines for VMs. It also deploys additional OpenShift Pipeline tasks that allow users to create VMs from templates, copy and modify templates, and create data volumes.



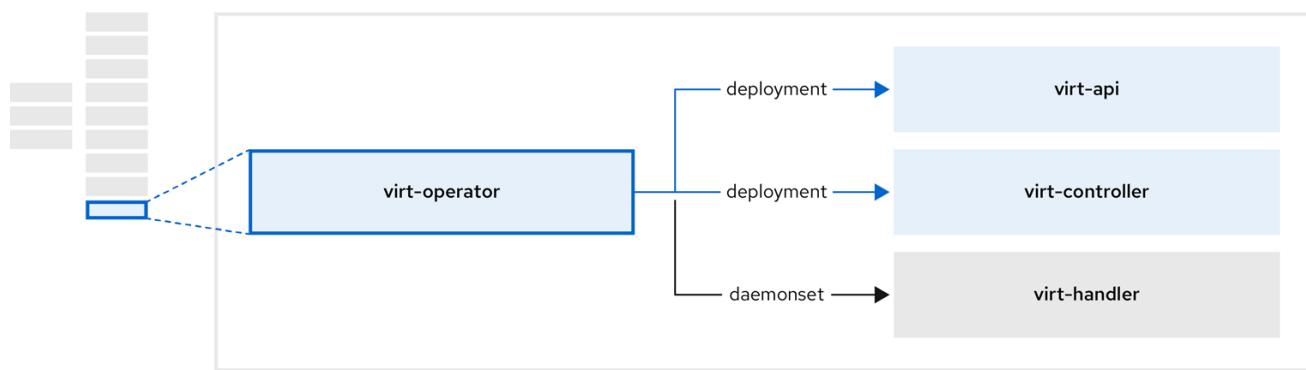
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Table 2.6. tekton-tasks-operator components

Component	Description
<b>deployment/create-vm-from-template</b>	Creates a VM from a template.
<b>deployment/copy-template</b>	Copies a VM template.
<b>deployment/modify-vm-template</b>	Creates or removes a VM template.
<b>deployment/modify-data-object</b>	Creates or removes data volumes or data sources.
<b>deployment/cleanup-vm</b>	Runs a script or a command on a VM, then stops or deletes the VM afterward.
<b>deployment/disk-virt-customize</b>	Runs a <b>customize</b> script on a target PVC using <b>virt-customize</b> .
<b>deployment/disk-virt-sysprep</b>	Runs a <b>sysprep</b> script on a target PVC by using <b>virt-sysprep</b> .
<b>deployment/wait-for-vmi-status</b>	Waits for a specific VMI status, then fails or succeeds according to that status.

## 2.8. ABOUT THE VIRT-OPERATOR

The **virt-operator** deploys, upgrades, and manages OpenShift Virtualization without disrupting current virtual machine (VM) workloads.



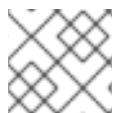
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Table 2.7. virt-operator components

Component	Description
<b>deployment/virt-api</b>	HTTP API server that serves as the entry point for all virtualization-related flows.
<b>deployment/virt-controller</b>	Observes the creation of a new VM instance object and creates a corresponding pod. When the pod is scheduled on a node, <b>virt-controller</b> updates the VM with the node name.
<b>daemonset/virt-handler</b>	Monitors any changes to a VM and instructs <b>virt-launcher</b> to perform the required operations. This component is node-specific.
<b>pod/virt-launcher</b>	Contains the VM that was created by the user as implemented by <b>libvirt</b> and <b>qemu</b> .

# CHAPTER 3. GETTING STARTED WITH OPENSHIFT VIRTUALIZATION

You can explore the features and functionalities of OpenShift Virtualization by installing and configuring a basic environment.



## NOTE

Cluster configuration procedures require **cluster-admin** privileges.

## 3.1. PLANNING AND INSTALLING OPENSIFT VIRTUALIZATION

Plan and install OpenShift Virtualization on an OpenShift Container Platform cluster:

- Plan your bare metal cluster for OpenShift Virtualization .
- Prepare your cluster for OpenShift Virtualization .
- Install the OpenShift Virtualization Operator .
- Install the **virtctl** command line interface (CLI) tool .

### Planning and installation resources

- About storage volumes for virtual machine disks .
- Using a CSI-enabled storage provider .
- Configuring local storage for virtual machines .
- Installing the Kubernetes NMState Operator .
- Specifying nodes for virtual machines .
- **Virtctl** commands .

## 3.2. CREATING AND MANAGING VIRTUAL MACHINES

Create virtual machines (VMs) by using the web console:

- Quick create a VM .
- Customize a template to create a VM .

Connect to VMs:

- Connect to the [serial console](#) or [VNC console](#) of a VM by using the web console.
- [Connect to a VM by using SSH](#) .
- [Connect to a Windows VM by using RDP](#) .

Manage VMs:

- [Stop, start, pause, and restart a VM by using the web console](#) .

- Manage a VM, expose a port, or connect to the serial console by using the `virtctl` CLI tool.
- Export VMs.

### 3.3. NEXT STEPS

- Connect the VMs to secondary networks:
  - [Connect a VM to a Linux bridge network](#) .
  - [Connect a VM to an SR-IOV network](#) .



#### NOTE

VMs are connected to the pod network by default. You must configure a secondary network, such as Linux bridge or SR-IOV, and then add the network to the VM configuration.

- [Live migrate VMs](#).
- [Back up and restore VMs](#).
- [Tune and scale your cluster](#)

## CHAPTER 4. WEB CONSOLE OVERVIEW

The **Virtualization** section of the OpenShift Container Platform web console contains the following pages for managing and monitoring your OpenShift Virtualization environment.

**Table 4.1. Virtualization pages**

Page	Description
<a href="#">Overview page</a>	Manage and monitor the OpenShift Virtualization environment.
<a href="#">Catalog page</a>	Create VirtualMachines from a catalog of templates.
<a href="#">VirtualMachines page</a>	Configure and monitor VirtualMachines.
<a href="#">Templates page</a>	Create and manage templates.
<a href="#">DataSources page</a>	Create and manage DataSources for VirtualMachine boot sources.
<a href="#">MigrationPolicies page</a>	Create and manage MigrationPolicies for workloads.

**Table 4.2. Key**

Icon	Description
	Edit icon
	Link icon

### 4.1. OVERVIEW PAGE

The Overview page displays resources, metrics, migration progress, and cluster-level settings.

**Example 4.1. Overview page**

Element	Description
<a href="#">Download virtctl</a>	Download the <b>virtctl</b> command line tool to manage resources.
<a href="#">Overview tab</a>	Resources, usage, alerts, and status
<a href="#">Top consumers tab</a>	Top consumers of CPU, memory, and storage resources
<a href="#">Migrations tab</a>	Status of live migrations

Element	Description
<a href="#">Settings tab</a>	Cluster-wide settings, including live migration limits and user permissions

### 4.1.1. Overview tab

The **Overview** tab displays resources, usage, alerts, and status.

#### Example 4.2. Overview tab

Element	Description
<b>Getting started resources</b> card	<ul style="list-style-type: none"> <li><b>Quick Starts</b> tile: Learn how to create, import, and run VirtualMachines with step-by-step instructions and tasks.</li> <li><b>Feature highlights</b> tile: Read the latest information about key virtualization features.</li> <li><b>Related operators</b> tile: Install Operators such as the Kubernetes NMState Operator or the OpenShift Data Foundation Operator.</li> </ul>
<b>VirtualMachines</b> tile	Number of VirtualMachines, with a chart showing the last 7 days' trend
<b>vCPU usage</b> tile	vCPU usage, with a chart showing the last 7 days' trend
<b>Memory</b> tile	Memory usage, with a chart showing the last 7 days' trend
<b>Storage</b> tile	Storage usage, with a chart showing the last 7 days' trend
<b>Alerts</b> tile	OpenShift Virtualization alerts, grouped by severity
<b>VirtualMachine statuses</b> tile	Number of VirtualMachines, grouped by status
<b>VirtualMachines per template</b> chart	Number of VirtualMachines created from templates, grouped by template name

### 4.1.2. Top consumers tab

The **Top consumers** tab displays the top consumers of CPU, memory, and storage.

#### Example 4.3. Top consumers tab

Element	Description
<b>View virtualization dashboard</b> 	Link to <b>Observe → Dashboards</b> , which displays the top consumers for OpenShift Virtualization
<b>Time period list</b>	Select a time period to filter the results.
<b>Top consumers</b> list	Select the number of top consumers to filter the results.
<b>CPU</b> chart	VirtualMachines with the highest CPU usage
<b>Memory</b> chart	VirtualMachines with the highest memory usage
<b>Memory swap traffic</b> chart	VirtualMachines with the highest memory swap traffic
<b>vCPU wait</b> chart	VirtualMachines with the highest vCPU wait periods
<b>Storage throughput</b> chart	VirtualMachines with the highest storage throughput usage
<b>Storage IOPS</b> chart	VirtualMachines with the highest storage input/output operations per second usage

#### 4.1.3. Migrations tab

The **Migrations** tab displays the status of VirtualMachineInstance migrations.

##### Example 4.4. Migrations tab

Element	Description
<b>Time period</b> list	Select a time period to filter VirtualMachineInstanceMigrations.
<b>VirtualMachineInstance</b> <b>eMigrations</b> table	List of VirtualMachineInstance migrations

#### 4.1.4. Settings tab

The **Settings** tab displays cluster-wide settings on the following tabs:

**Table 4.3. Tabs on Settings tab**

Tab	Description
<a href="#">General tab</a>	OpenShift Virtualization version and update status
<a href="#">Live migration tab</a>	Live migration limits and network settings
<a href="#">Templates project tab</a>	Project for Red Hat templates
<a href="#">User permissions tab</a>	Cluster-wide user permissions

#### 4.1.4.1. General tab

The **General** tab displays the OpenShift Virtualization version and update status.

##### Example 4.5. General tab

Label	Description
Service name	OpenShift Virtualization
Provider	Red Hat
Installed version	4.13.4
Update status	Example: <b>Up to date</b>
Channel	Channel selected for updates

#### 4.1.4.2. Live migration tab

You can configure live migration on the **Live migration** tab.

##### Example 4.6. Live migration tab

Element	Description
<b>Max. migrations per cluster</b> field	Select the maximum number of live migrations per cluster.
<b>Max. migrations per node</b> field	Select the maximum number of live migrations per node.
<b>Live migration network</b> list	Select a dedicated secondary network for live migration.

#### 4.1.4.3. Templates project tab

You can select a project for templates on the **Templates project** tab.

##### Example 4.7. Templates project tab

Element	Description
<b>Project list</b>	Select a project in which to store Red Hat templates. The default template project is <b>openshift</b> .  If you want to define multiple template projects, you must clone the templates on the <a href="#">Templates page</a> for each project.

#### 4.1.4.4. User permissions tab

The **User permissions** tab displays cluster-wide user permissions for tasks.

##### Example 4.8. User permissions tab

Element	Description
<b>User permissions</b> table	List of tasks, such as <b>Share templates</b> , and permissions

## 4.2. CATALOG PAGE

You can create a VirtualMachine by selecting a template or boot source on the Catalog page.

##### Example 4.9. Catalog page

Element	Description
<a href="#">Template catalog</a> tab	Select a template to create a VirtualMachine from.

#### 4.2.1. Template catalog tab

Element	Description
<b>Template project</b> list	Select the project in which your templates are located.  By default, Red Hat templates are stored in the <b>openshift</b> project. You can edit the template project on the <a href="#">Overview</a> → <a href="#">Settings</a> → <a href="#">Template project</a> tab.

Element	Description
All items Default templates	Click <b>Default templates</b> to display only default templates.
<b>Boot source available</b> checkbox	Select the checkbox to display templates with an available boot source.
<b>Operating system</b> checkboxes	Select checkboxes to display templates with selected operating systems.
<b>Workload</b> checkboxes	Select checkboxes to display templates with selected workloads.
Search field	Search templates by keyword.
Template tiles	Click a template tile to view template details and to create a VirtualMachine.

## 4.3. VIRTUALMACHINES PAGE

You can create and manage VirtualMachines on the VirtualMachines page.

### Example 4.10. VirtualMachines page

Element	Description
Create → From template	Create a VirtualMachine on the <b>Catalog</b> page → <b>Template catalog</b> tab.
Create → From YAML	Create a VirtualMachine by editing a YAML configuration file.
Filter field	Filter VirtualMachines by status, template, operating system, or node.
Search field	Search for VirtualMachines by name or by label.
VirtualMachines table	<p>List of VirtualMachines</p> <p>Click the <b>Options</b> menu  beside a VirtualMachine to select <b>Stop</b>, <b>Restart</b>, <b>Pause</b>, <b>Clone</b>, <b>Migrate</b>, <b>Copy SSH command</b>, <b>Edit labels</b>, <b>Edit annotations</b>, or <b>Delete</b>.</p> <p>Click a VirtualMachine to navigate to the VirtualMachine details page.</p>

### 4.3.1. VirtualMachine details page

You can configure a VirtualMachine on the VirtualMachine details page.

#### Example 4.11. VirtualMachine details page

Element	Description
<b>Actions</b> menu	Click the <b>Actions</b> menu to select <b>Stop</b> , <b>Restart</b> , <b>Pause</b> , <b>Clone</b> , <b>Migrate</b> , <b>Copy SSH command</b> , <b>Edit labels</b> , <b>Edit annotations</b> , or <b>Delete</b> .
<a href="#">Overview tab</a>	Resource usage, alerts, disks, and devices
<a href="#">Details tab</a>	VirtualMachine details and configurations
<a href="#">Metrics tab</a>	Memory, CPU, storage, network, and migration metrics
<a href="#">YAML tab</a>	VirtualMachine YAML configuration file
<a href="#">Configuration tab</a>	Contains the <b>Scheduling</b> , <b>Environment</b> , <b>Network interfaces</b> , <b>Disks</b> , and <b>Scripts</b> tabs
<a href="#">Configuration → Scheduling tab</a>	Scheduling a VirtualMachine to run on specific nodes
<a href="#">Configuration → Environment tab</a>	Config map, secret, and service account management
<a href="#">Configuration → Network interfaces tab</a>	Network interfaces
<a href="#">Configuration → Disks tab</a>	Disks
<a href="#">Configuration → Scripts tab</a>	Cloud-init settings, SSH key for Linux VirtualMachines, Sysprep answer file for Windows VirtualMachines
<a href="#">Events tab</a>	VirtualMachine event stream
<a href="#">Console tab</a>	Console session management
<a href="#">Snapshots tab</a>	Snapshot management
<a href="#">Diagnostics tab</a>	Status conditions and volume snapshot status

##### 4.3.1.1. Overview tab

The **Overview** tab displays resource usage, alerts, and configuration information.

### Example 4.12. Overview tab

Element	Description
Details tile	General VirtualMachine information
Utilization tile	CPU, Memory, Storage, and Network transfer charts. By default, Network transfer displays the sum of all networks. To view the breakdown for a specific network, click Breakdown by network.
Hardware devices tile	GPU and host devices
Alerts tile	OpenShift Virtualization alerts, grouped by severity
Snapshots tile	Take snapshot  and Snapshots table
Network interfaces tile	Network interfaces table
Disk tiles	Disk table

#### 4.3.1.2. Details tab

You can view information about the VirtualMachine and edit labels, annotations, and other metadata and on the Details tab.

### Example 4.13. Details tab

Element	Description
YAML switch	Set to ON to view your live changes in the YAML configuration file.
Name	VirtualMachine name
Namespace	VirtualMachine namespace
Labels	Click the edit icon to edit the labels.
Annotations	Click the edit icon to edit the annotations.
Description	Click the edit icon to enter a description.
Operating system	Operating system name

Element	Description
CPU Memory	<p>Click the edit icon to edit the CPU Memory request.</p> <p>The number of CPUs is calculated by using the following formula: <b>sockets * threads * cores</b>.</p>
Machine type	VirtualMachine machine type
Boot mode	Click the edit icon to edit the boot mode.
Start in pause mode	Click the edit icon to enable this setting.
Template	Name of the template used to create the VirtualMachine
Created at	VirtualMachine creation date
Owner	VirtualMachine owner
Status	VirtualMachine status
Pod	<b>virt-launcher</b> pod name
VirtualMachineInstance	VirtualMachineInstance name
Boot order	Click the edit icon to select a boot source.
IP address	IP address of the VirtualMachine
Hostname	Hostname of the VirtualMachine
Time zone	Time zone of the VirtualMachine
Node	Node on which the VirtualMachine is running
Workload profile	Click the edit icon to edit the workload profile.
SSH using virtctl	Click the copy icon to copy the <b>virtctl ssh</b> command to the clipboard.
SSH service type options	Select <b>SSH over LoadBalancer</b> or <b>SSH over NodePort</b>
GPU devices	Click the edit icon to add a GPU device.
Host devices	Click the edit icon to add a host device.
Headless mode	Click the edit icon to enable headless mode.

Element	Description
Services section	Displays services if QEMU guest agent is installed.
Active users section	Displays active users if QEMU guest agent is installed.

#### 4.3.1.3. Metrics tab

The **Metrics** tab displays memory, CPU, storage, network, and migration usage charts.

##### Example 4.14. Metrics tab

Element	Description
Time range list	Select a time range to filter the results.
Virtualization dashboard 	Link to the <b>Workloads</b> tab of the current project
Utilization section	<b>Memory</b> and <b>CPU</b> charts
Storage section	<b>Storage total read/write</b> and <b>Storage IOPS total read/write</b> charts
Network section	<b>Network in</b> , <b>Network out</b> , <b>Network bandwidth</b> , and <b>Network interface</b> charts. Select <b>All networks</b> or a specific network from the <b>Network interface</b> dropdown.
Migration section	<b>Migration</b> and <b>KV data transfer rate</b> charts

#### 4.3.1.4. YAML tab

You can configure the VirtualMachine by editing the YAML file on the **YAML** tab.

##### Example 4.15. YAML tab

Element	Description
<b>Save</b> button	Save changes to the YAML file.
<b>Reload</b> button	Discard your changes and reload the YAML file.
<b>Cancel</b> button	Exit the <b>YAML</b> tab.

Element	Description
Download button	Download the YAML file to your local machine.

#### 4.3.1.5. Configuration tab

You can configure scheduling, network interfaces, disks, and other options on the **Configuration** tab.

##### Example 4.16. Tabs on the Configuration tab

Tab	Description
<a href="#">Scheduling tab</a>	Scheduling a VirtualMachine to run on specific nodes
<a href="#">Environment tab</a>	Config maps, secrets, and service accounts
<a href="#">Network interfaces tab</a>	Network interfaces
<a href="#">Disks tab</a>	Disks
<a href="#">Scripts tab</a>	Cloud-init settings, SSH key for Linux VirtualMachines, Sysprep answer file for Windows VirtualMachines

##### 4.3.1.5.1. Scheduling tab

You can configure VirtualMachines to run on specific nodes on the **Scheduling** tab.

##### Example 4.17. Scheduling tab

Setting	Description
<b>YAML</b> switch	Set to <b>ON</b> to view your live changes in the YAML configuration file.
Node selector	Click the edit icon to add a label to specify qualifying nodes.
Tolerations	Click the edit icon to add a toleration to specify qualifying nodes.
Affinity rules	Click the edit icon to add an affinity rule.
<b>Descheduler</b> switch	Enable or disable the descheduler. The descheduler evicts a running pod so that the pod can be rescheduled onto a more suitable node.

Setting	Description
Dedicated resources	Click the edit icon to select <b>Schedule this workload with dedicated resources (guaranteed policy)</b> .
Eviction strategy	Click the edit icon to select <b>LiveMigrate</b> as the VirtualMachineInstance eviction strategy.

#### 4.3.15.2. Environment tab

You can manage config maps, secrets, and service accounts on the **Environment** tab.

**Example 4.18. Environment tab**

Element	Description
<b>YAML</b> switch	Set to <b>ON</b> to view your live changes in the YAML configuration file.
<b>Add Config Map, Secret or Service Account</b> 	Click the link and select a config map, secret, or service account from the resource list.

#### 4.3.15.3. Network interfaces tab

You can manage network interfaces on the **Network interfaces** tab.

**Example 4.19. Network interfaces tab**

Setting	Description
<b>YAML</b> switch	Set to <b>ON</b> to view your live changes in the YAML configuration file.
<b>Add network interface</b> button	Add a network interface to the VirtualMachine.
<b>Filter</b> field	Filter by interface type.
<b>Search</b> field	Search for a network interface by name or by label.
<b>Network interface</b> table	List of network interfaces  Click the <b>Options</b> menu  beside a network interface to select <b>Edit</b> or <b>Delete</b> .

#### 4.3.1.5.4. Disks tab

You can manage disks on the **Disks** tab.

##### Example 4.20. Disks tab

Setting	Description
<b>YAML</b> switch	Set to <b>ON</b> to view your live changes in the YAML configuration file.
<b>Add disk</b> button	Add a disk to the VirtualMachine.
<b>Filter</b> field	Filter by disk type.
<b>Search</b> field	Search for a disk by name.
<b>Mount Windows drivers disk</b> checkbox	Select to mount an ephemeral container disk as a CD-ROM.
<b>Disks</b> table	List of VirtualMachine disks <div style="text-align: center; margin-top: 10px;">  Click the <b>Options</b> menu beside a disk to select <b>Edit</b>, <b>Detach</b>, or <b>Make persistent</b>.           </div>
<b>File systems</b> table	List of VirtualMachine file systems if QEMU guest agent is installed

#### 4.3.1.5.5. Scripts tab

You can configure cloud-init, add an SSH key for a Linux VirtualMachine, and upload a Sysprep answer file for a Windows VirtualMachine on the **Scripts** tab.

##### Example 4.21. Scripts tab

Element	Description
<b>YAML</b> switch	Set to <b>ON</b> to view your live changes in the YAML configuration file.
Cloud-init	Click the edit icon to edit the cloud-init settings.
Authorized SSH Key	Click the edit icon to create a new secret or to attach an existing secret.
Sysprep	Click the edit icon to upload an <b>Autounattend.xml</b> or <b>Unattend.xml</b> answer file to automate Windows VirtualMachine setup.

#### 4.3.1.6. Events tab

The **Events** tab displays a list of VirtualMachine events.

#### 4.3.1.7. Console tab

You can open a console session to the VirtualMachine on the **Console** tab.

##### Example 4.22. Console tab

Element	Description
Guest login credentials section	Expand <b>Guest login credentials</b> to view the credentials created with <b>cloud-init</b> . Click the copy icon to copy the credentials to the clipboard.
<b>Console</b> list	Select <b>VNC console</b> or <b>Serial console</b> .  You can select <b>Desktop viewer</b> to connect to Windows VirtualMachines by using Remote Desktop Protocol (RDP). You must install an RDP client on a machine on the same network.
<b>Send key</b> list	Select a key-stroke combination to send to the console.
<b>Disconnect</b> button	Disconnect the console connection.  You must manually disconnect the console connection if you open a new console session. Otherwise, the first console session continues to run in the background.
<b>Paste</b> button	You can paste a string from your client's clipboard into the guest when using the VNC console.

#### 4.3.1.8. Snapshots tab

You can create snapshots and restore VirtualMachines from snapshots on the **Snapshots** tab.

##### Example 4.23. Snapshots tab

Element	Description
<b>Take snapshot</b> button	Create a snapshot.
<b>Filter</b> field	Filter snapshots by status.
<b>Search</b> field	Search for snapshots by name or by label.

Element	Description
<b>Snapshot table</b>	<p>List of snapshots</p> <p>Click the snapshot name to edit the labels or annotations.</p> <p>Click the <b>Options</b> menu  beside a snapshot to select <b>Restore</b> or <b>Delete</b>.</p>

#### 4.3.1.9. Diagnostics tab

You can view the status conditions and volume snapshot status on the **Diagnostics** tab.

##### Example 4.24. Diagnostics tab

Element	Description
<b>Status conditions table</b>	Display a list of conditions that are reported for all aspects of a VM.
<b>Filter field</b>	Filter status conditions by category and condition.
<b>Search field</b>	Search status conditions by reason.
<b>Manage columns</b> icon	Select columns to display.
<b>Volume snapshot</b> table	List of volumes, their snapshot enablement status, and reason

## 4.4. TEMPLATES PAGE

You can create, edit, and clone VirtualMachine templates on the Templates page.



### NOTE

You cannot edit a Red Hat template. You can clone a Red Hat template and edit it to create a custom template.

##### Example 4.25. Templates page

Element	Description
<b>Create Template button</b>	Create a template by editing a YAML configuration file.

Element	Description
Filter field	Filter templates by type, boot source, template provider, or operating system.
Search field	Search for templates by name or by label.
Templates table	List of templates   Click the <b>Options</b> menu beside a template to select <b>Edit</b> , <b>Clone</b> , <b>Edit boot source</b> , <b>Edit boot source reference</b> , <b>Edit labels</b> , <b>Edit annotations</b> , or <b>Delete</b> .

#### 4.4.1. Template details page

You can view template settings and edit custom templates on the Template details page.

##### Example 4.26. Template details page

Element	Description
<b>Actions</b> menu	Click the <b>Actions</b> menu to select <b>Edit</b> , <b>Clone</b> , <b>Edit boot source</b> , <b>Edit boot source reference</b> , <b>Edit labels</b> , <b>Edit annotations</b> , or <b>Delete</b> .
<b>Details</b> tab	Template settings and configurations
<b>YAML</b> tab	YAML configuration file
<b>Scheduling</b> tab	Scheduling configurations
<b>Network interfaces</b> tab	Network interface management
<b>Disks</b> tab	Disk management
<b>Scripts</b> tab	Cloud-init, SSH key, and Sysprep management
<b>Parameters</b> tab	Parameters

#### 4.4.1.1. Details tab

You can configure a custom template on the **Details** tab.

##### Example 4.27. Details tab

Element	Description
<b>YAML</b> switch	Set to <b>ON</b> to view your live changes in the YAML configuration file.
Name	Template name
Namespace	Template namespace
Labels	Click the edit icon to edit the labels.
Annotations	Click the edit icon to edit the annotations.
Display name	Click the edit icon to edit the display name.
Description	Click the edit icon to enter a description.
Operating system	Operating system name
CPU Memory	<p>Click the edit icon to edit the CPU Memory request.</p> <p>The number of CPUs is calculated by using the following formula: <b>sockets * threads * cores</b>.</p>
Machine type	Template machine type
Boot mode	Click the edit icon to edit the boot mode.
Base template	Name of the base template used to create this template
Created at	Template creation date
Owner	Template owner
Boot order	Template boot order
Boot source	Boot source availability
Provider	Template provider
Support	Template support level
GPU devices	Click the edit icon to add a GPU device.
Host devices	Click the edit icon to add a host device.

#### 4.4.1.2. YAML tab

You can configure a custom template by editing the YAML file on the **YAML** tab.

#### Example 4.28. YAML tab

Element	Description
<b>Save</b> button	Save changes to the YAML file.
<b>Reload</b> button	Discard your changes and reload the YAML file.
<b>Cancel</b> button	Exit the <b>YAML</b> tab.
<b>Download</b> button	Download the YAML file to your local machine.

#### 4.4.1.3. Scheduling tab

You can configure scheduling on the **Scheduling** tab.

#### Example 4.29. Scheduling tab

Setting	Description
<b>YAML</b> switch	Set to <b>ON</b> to view your live changes in the YAML configuration file.
Node selector	Click the edit icon to add a label to specify qualifying nodes.
Tolerations	Click the edit icon to add a toleration to specify qualifying nodes.
Affinity rules	Click the edit icon to add an affinity rule.
<b>Descheduler</b> switch	Enable or disable the descheduler. The descheduler evicts a running pod so that the pod can be rescheduled onto a more suitable node.
Dedicated resources	Click the edit icon to select <b>Schedule this workload with dedicated resources (guaranteed policy)</b> .
Eviction strategy	Click the edit icon to select <b>LiveMigrate</b> as the VirtualMachineInstance eviction strategy.

#### 4.4.1.4. Network interfaces tab

You can manage network interfaces on the **Network interfaces** tab.

#### Example 4.30. Network interfaces tab

Setting	Description
<b>YAML</b> switch	Set to <b>ON</b> to view your live changes in the YAML configuration file.
<b>Add network interface</b> button	Add a network interface to the template.
<b>Filter</b> field	Filter by interface type.
<b>Search</b> field	Search for a network interface by name or by label.
<b>Network interface</b> table	List of network interfaces <div style="text-align: right; margin-top: 10px;">  Click the <b>Options</b> menu beside a network interface to select <b>Edit</b> or <b>Delete</b>.           </div>

#### 4.4.1.5. Disks tab

You can manage disks on the **Disks** tab.

##### Example 4.31. Disks tab

Setting	Description
<b>YAML</b> switch	Set to <b>ON</b> to view your live changes in the YAML configuration file.
<b>Add disk</b> button	Add a disk to the template.
<b>Filter</b> field	Filter by disk type.
<b>Search</b> field	Search for a disk by name.
<b>Disks</b> table	List of template disks <div style="text-align: right; margin-top: 10px;">  Click the <b>Options</b> menu beside a disk to select <b>Edit</b> or <b>Detach</b>.           </div>

#### 4.4.1.6. Scripts tab

You can manage the cloud-init settings, SSH keys, and Sysprep answer files on the **Scripts** tab.

##### Example 4.32. Scripts tab

Element	Description
YAML switch	Set to <b>ON</b> to view your live changes in the YAML configuration file.
Cloud-init	Click the edit icon to edit the cloud-init settings.
Authorized SSH Key	Click the edit icon to create a new secret or to attach an existing secret.
Sysprep	Click the edit icon to upload an <b>Autounattend.xml</b> or <b>Unattend.xml</b> answer file to automate Windows VirtualMachine setup.

#### 4.4.1.7. Parameters tab

You can edit selected template settings on the **Parameters** tab.

##### Example 4.33. Parameters tab

Element	Description
YAML switch	Set to <b>ON</b> to view your live changes in the YAML configuration file.
VM name	Select <b>Generated (expression)</b> for a generated value, <b>Value</b> to set a default value, or <b>None</b> from the <b>Default value type</b> list.
DataSource name	Select <b>Generated (expression)</b> for a generated value, <b>Value</b> to set a default value, or <b>None</b> from the <b>Default value type</b> list.
DataSource namespace	Select <b>Generated (expression)</b> for a generated value, <b>Value</b> to set a default value, or <b>None</b> from the <b>Default value type</b> list.
Cloud user password	Select <b>Generated (expression)</b> for a generated value, <b>Value</b> to set a default value, or <b>None</b> from the <b>Default value type</b> list.

## 4.5. DATASOURCES PAGE

You can create and configure DataSources for VirtualMachine boot sources on the DataSources page.

When you create a DataSource, a **DataImportCron** resource defines a cron job to poll and import the disk image unless you disable automatic boot source updates.

##### Example 4.34. DataSources page

Element	Description
<b>Create DataSource → With form</b>	Create a DataSource by entering the registry URL, disk size, number of revisions, and cron expression in a form.
<b>Create DataSources → With YAML</b>	Create a DataSource by editing a YAML configuration file.
<b>Filter field</b>	Filter DataSources by attributes such as DataImportCron available.
<b>Search field</b>	Search for a DataSource by name or by label.
<b>DataSources</b> table	List of DataSources   Click the <b>Options</b> menu beside a DataSource to select <b>Edit labels</b> , <b>Edit annotations</b> , or <b>Delete</b> .

Click a DataSource to view the DataSource details page.

#### 4.5.1. DataSource details page

You can configure a DataSource on the DataSource details page.

##### Example 4.35. DataSource details page

Element	Description
<b>Details</b> tab	Configure a DataSource by editing a form.
<b>YAML</b> tab	Configure a DataSource by editing a YAML configuration file.
<b>Actions</b> menu	Select <b>Edit labels</b> , <b>Edit annotations</b> , <b>Delete</b> , or <b>Manage source</b> .
Name	DataSource name
Namespace	DataSource namespace
DataImportCron	DataSource DataImportCron
Labels	Click the edit icon to edit the labels.
Annotations	Click the edit icon to edit the annotations.
Conditions	Displays the status conditions of the DataSource.

Element	Description
Created at	DataSource creation date
Owner	DataSource owner

## 4.6. MIGRATIONPOLICIES PAGE

You can manage MigrationPolicies for your workloads on the MigrationPolicies page.

### Example 4.36. MigrationPolicies page

Element	Description
Create MigrationPolicy → With form	Create a MigrationPolicy by entering configurations and labels in a form.
Create MigrationPolicy → With YAML	Create a MigrationPolicy by editing a YAML configuration file.
Name   Label search field	Search for a MigrationPolicy by name or by label.
MigrationPolicies table	List of MigrationPolicies <div style="text-align: center; margin-top: 10px;">  Click the <b>Options</b> menu beside a MigrationPolicy to select <b>Edit</b> or <b>Delete</b>.           </div>

Click a MigrationPolicy to view the MigrationPolicy details page.

### 4.6.1. MigrationPolicy details page

You can configure a MigrationPolicy on the MigrationPolicy details page.

### Example 4.37. MigrationPolicy details page

Element	Description
Details tab	Configure a MigrationPolicy by editing a form.
YAML tab	Configure a MigrationPolicy by editing a YAML configuration file.

Element	Description
<b>Actions</b> menu	Select <b>Edit</b> or <b>Delete</b> .
Name	MigrationPolicy name
Description	MigrationPolicy description
Configurations	Click the edit icon to update the MigrationPolicy configurations.
Bandwidth per migration	Bandwidth request per migration. For unlimited bandwidth, set the value to <b>0</b> .
Auto converge	Auto converge policy
Post-copy	Post-copy policy
Completion timeout	Completion timeout value in seconds
Project labels	Click <b>Edit</b> to edit the project labels.
VirtualMachine labels	Click <b>Edit</b> to edit the VirtualMachine labels.

# CHAPTER 5. OPENSHIFT VIRTUALIZATION RELEASE NOTES

## 5.1. MAKING OPEN SOURCE MORE INCLUSIVE

Red Hat is committed to replacing problematic language in our code, documentation, and web properties. We are beginning with these four terms: master, slave, blacklist, and whitelist. Because of the enormity of this endeavor, these changes will be implemented gradually over several upcoming releases. For more details, see [our CTO Chris Wright's message](#).

## 5.2. ABOUT RED HAT OPENSHIFT VIRTUALIZATION

Red Hat OpenShift Virtualization enables you to bring traditional virtual machines (VMs) into OpenShift Container Platform where they run alongside containers, and are managed as native Kubernetes objects.



OpenShift Virtualization is represented by the  icon.

You can use OpenShift Virtualization with either the [OVN-Kubernetes](#) or the [OpenShiftSDN](#) default Container Network Interface (CNI) network provider.

Learn more about [what you can do with OpenShift Virtualization](#).

Learn more about [OpenShift Virtualization architecture and deployments](#).

[Prepare your cluster](#) for OpenShift Virtualization.

### 5.2.1. OpenShift Virtualization supported cluster version

OpenShift Virtualization 4.13 is supported for use on OpenShift Container Platform 4.13 clusters. To use the latest z-stream release of OpenShift Virtualization, you must first upgrade to the latest version of OpenShift Container Platform.



#### IMPORTANT

Updating to OpenShift Virtualization 4.13 from OpenShift Virtualization 4.12.2 is not supported.

### 5.2.2. Supported guest operating systems

To view the supported guest operating systems for OpenShift Virtualization, see [Certified Guest Operating Systems in Red Hat OpenStack Platform](#), [Red Hat Virtualization](#), [OpenShift Virtualization](#) and [Red Hat Enterprise Linux with KVM](#).

## 5.3. NEW AND CHANGED FEATURES

- OpenShift Virtualization is FIPS ready. However, OpenShift Container Platform 4.13 is based on Red Hat Enterprise Linux (RHEL) 9.2. RHEL 9.2 has not yet been submitted for FIPS validation. Red Hat expects, though cannot commit to a specific timeframe, to obtain FIPS validation for RHEL 9.0 and RHEL 9.2 modules, and later even minor releases of RHEL 9.x. Updates will be available in [Compliance Activities and Government Standards](#).

- OpenShift Virtualization is certified in Microsoft's Windows Server Virtualization Validation Program (SVVP) to run Windows Server workloads.  
The SVVP Certification applies to:
  - Red Hat Enterprise Linux CoreOS workers. In the Microsoft SVVP Catalog, they are named *Red Hat OpenShift Container Platform 4 on RHEL CoreOS 9*.
  - Intel and AMD CPUs.
- OpenShift Virtualization now adheres to the **restricted** Kubernetes pod security standards profile. To learn more, see the OpenShift Virtualization [security policies](#) documentation.
- OpenShift Virtualization is now based on Red Hat Enterprise Linux (RHEL) 9.
  - There is a new RHEL 9 machine type for VMs: **machineType: pc-q35-rhel9.2.0**.  
All VM templates that are included with OpenShift Virtualization now use this machine type by default.
  - For more information, see [OpenShift Virtualization on RHEL 9](#).
- You can now obtain the **VirtualMachine**, **ConfigMap**, and **Secret** manifests from the export server after you export a VM or snapshot. For more information, see [accessing exported VM manifests](#).
- The "Logging, events, and monitoring" documentation is now called [Support](#). The monitoring tools documentation has been moved to [Monitoring](#).
- You can view and filter aggregated OpenShift Virtualization logs in the web console by using the [LokiStack](#).

### 5.3.1. Quick starts

- Quick start tours are available for several OpenShift Virtualization features. To view the tours, click the **Help** icon ? in the menu bar on the header of the OpenShift Virtualization console and then select **Quick Starts**. You can filter the available tours by entering the **virtualization** keyword in the **Filter** field.

### 5.3.2. Networking

- You can now [send unfragmented jumbo frame packets](#) between two virtual machines (VMs) that are connected on the default pod network when you use the OVN-Kubernetes CNI plugin.

### 5.3.3. Storage

- OpenShift Virtualization storage resources now migrate automatically to the beta API versions. Alpha API versions are no longer supported.

### 5.3.4. Web console

- On the **VirtualMachine details** page, the **Scheduling**, **Environment**, **Network interfaces**, **Disks**, and **Scripts** tabs are displayed on the new [Configuration tab](#).
- You can now [paste a string](#) from your client's clipboard into the guest when using the VNC console.

- The **VirtualMachine details → Details** tab now provides a new SSH service type **SSH over LoadBalancer** to expose the SSH service over a load balancer.
- The option to make a hot-plug volume a persistent volume is added to the **Disks tab**.
- There is now a **VirtualMachine details → Diagnostics** tab where you can view the status conditions of VMs and the snapshot status of volumes.
- You can now enable headless mode for high performance VMs in the web console.

## 5.4. DEPRECATED AND REMOVED FEATURES

### 5.4.1. Deprecated features

Deprecated features are included and supported in the current release. However, they will be removed in a future release and are not recommended for new deployments.

- Support for **virctl** command line tool installation for Red Hat Enterprise Linux (RHEL) 7 and RHEL 9 by an RPM is deprecated and is planned to be removed in a future release.

### 5.4.2. Removed features

Removed features are not supported in the current release.

- Red Hat Enterprise Linux 6 is no longer supported on OpenShift Virtualization.
- Support for the legacy HPP custom resource, and the associated storage class, has been removed for all new deployments. In OpenShift Virtualization 4.13, the HPP Operator uses the Kubernetes Container Storage Interface (CSI) driver to configure local storage. A legacy HPP custom resource is supported only if it had been installed on a previous version of OpenShift Virtualization.

## 5.5. TECHNOLOGY PREVIEW FEATURES

Some features in this release are currently in Technology Preview. These experimental features are not intended for production use. Note the following scope of support on the Red Hat Customer Portal for these features:

### Technology Preview Features Support Scope

- You can now use **Prometheus** to monitor the following metrics:
  - **kubevirt\_vmi\_cpu\_system\_usage\_seconds** returns the physical system CPU time consumed by the hypervisor.
  - **kubevirt\_vmi\_cpu\_user\_usage\_seconds** returns the physical user CPU time consumed by the hypervisor.
  - **kubevirt\_vmi\_cpu\_usage\_seconds** returns the total CPU time used in seconds by calculating the sum of the vCPU and the hypervisor usage.
- You can now run a **checkup** to verify if your OpenShift Container Platform cluster node can run a virtual machine with a Data Plane Development Kit (DPDK) workload with zero packet loss.

- You can [configure your virtual machine to run DPDK workloads](#) to achieve lower latency and higher throughput for faster packet processing in the user space.
- You can now [access a VM that is attached to a secondary network interface](#) from outside the cluster by using its fully qualified domain name (FQDN).
- You can now create OpenShift Container Platform clusters with worker nodes that are hosted by OpenShift Virtualization VMs. For more information, see [Managing hosted control plane clusters on OpenShift Virtualization](#) in the Red Hat Advanced Cluster Management (RHACM) documentation.
- You can now use Microsoft Windows 11 as a guest operating system. However, OpenShift Virtualization 4.13 does not support USB disks, which are required for a critical function of BitLocker recovery. To protect recovery keys, use other methods described in the [BitLocker recovery guide](#).

## 5.6. BUG FIX

- The virtual machine snapshot restore operation no longer hangs indefinitely due to some persistent volume claim (PVC) annotations created by the Containerized Data Importer (CDI). ([BZ#2070366](#))

## 5.7. KNOWN ISSUES

- With the release of the [RHSA-2023:3722](#) advisory, the TLS **Extended Master Secret** (EMS) extension ([RFC 7627](#)) is mandatory for TLS 1.2 connections on FIPS-enabled RHEL 9 systems. This is in accordance with FIPS-140-3 requirements. TLS 1.3 is not affected. Legacy OpenSSL clients that do not support EMS or TLS 1.3 now cannot connect to FIPS servers running on RHEL 9. Similarly, RHEL 9 clients in FIPS mode cannot connect to servers that only support TLS 1.2 without EMS. This in practice means that these clients cannot connect to servers on RHEL 6, RHEL 7 and non-RHEL legacy operating systems. This is because the legacy 1.0.x versions of OpenSSL do not support EMS or TLS 1.3. For more information, see [TLS Extension "Extended Master Secret" enforced with Red Hat Enterprise Linux 9.2](#).

As a workaround, upgrade legacy OpenSSL clients to a version that supports TLS 1.3 and configure OpenShift Virtualization to use TLS 1.3, with the **Modern** TLS security profile type, for FIPS mode.

- If you enabled the **DisableMDEVConfiguration** feature gate by editing the **HyperConverged** custom resource in OpenShift Virtualization 4.12.4, you must re-enable the feature gate after you upgrade to versions 4.13.0 or 4.13.1 by creating a JSON Patch annotation ([BZ#2184439](#)):

```
$ oc annotate --overwrite -n openshift-cnv hyperconverged kubevirt-hyperconverged \
  kubevirt.kubevirt.io/jsonpatch='[{"op": "add", "path": \
  "/spec/configuration/developerConfiguration/featureGates/-", \
  "value": "DisableMDEVConfiguration"}]'
```

- OpenShift Virtualization versions 4.12.2 and earlier are not compatible with OpenShift Container Platform 4.13. Updating OpenShift Container Platform to 4.13 is blocked by design in OpenShift Virtualization 4.12.1 and 4.12.2, but this restriction could not be added to OpenShift Virtualization 4.12.0. If you have OpenShift Virtualization 4.12.0, ensure that you do not update OpenShift Container Platform to 4.13.



## IMPORTANT

Your cluster becomes unsupported if you run incompatible versions of OpenShift Container Platform and OpenShift Virtualization.

- Enabling descheduler evictions on a virtual machine is a Technical Preview feature and might cause failed migrations and unstable scheduling.
- You cannot run OpenShift Virtualization on a single-stack IPv6 cluster. ([BZ#2193267](#))
- When you use two pods with different SELinux contexts, VMs with the **ocs-storagecluster-cephfs** storage class fail to migrate and the VM status changes to **Paused**. This is because both pods try to access the shared **ReadWriteMany** CephFS volume at the same time. ([BZ#2092271](#))
  - As a workaround, use the **ocs-storagecluster-ceph-rbd** storage class to live migrate VMs on a cluster that uses Red Hat Ceph Storage.
- If you clone more than 100 VMs using the **csi-clone** cloning strategy, then the Ceph CSI might not purge the clones. Manually deleting the clones might also fail. ([BZ#2055595](#))
  - As a workaround, you can restart the **ceph-mgr** to purge the VM clones.
- If you stop a node on a cluster and then use the Node Health Check Operator to bring the node back up, connectivity to Multus might be lost. ([OCPBUGS-8398](#))
- The **TopoLVM** provisioner name string has changed in OpenShift Virtualization 4.12. As a result, the automatic import of operating system images might fail with the following error message ([BZ#2158521](#)):
 

DataVolume.storage spec is missing accessMode and volumeMode, cannot get access mode from StorageProfile.

  - As a workaround:
    1. Update the **claimPropertySets** array of the storage profile:
 

```
$ oc patch storageprofile <storage_profile> --type=merge -p '{"spec": {"claimPropertySets": [{"accessModes": ["ReadWriteOnce"], "volumeMode": "Block"}, {"accessModes": ["ReadWriteOnce"], "volumeMode": "Filesystem"}]}'}
```
    2. Delete the affected data volumes in the **openshift-virtualization-os-images** namespace. They are recreated with the access mode and volume mode from the updated storage profile.
- When restoring a VM snapshot for storage whose binding mode is **WaitForFirstConsumer**, the restored PVCs remain in the **Pending** state and the restore operation does not progress.
  - As a workaround, start the restored VM, stop it, and then start it again. The VM will be scheduled, the PVCs will be in the **Bound** state, and the restore operation will complete. ([BZ#2149654](#))
- VMs created from common templates on a Single Node OpenShift (SNO) cluster display a **VMCannotBeEvicted** alert because the template's default eviction strategy is **LiveMigrate**. You can ignore this alert or remove the alert by updating the VM's eviction strategy. ([BZ#2092412](#))

- Uninstalling OpenShift Virtualization does not remove the **feature.node.kubevirt.io** node labels created by OpenShift Virtualization. You must remove the labels manually. ([CNV-22036](#))
- Windows 11 virtual machines do not boot on clusters running in **FIPS mode**. Windows 11 requires a TPM (trusted platform module) device by default. However, the **swtpm** (software TPM emulator) package is incompatible with FIPS. ([BZ#2089301](#))
- If your OpenShift Container Platform cluster uses OVN-Kubernetes as the default Container Network Interface (CNI) provider, you cannot attach a Linux bridge or bonding device to a host's default interface because of a change in the host network topology of OVN-Kubernetes. ([BZ#1885605](#))
  - As a workaround, you can use a secondary network interface connected to your host, or switch to the OpenShift SDN default CNI provider.
- In some instances, multiple virtual machines can mount the same PVC in read-write mode, which might result in data corruption. ([BZ#1992753](#))
  - As a workaround, avoid using a single PVC in read-write mode with multiple VMs.
- The Pod Disruption Budget (PDB) prevents pod disruptions for migratable virtual machine images. If the PDB detects pod disruption, then **openshift-monitoring** sends a **PodDisruptionBudgetAtLimit** alert every 60 minutes for virtual machine images that use the **LiveMigrate** eviction strategy. ([BZ#2026733](#))
  - As a workaround, [silence alerts](#).
- OpenShift Virtualization links a service account token in use by a pod to that specific pod. OpenShift Virtualization implements a service account volume by creating a disk image that contains a token. If you migrate a VM, then the service account volume becomes invalid. ([BZ#2037611](#))
  - As a workaround, use user accounts rather than service accounts because user account tokens are not bound to a specific pod.
- In a heterogeneous cluster with different compute nodes, virtual machines that have HyperV Reenlightenment enabled cannot be scheduled on nodes that do not support timestamp-counter scaling (TSC) or have the appropriate TSC frequency. ([BZ#2151169](#))
- If you deploy OpenShift Virtualization with Red Hat OpenShift Data Foundation, you must create a dedicated storage class for Windows virtual machine disks. See [Optimizing ODF PersistentVolumes for Windows VMs](#) for details.

# CHAPTER 6. INSTALLING

## 6.1. PREPARING YOUR CLUSTER FOR OPENSHIFT VIRTUALIZATION

Review this section before you install OpenShift Virtualization to ensure that your cluster meets the requirements.



### IMPORTANT

You can use any installation method, including user-provisioned, installer-provisioned, or assisted installer, to deploy OpenShift Container Platform. However, the installation method and the cluster topology might affect OpenShift Virtualization functionality, such as snapshots or live migration.

### IPv6

You cannot run OpenShift Virtualization on a single-stack IPv6 cluster. ([BZ#2193267](#))

### 6.1.1. Hardware and operating system requirements

Review the following hardware and operating system requirements for OpenShift Virtualization.

#### Supported platforms

- On-premise bare metal servers
- Amazon Web Services bare metal instances. See [Deploy OpenShift Virtualization on AWS Bare Metal Nodes](#) for details.
- IBM Cloud Bare Metal Servers. See [Deploy OpenShift Virtualization on IBM Cloud Bare Metal Nodes](#) for details.



### IMPORTANT

Installing OpenShift Virtualization on AWS bare metal instances or on IBM Cloud Bare Metal Servers 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](#).

- Bare metal instances or servers offered by other cloud providers are not supported.

#### CPU requirements

- Supported by Red Hat Enterprise Linux (RHEL) 9
- Support for Intel 64 or AMD64 CPU extensions
- Intel VT or AMD-V hardware virtualization extensions enabled

- NX (no execute) flag enabled

## Storage requirements

- Supported by OpenShift Container Platform



### WARNING

If you deploy OpenShift Virtualization with Red Hat OpenShift Data Foundation, you must create a dedicated storage class for Windows virtual machine disks. See [Optimizing ODF PersistentVolumes for Windows VMs](#) for details.

## Operating system requirements

- Red Hat Enterprise Linux CoreOS (RHCOS) installed on worker nodes



### NOTE

RHEL worker nodes are not supported.

- If your cluster uses worker nodes with different CPUs, live migration failures can occur because different CPUs have different capabilities. To avoid such failures, use CPUs with appropriate capacity for each node and set node affinity on your virtual machines to ensure successful migration. See [Configuring a required node affinity rule](#) for more information.

## Additional resources

- [About RHCOS](#).
- [Red Hat Ecosystem Catalog](#) for supported CPUs.
- [Supported storage](#).

### 6.1.2. Physical resource overhead requirements

OpenShift Virtualization is an add-on to OpenShift Container Platform and imposes additional overhead that you must account for when planning a cluster. Each cluster machine must accommodate the following overhead requirements in addition to the OpenShift Container Platform requirements. Oversubscribing the physical resources in a cluster can affect performance.



### IMPORTANT

The numbers noted in this documentation are based on Red Hat's test methodology and setup. These numbers can vary based on your own individual setup and environments.

#### 6.1.2.1. Memory overhead

Calculate the memory overhead values for OpenShift Virtualization by using the equations below.

## Cluster memory overhead

Memory overhead per infrastructure node  $\approx$  150 MiB

Memory overhead per worker node  $\approx$  360 MiB

Additionally, OpenShift Virtualization environment resources require a total of 2179 MiB of RAM that is spread across all infrastructure nodes.

## Virtual machine memory overhead

Memory overhead per virtual machine  $\approx$  (1.002 \* requested memory) + 146 MiB \  
 + 8 MiB \* (number of vCPUs) \ ①  
 + 16 MiB \* (number of graphics devices) ②

① Number of virtual CPUs requested by the virtual machine

② Number of virtual graphics cards requested by the virtual machine

If your environment includes a Single Root I/O Virtualization (SR-IOV) network device or a Graphics Processing Unit (GPU), allocate 1 GiB additional memory overhead for each device.

### 6.1.2.2. CPU overhead

Calculate the cluster processor overhead requirements for OpenShift Virtualization by using the equation below. The CPU overhead per virtual machine depends on your individual setup.

#### Cluster CPU overhead

CPU overhead for infrastructure nodes  $\approx$  4 cores

OpenShift Virtualization increases the overall utilization of cluster level services such as logging, routing, and monitoring. To account for this workload, ensure that nodes that host infrastructure components have capacity allocated for 4 additional cores (4000 millicores) distributed across those nodes.

CPU overhead for worker nodes  $\approx$  2 cores + CPU overhead per virtual machine

Each worker node that hosts virtual machines must have capacity for 2 additional cores (2000 millicores) for OpenShift Virtualization management workloads in addition to the CPUs required for virtual machine workloads.

#### Virtual machine CPU overhead

If dedicated CPUs are requested, there is a 1:1 impact on the cluster CPU overhead requirement. Otherwise, there are no specific rules about how many CPUs a virtual machine requires.

### 6.1.2.3. Storage overhead

Use the guidelines below to estimate storage overhead requirements for your OpenShift Virtualization environment.

#### Cluster storage overhead

## Aggregated storage overhead per node $\approx$ 10 GiB

10 GiB is the estimated on-disk storage impact for each node in the cluster when you install OpenShift Virtualization.

### Virtual machine storage overhead

Storage overhead per virtual machine depends on specific requests for resource allocation within the virtual machine. The request could be for ephemeral storage on the node or storage resources hosted elsewhere in the cluster. OpenShift Virtualization does not currently allocate any additional ephemeral storage for the running container itself.

#### 6.1.2.4. Example

As a cluster administrator, if you plan to host 10 virtual machines in the cluster, each with 1 GiB of RAM and 2 vCPUs, the memory impact across the cluster is 11.68 GiB. The estimated on-disk storage impact for each node in the cluster is 10 GiB and the CPU impact for worker nodes that host virtual machine workloads is a minimum of 2 cores.

### 6.1.3. About storage volumes for virtual machine disks

If you use the storage API with known storage providers, volume and access modes are selected automatically. However, if you use a storage class that does not have a storage profile, you must select the volume and access mode.

For best results, use **accessMode: ReadWriteMany** and **volumeMode: Block**. This is important for the following reasons:

- The **ReadWriteMany** (RWX) access mode is required for live migration.
- The **Block** volume mode performs significantly better in comparison to the **Filesystem** volume mode. This is because the **Filesystem** volume mode uses more storage layers, including a file system layer and a disk image file. These layers are not necessary for VM disk storage.  
For example, if you use Red Hat OpenShift Data Foundation, Ceph RBD volumes are preferable to CephFS volumes.



#### IMPORTANT

You cannot live migrate virtual machines that use:

- A storage volume with **ReadWriteOnce** (RWO) access mode
- Passthrough features such as GPUs

Do not set the **evictionStrategy** field to **LiveMigrate** for these virtual machines.

### Additional resources

- [Glossary of common terms for OpenShift Container Platform storage](#)

#### 6.1.4. Object maximums

You must consider the following tested object maximums when planning your cluster:

- [OpenShift Container Platform object maximums](#).

- OpenShift Virtualization object maximums.

### 6.1.5. Restricted network environments

If you install OpenShift Virtualization in a restricted environment with no internet connectivity, you must [configure Operator Lifecycle Manager for restricted networks](#).

If you have limited internet connectivity, you can [configure proxy support in Operator Lifecycle Manager](#) to access the Red Hat-provided OperatorHub.

### 6.1.6. Live migration

Live migration has the following requirements:

- Shared storage with **ReadWriteMany** (RWX) access mode.
- Sufficient RAM and network bandwidth.
- If the virtual machine uses a host model CPU, the nodes must support the virtual machine's host model CPU.



#### NOTE

You must ensure that there is enough memory request capacity in the cluster to support node drains that result in live migrations. You can determine the approximate required spare memory by using the following calculation:

Product of (Maximum number of nodes that can drain in parallel) and (Highest total VM memory request allocations across nodes)

The default [number of migrations that can run in parallel](#) in the cluster is 5.

### 6.1.7. Cluster high-availability options

You can configure one of the following high-availability (HA) options for your cluster:

- Automatic high availability for [installer-provisioned infrastructure](#) (IPI) is available by deploying [machine health checks](#).



#### NOTE

In OpenShift Container Platform clusters installed using installer-provisioned infrastructure and with MachineHealthCheck properly configured, if a node fails the MachineHealthCheck and becomes unavailable to the cluster, it is recycled. What happens next with VMs that ran on the failed node depends on a series of conditions. See [About RunStrategies for virtual machines](#) for more detailed information about the potential outcomes and how RunStrategies affect those outcomes.

- Automatic high availability for both IPI and non-IPI is available by using the **Node Health Check Operator** on the OpenShift Container Platform cluster to deploy the **NodeHealthCheck** controller. The controller identifies unhealthy nodes and uses the Self Node Remediation Operator to remediate the unhealthy nodes. For more information on remediation, fencing, and maintaining nodes, see the [Workload Availability for Red Hat OpenShift](#) documentation.



## IMPORTANT

Node Health Check Operator 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](#).

- High availability for any platform is available by using either a monitoring system or a qualified human to monitor node availability. When a node is lost, shut it down and run `oc delete node <lost_node>`.



## NOTE

Without an external monitoring system or a qualified human monitoring node health, virtual machines lose high availability.

## 6.2. SPECIFYING NODES FOR OPENSHIFT VIRTUALIZATION COMPONENTS

Specify the nodes where you want to deploy OpenShift Virtualization Operators, workloads, and controllers by configuring node placement rules.



## NOTE

You can configure node placement for some components after installing OpenShift Virtualization, but there must not be virtual machines present if you want to configure node placement for workloads.

### 6.2.1. About node placement for virtualization components

You might want to customize where OpenShift Virtualization deploys its components to ensure that:

- Virtual machines only deploy on nodes that are intended for virtualization workloads.
- Operators only deploy on infrastructure nodes.
- Certain nodes are unaffected by OpenShift Virtualization. For example, you have workloads unrelated to virtualization running on your cluster, and you want those workloads to be isolated from OpenShift Virtualization.

### 6.2.1.1. How to apply node placement rules to virtualization components

You can specify node placement rules for a component by editing the corresponding object directly or by using the web console.

- For the OpenShift Virtualization Operators that Operator Lifecycle Manager (OLM) deploys, edit the OLM **Subscription** object directly. Currently, you cannot configure node placement rules for the **Subscription** object by using the web console.

- For components that the OpenShift Virtualization Operators deploy, edit the **HyperConverged** object directly or configure it by using the web console during OpenShift Virtualization installation.
- For the hostpath provisioner, edit the **HostPathProvisioner** object directly or configure it by using the web console.



### WARNING

You must schedule the hostpath provisioner and the virtualization components on the same nodes. Otherwise, virtualization pods that use the hostpath provisioner cannot run.

Depending on the object, you can use one or more of the following rule types:

#### **nodeSelector**

Allows pods to be scheduled on nodes that are labeled with the key-value pair or pairs that you specify in this field. The node must have labels that exactly match all listed pairs.

#### **affinity**

Enables you to use more expressive syntax to set rules that match nodes with pods. Affinity also allows for more nuance in how the rules are applied. For example, you can specify that a rule is a preference, rather than a hard requirement, so that pods are still scheduled if the rule is not satisfied.

#### **tolerations**

Allows pods to be scheduled on nodes that have matching taints. If a taint is applied to a node, that node only accepts pods that tolerate the taint.

### 6.2.1.2. Node placement in the OLM Subscription object

To specify the nodes where OLM deploys the OpenShift Virtualization Operators, edit the **Subscription** object during OpenShift Virtualization installation. You can include node placement rules in the **spec.config** field, as shown in the following example:

```
apiVersion: operators.coreos.com/v1beta1
kind: Subscription
metadata:
  name: hco-operatorhub
  namespace: openshift-cnv
spec:
  source: redhat-operators
  sourceNamespace: openshift-marketplace
  name: kubevirt-hyperconverged
  startingCSV: kubevirt-hyperconverged-operator.v4.13.4
  channel: "stable"
  config: ①
```

① The **config** field supports **nodeSelector** and **tolerations**, but it does not support **affinity**.

### 6.2.1.3. Node placement in the HyperConverged object

To specify the nodes where OpenShift Virtualization deploys its components, you can include the **nodePlacement** object in the HyperConverged Cluster custom resource (CR) file that you create during OpenShift Virtualization installation. You can include **nodePlacement** under the **spec.infra** and **spec.workloads** fields, as shown in the following example:

```
apiVersion: hco.kubevirt.io/v1beta1
kind: HyperConverged
metadata:
  name: kubevirt-hyperconverged
  namespace: openshift-cnv
spec:
  infra:
    nodePlacement: ①
    ...
  workloads:
    nodePlacement:
    ...

```

- ① The **nodePlacement** fields support **nodeSelector**, **affinity**, and **tolerations** fields.

### 6.2.1.4. Node placement in the HostPathProvisioner object

You can configure node placement rules in the **spec.workload** field of the **HostPathProvisioner** object that you create when you install the hostpath provisioner.

```
apiVersion: hostpathprovisioner.kubevirt.io/v1beta1
kind: HostPathProvisioner
metadata:
  name: hostpath-provisioner
spec:
  imagePullPolicy: IfNotPresent
  pathConfig:
    path: "</path/to/backing/directory>"
    useNamingPrefix: false
  workload: ①
```

- ① The **workload** field supports **nodeSelector**, **affinity**, and **tolerations** fields.

### 6.2.1.5. Additional resources

- [Specifying nodes for virtual machines](#)
- [Placing pods on specific nodes using node selectors](#)
- [Controlling pod placement on nodes using node affinity rules](#)
- [Controlling pod placement using node taints](#)
- [Installing OpenShift Virtualization using the CLI](#)
- [Installing OpenShift Virtualization using the web console](#)

- Configuring local storage for virtual machines

## 6.2.2. Example manifests

The following example YAML files use **nodePlacement**, **affinity**, and **tolerations** objects to customize node placement for OpenShift Virtualization components.

### 6.2.2.1. Operator Lifecycle Manager Subscription object

#### 6.2.2.1.1. Example: Node placement with nodeSelector in the OLM Subscription object

In this example, **nodeSelector** is configured so that OLM places the OpenShift Virtualization Operators on nodes that are labeled with **example.io/example-infra-key = example-infra-value**.

```
apiVersion: operators.coreos.com/v1beta1
kind: Subscription
metadata:
  name: hco-operatorhub
  namespace: openshift-cnv
spec:
  source: redhat-operators
  sourceNamespace: openshift-marketplace
  name: kubevirt-hyperconverged
  startingCSV: kubevirt-hyperconverged-operator.v4.13.4
  channel: "stable"
  config:
    nodeSelector:
      example.io/example-infra-key: example-infra-value
```

#### 6.2.2.1.2. Example: Node placement with tolerations in the OLM Subscription object

In this example, nodes that are reserved for OLM to deploy OpenShift Virtualization Operators are labeled with the **key=virtualization:NoSchedule** taint. Only pods with the matching tolerations are scheduled to these nodes.

```
apiVersion: operators.coreos.com/v1beta1
kind: Subscription
metadata:
  name: hco-operatorhub
  namespace: openshift-cnv
spec:
  source: redhat-operators
  sourceNamespace: openshift-marketplace
  name: kubevirt-hyperconverged
  startingCSV: kubevirt-hyperconverged-operator.v4.13.4
  channel: "stable"
  config:
    tolerations:
    - key: "key"
      operator: "Equal"
      value: "virtualization"
      effect: "NoSchedule"
```

## 6.2.2.2. HyperConverged object

### 6.2.2.2.1. Example: Node placement with nodeSelector in the HyperConverged Cluster CR

In this example, **nodeSelector** is configured so that infrastructure resources are placed on nodes that are labeled with **example.io/example-infra-key = example-infra-value** and workloads are placed on nodes labeled with **example.io/example-workloads-key = example-workloads-value**.

```
apiVersion: hco.kubevirt.io/v1beta1
kind: HyperConverged
metadata:
  name: kubevirt-hyperconverged
  namespace: openshift-cnv
spec:
  infra:
    nodePlacement:
      nodeSelector:
        example.io/example-infra-key: example-infra-value
  workloads:
    nodePlacement:
      nodeSelector:
        example.io/example-workloads-key: example-workloads-value
```

### 6.2.2.2.2. Example: Node placement with affinity in the HyperConverged Cluster CR

In this example, **affinity** is configured so that infrastructure resources are placed on nodes that are labeled with **example.io/example-infra-key = example-value** and workloads are placed on nodes labeled with **example.io/example-workloads-key = example-workloads-value**. Nodes that have more than eight CPUs are preferred for workloads, but if they are not available, pods are still scheduled.

```
apiVersion: hco.kubevirt.io/v1beta1
kind: HyperConverged
metadata:
  name: kubevirt-hyperconverged
  namespace: openshift-cnv
spec:
  infra:
    nodePlacement:
      affinity:
        nodeAffinity:
          requiredDuringSchedulingIgnoredDuringExecution:
            nodeSelectorTerms:
              - matchExpressions:
                  - key: example.io/example-infra-key
                    operator: In
                    values:
                      - example-infra-value
  workloads:
    nodePlacement:
      affinity:
        nodeAffinity:
          requiredDuringSchedulingIgnoredDuringExecution:
            nodeSelectorTerms:
              - matchExpressions:
                  - key: example.io/example-workloads-key
```

```

operator: In
values:
- example-workloads-value
preferredDuringSchedulingIgnoredDuringExecution:
- weight: 1
preference:
matchExpressions:
- key: example.io/num-cpus
operator: Gt
values:
- 8

```

#### 6.2.2.2.3. Example: Node placement with tolerations in the HyperConverged Cluster CR

In this example, nodes that are reserved for OpenShift Virtualization components are labeled with the **key=virtualization:NoSchedule** taint. Only pods with the matching tolerations are scheduled to these nodes.

```

apiVersion: hco.kubevirt.io/v1beta1
kind: HyperConverged
metadata:
  name: kubevirt-hyperconverged
  namespace: openshift-cnv
spec:
  workloads:
    nodePlacement:
      tolerations:
        - key: "key"
          operator: "Equal"
          value: "virtualization"
          effect: "NoSchedule"

```

#### 6.2.2.3. HostPathProvisioner object

##### 6.2.2.3.1. Example: Node placement with nodeSelector in the HostPathProvisioner object

In this example, **nodeSelector** is configured so that workloads are placed on nodes labeled with **example.io/example-workloads-key = example-workloads-value**.

```

apiVersion: hostpathprovisioner.kubevirt.io/v1beta1
kind: HostPathProvisioner
metadata:
  name: hostpath-provisioner
spec:
  imagePullPolicy: IfNotPresent
  pathConfig:
    path: "</path/to/backing/directory>"
    useNamingPrefix: false
  workload:
    nodeSelector:
      example.io/example-workloads-key: example-workloads-value

```

## 6.3. INSTALLING OPENSIFT VIRTUALIZATION USING THE WEB CONSOLE

Install OpenShift Virtualization to add virtualization functionality to your OpenShift Container Platform cluster.

You can use the OpenShift Container Platform 4.13 [web console](#) to subscribe to and deploy the OpenShift Virtualization Operators.

### 6.3.1. Installing the OpenShift Virtualization Operator

You can install the OpenShift Virtualization Operator from the OpenShift Container Platform web console.

#### Prerequisites

- Install OpenShift Container Platform 4.13 on your cluster.
- Log in to the OpenShift Container Platform web console as a user with **cluster-admin** permissions.

#### Procedure

1. From the **Administrator** perspective, click **Operators** → **OperatorHub**.
2. In the **Filter by keyword** field, type **Virtualization**.
3. Select the **OpenShift Virtualization Operator** tile with the **Red Hat** source label.
4. Read the information about the Operator and click **Install**.
5. On the **Install Operator** page:
  - a. Select **stable** from the list of available **Update Channel** options. This ensures that you install the version of OpenShift Virtualization that is compatible with your OpenShift Container Platform version.
  - b. For **Installed Namespace**, ensure that the **Operator recommended namespace** option is selected. This installs the Operator in the mandatory **openshift-cnv** namespace, which is automatically created if it does not exist.



#### WARNING

Attempting to install the OpenShift Virtualization Operator in a namespace other than **openshift-cnv** causes the installation to fail.

- c. For **Approval Strategy**, it is highly recommended that you select **Automatic**, which is the default value, so that OpenShift Virtualization automatically updates when a new version is available in the **stable** update channel.

While it is possible to select the **Manual** approval strategy, this is inadvisable because of the high risk that it presents to the supportability and functionality of your cluster. Only select **Manual** if you fully understand these risks and cannot use **Automatic**.



### WARNING

Because OpenShift Virtualization is only supported when used with the corresponding OpenShift Container Platform version, missing OpenShift Virtualization updates can cause your cluster to become unsupported.

6. Click **Install** to make the Operator available to the **openshift-cnv** namespace.
7. When the Operator installs successfully, click **Create HyperConverged**.
8. Optional: Configure **Infra** and **Workloads** node placement options for OpenShift Virtualization components.
9. Click **Create** to launch OpenShift Virtualization.

### Verification

- Navigate to the **Workloads → Pods** page and monitor the OpenShift Virtualization pods until they are all **Running**. After all the pods display the **Running** state, you can use OpenShift Virtualization.

### 6.3.2. Next steps

You might want to additionally configure the following components:

- The [hostpath provisioner](#) is a local storage provisioner designed for OpenShift Virtualization. If you want to configure local storage for virtual machines, you must enable the hostpath provisioner first.

## 6.4. INSTALLING OPENSIFT VIRTUALIZATION USING THE CLI

Install OpenShift Virtualization to add virtualization functionality to your OpenShift Container Platform cluster. You can subscribe to and deploy the OpenShift Virtualization Operators by using the command line to apply manifests to your cluster.



### NOTE

To specify the nodes where you want OpenShift Virtualization to install its components, [configure node placement rules](#).

### 6.4.1. Prerequisites

- Install OpenShift Container Platform 4.13 on your cluster.
- Install the OpenShift CLI (**oc**).

- Log in as a user with **cluster-admin** privileges.

#### 6.4.2. Subscribing to the OpenShift Virtualization catalog by using the CLI

Before you install OpenShift Virtualization, you must subscribe to the OpenShift Virtualization catalog. Subscribing gives the **openshift-cnv** namespace access to the OpenShift Virtualization Operators.

To subscribe, configure **Namespace**, **OperatorGroup**, and **Subscription** objects by applying a single manifest to your cluster.

##### Procedure

- 1 Create a YAML file that contains the following manifest:

```
apiVersion: v1
kind: Namespace
metadata:
  name: openshift-cnv
---
apiVersion: operators.coreos.com/v1
kind: OperatorGroup
metadata:
  name: kubevirt-hyperconverged-group
  namespace: openshift-cnv
spec:
  targetNamespaces:
    - openshift-cnv
---
apiVersion: operators.coreos.com/v1beta1
kind: Subscription
metadata:
  name: hco-operatorhub
  namespace: openshift-cnv
spec:
  source: redhat-operators
  sourceNamespace: openshift-marketplace
  name: kubevirt-hyperconverged
  startingCSV: kubevirt-hyperconverged-operator.v4.13.4
  channel: "stable" 1
```

- 1** Using the **stable** channel ensures that you install the version of OpenShift Virtualization that is compatible with your OpenShift Container Platform version.

- 2 Create the required **Namespace**, **OperatorGroup**, and **Subscription** objects for OpenShift Virtualization by running the following command:

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



##### NOTE

You can [configure certificate rotation](#) parameters in the YAML file.

#### 6.4.3. Deploying the OpenShift Virtualization Operator by using the CLI

You can deploy the OpenShift Virtualization Operator by using the **oc** CLI.

## Prerequisites

- An active subscription to the OpenShift Virtualization catalog in the **openshift-cnv** namespace.

## Procedure

1. Create a YAML file that contains the following manifest:

```
apiVersion: hco.kubevirt.io/v1beta1
kind: HyperConverged
metadata:
  name: kubevirt-hyperconverged
  namespace: openshift-cnv
spec:
```

2. Deploy the OpenShift Virtualization Operator by running the following command:

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

## Verification

- Ensure that OpenShift Virtualization deployed successfully by watching the **PHASE** of the cluster service version (CSV) in the **openshift-cnv** namespace. Run the following command:

```
$ watch oc get csv -n openshift-cnv
```

The following output displays if deployment was successful:

### Example output

NAME	DISPLAY	VERSION	REPLACES	PHASE
kubevirt-hyperconverged-operator.v4.13.4	OpenShift Virtualization	4.13.4		Succeeded

## 6.4.4. Next steps

You might want to additionally configure the following components:

- The [hostpath provisioner](#) is a local storage provisioner designed for OpenShift Virtualization. If you want to configure local storage for virtual machines, you must enable the hostpath provisioner first.

## 6.5. UNINSTALLING OPENSHIFT VIRTUALIZATION

You uninstall OpenShift Virtualization by using the web console or the command line interface (CLI) to delete the OpenShift Virtualization workloads, the Operator, and its resources.

### 6.5.1. Uninstalling OpenShift Virtualization by using the web console

You uninstall OpenShift Virtualization by using the [web console](#) to perform the following tasks:

1. Delete the **HyperConverged** CR.
2. Delete the OpenShift Virtualization Operator.
3. Delete the **openshift-cnv** namespace.
4. Delete the OpenShift Virtualization custom resource definitions (CRDs).



### IMPORTANT

You must first delete all [virtual machines](#), and [virtual machine instances](#).

You cannot uninstall OpenShift Virtualization while its workloads remain on the cluster.

#### 6.5.1.1. Deleting the HyperConverged custom resource

To uninstall OpenShift Virtualization, you first delete the **HyperConverged** custom resource (CR).

##### Prerequisites

- You have access to an OpenShift Container Platform cluster using an account with **cluster-admin** permissions.

##### Procedure

1. Navigate to the [Operators → Installed Operators](#) page.
2. Select the OpenShift Virtualization Operator.
3. Click the [OpenShift Virtualization Deployment](#) tab.
4. Click the Options menu  beside **kubevirt-hyperconverged** and select **Delete HyperConverged**.
5. Click **Delete** in the confirmation window.

#### 6.5.1.2. Deleting Operators from a cluster using the web console

Cluster administrators can delete installed Operators from a selected namespace by using the web console.

##### Prerequisites

- You have access to an OpenShift Container Platform cluster web console using an account with **cluster-admin** permissions.

##### Procedure

1. Navigate to the [Operators → Installed Operators](#) page.
2. Scroll or enter a keyword into the **Filter by name** field to find the Operator that you want to remove. Then, click on it.

3. On the right side of the **Operator Details** page, select **Uninstall Operator** from the **Actions** list. An **Uninstall Operator?** dialog box is displayed.
4. Select **Uninstall** to remove the Operator, Operator deployments, and pods. Following this action, the Operator stops running and no longer receives updates.



#### NOTE

This action does not remove resources managed by the Operator, including custom resource definitions (CRDs) and custom resources (CRs). Dashboards and navigation items enabled by the web console and off-cluster resources that continue to run might need manual clean up. To remove these after uninstalling the Operator, you might need to manually delete the Operator CRDs.

### 6.5.1.3. Deleting a namespace using the web console

You can delete a namespace by using the OpenShift Container Platform web console.

#### Prerequisites

- You have access to an OpenShift Container Platform cluster using an account with **cluster-admin** permissions.

#### Procedure

1. Navigate to **Administration** → **Namespaces**.
2. Locate the namespace that you want to delete in the list of namespaces.
3. On the far right side of the namespace listing, select **Delete Namespace** from the Options menu .
4. When the **Delete Namespace** pane opens, enter the name of the namespace that you want to delete in the field.
5. Click **Delete**.

### 6.5.1.4. Deleting OpenShift Virtualization custom resource definitions

You can delete the OpenShift Virtualization custom resource definitions (CRDs) by using the web console.

#### Prerequisites

- You have access to an OpenShift Container Platform cluster using an account with **cluster-admin** permissions.

#### Procedure

1. Navigate to **Administration** → **CustomResourceDefinitions**.
2. Select the **Label** filter and enter **operators.coreos.com/kubevirt-hyperconverged.openshift-cnv** in the **Search** field to display the OpenShift Virtualization CRDs.

3. Click the Options menu  beside each CRD and select **Delete CustomResourceDefinition**.

### 6.5.2. Uninstalling OpenShift Virtualization by using the CLI

You can uninstall OpenShift Virtualization by using the OpenShift CLI (**oc**).

#### Prerequisites

- You have access to an OpenShift Container Platform cluster using an account with **cluster-admin** permissions.
- You have installed the OpenShift CLI (**oc**).
- You have deleted all virtual machines and virtual machine instances. You cannot uninstall OpenShift Virtualization while its workloads remain on the cluster.

#### Procedure

1. Delete the **HyperConverged** custom resource:

```
$ oc delete HyperConverged kubevirt-hyperconverged -n openshift-cnv
```

2. Delete the OpenShift Virtualization Operator subscription:

```
$ oc delete subscription kubevirt-hyperconverged -n openshift-cnv
```

3. Delete the OpenShift Virtualization **ClusterServiceVersion** resource:

```
$ oc delete csv -n openshift-cnv -l operators.coreos.com/kubevirt-hyperconverged.openshift-cnv
```

4. Delete the OpenShift Virtualization namespace:

```
$ oc delete namespace openshift-cnv
```

5. List the OpenShift Virtualization custom resource definitions (CRDs) by running the **oc delete crd** command with the **dry-run** option:

```
$ oc delete crd --dry-run=client -l operators.coreos.com/kubevirt-hyperconverged.openshift-cnv
```

#### Example output

```
customresourcedefinition.apiextensions.k8s.io "cdis.cdi.kubevirt.io" deleted (dry run)
customresourcedefinition.apiextensions.k8s.io "hostpathprovisioners.hostpathprovisioner.kubevirt.io" deleted (dry run)
customresourcedefinition.apiextensions.k8s.io "hyperconvergeds.hco.kubevirt.io" deleted (dry run)
customresourcedefinition.apiextensions.k8s.io "kubevirtss.kubevirt.io" deleted (dry run)
customresourcedefinition.apiextensions.k8s.io "networkaddonsconfigs.networkaddonsoperator.network.kubevirt.io" deleted (dry run)
```

```
customresourcedefinition.apiextensions.k8s.io "ssps.ssp.kubevirt.io" deleted (dry run)
customresourcedefinition.apiextensions.k8s.io "tektontasks.tektontasks.kubevirt.io" deleted
(dry run)
```

6. Delete the CRDs by running the **oc delete crd** command without the **dry-run** option:

```
$ oc delete crd -l operators.coreos.com/kubevirt-hyperconverged.openshift-cnv
```

## Additional resources

- [Deleting virtual machines](#)
- [Deleting virtual machine instances](#)

# CHAPTER 7. UPDATING OPENSIFT VIRTUALIZATION

Learn how Operator Lifecycle Manager (OLM) delivers z-stream and minor version updates for OpenShift Virtualization.



## IMPORTANT

Updating to OpenShift Virtualization 4.13 from OpenShift Virtualization 4.12.2 is not supported.

## 7.1. OPENSIFT VIRTUALIZATION ON RHEL 9

OpenShift Virtualization 4.13 is based on Red Hat Enterprise Linux (RHEL) 9. You can update to OpenShift Virtualization 4.13 from a version that was based on RHEL 8 by following the standard OpenShift Virtualization update procedure. No additional steps are required.

As in previous versions, you can perform the update without disrupting running workloads. OpenShift Virtualization 4.13 supports live migration from RHEL 8 nodes to RHEL 9 nodes.

### 7.1.1. New RHEL 9 machine type

This update also introduces a new RHEL 9 machine type for VMs: **machineType: pc-q35-rhel9.2.0**. All VM templates that are included with OpenShift Virtualization now use this machine type by default.

Updating OpenShift Virtualization does not change the **machineType** value of any existing VMs. These VMs continue to function as they did before the update.

While it is not required, you might want to change a VM's machine type to **pc-q35-rhel9.2.0** so that it can benefit from RHEL 9 improvements.



## IMPORTANT

Before you change a VM's **machineType** value, you must shut down the VM.

## 7.2. ABOUT UPDATING OPENSIFT VIRTUALIZATION

- Operator Lifecycle Manager (OLM) manages the lifecycle of the OpenShift Virtualization Operator. The Marketplace Operator, which is deployed during OpenShift Container Platform installation, makes external Operators available to your cluster.
- OLM provides z-stream and minor version updates for OpenShift Virtualization. Minor version updates become available when you update OpenShift Container Platform to the next minor version. You cannot update OpenShift Virtualization to the next minor version without first updating OpenShift Container Platform.
- OpenShift Virtualization subscriptions use a single update channel that is named **stable**. The **stable** channel ensures that your OpenShift Virtualization and OpenShift Container Platform versions are compatible.
- If your subscription's approval strategy is set to **Automatic**, the update process starts as soon as a new version of the Operator is available in the **stable** channel. It is highly recommended to use the **Automatic** approval strategy to maintain a supportable environment. Each minor version of

OpenShift Virtualization is only supported if you run the corresponding OpenShift Container Platform version. For example, you must run OpenShift Virtualization 4.13 on OpenShift Container Platform 4.13.

- Though it is possible to select the **Manual** approval strategy, this is not recommended because it risks the supportability and functionality of your cluster. With the **Manual** approval strategy, you must manually approve every pending update. If OpenShift Container Platform and OpenShift Virtualization updates are out of sync, your cluster becomes unsupported.
- The amount of time an update takes to complete depends on your network connection. Most automatic updates complete within fifteen minutes.
- Updating OpenShift Virtualization does not interrupt network connections.
- Data volumes and their associated persistent volume claims are preserved during update.



### IMPORTANT

If you have virtual machines running that use hostpath provisioner storage, they cannot be live migrated and might block an OpenShift Container Platform cluster update.

As a workaround, you can reconfigure the virtual machines so that they can be powered off automatically during a cluster update. Remove the **evictionStrategy: LiveMigrate** field and set the **runStrategy** field to **Always**.

#### 7.2.1. About workload updates

When you update OpenShift Virtualization, virtual machine workloads, including **libvirt**, **virt-launcher**, and **qemu**, update automatically if they support live migration.



### NOTE

Each virtual machine has a **virt-launcher** pod that runs the virtual machine instance (VMI). The **virt-launcher** pod runs an instance of **libvirt**, which is used to manage the virtual machine (VM) process.

You can configure how workloads are updated by editing the **spec.workloadUpdateStrategy** stanza of the **HyperConverged** custom resource (CR). There are two available workload update methods: **LiveMigrate** and **Evict**.

Because the **Evict** method shuts down VMI pods, only the **LiveMigrate** update strategy is enabled by default.

When **LiveMigrate** is the only update strategy enabled:

- VMIs that support live migration are migrated during the update process. The VM guest moves into a new pod with the updated components enabled.
- VMIs that do not support live migration are not disrupted or updated.
  - If a VMI has the **LiveMigrate** eviction strategy but does not support live migration, it is not updated.

If you enable both **LiveMigrate** and **Evict**:

- VMIs that support live migration use the **LiveMigrate** update strategy.
- VMIs that do not support live migration use the **Evict** update strategy. If a VMI is controlled by a **VirtualMachine** object that has a **runStrategy** value of **always**, a new VMI is created in a new pod with updated components.

### Migration attempts and timeouts

When updating workloads, live migration fails if a pod is in the **Pending** state for the following periods:

#### 5 minutes

If the pod is pending because it is **Unschedulable**.

#### 15 minutes

If the pod is stuck in the pending state for any reason.

When a VMI fails to migrate, the **virt-controller** tries to migrate it again. It repeats this process until all migratable VMIs are running on new **virt-launcher** pods. If a VMI is improperly configured, however, these attempts can repeat indefinitely.



#### NOTE

Each attempt corresponds to a migration object. Only the five most recent attempts are held in a buffer. This prevents migration objects from accumulating on the system while retaining information for debugging.

### 7.2.2. About EUS-to-EUS updates

Every even-numbered minor version of OpenShift Container Platform, including 4.10 and 4.12, is an Extended Update Support (EUS) version. However, because Kubernetes design mandates serial minor version updates, you cannot directly update from one EUS version to the next.

After you update from the source EUS version to the next odd-numbered minor version, you must sequentially update OpenShift Virtualization to all z-stream releases of that minor version that are on your update path. When you have upgraded to the latest applicable z-stream version, you can then update OpenShift Container Platform to the target EUS minor version.

When the OpenShift Container Platform update succeeds, the corresponding update for OpenShift Virtualization becomes available. You can now update OpenShift Virtualization to the target EUS version.

#### 7.2.2.1. Preparing to update

Before beginning an EUS-to-EUS update, you must:

- Pause worker nodes' machine config pools before you start an EUS-to-EUS update so that the workers are not rebooted twice.
- Disable automatic workload updates before you begin the update process. This is to prevent OpenShift Virtualization from migrating or evicting your virtual machines (VMs) until you update to your target EUS version.

**NOTE**

By default, OpenShift Virtualization automatically updates workloads, such as the **virt-launcher** pod, when you update the OpenShift Virtualization Operator. You can configure this behavior in the **spec.workloadUpdateStrategy** stanza of the **HyperConverged** custom resource.

Learn more about [preparing to perform an EUS-to-EUS update](#).

## 7.3. PREVENTING WORKLOAD UPDATES DURING AN EUS-TO-EUS UPDATE

When you update from one Extended Update Support (EUS) version to the next, you must manually disable automatic workload updates to prevent OpenShift Virtualization from migrating or evicting workloads during the update process.

### Prerequisites

- You are running an EUS version of OpenShift Container Platform and want to update to the next EUS version. You have not yet updated to the odd-numbered version in between.
- You read "Preparing to perform an EUS-to-EUS update" and learned the caveats and requirements that pertain to your OpenShift Container Platform cluster.
- You paused the worker nodes' machine config pools as directed by the OpenShift Container Platform documentation.
- It is recommended that you use the default **Automatic** approval strategy. If you use the **Manual** approval strategy, you must approve all pending updates in the web console. For more details, refer to the "Manually approving a pending Operator update" section.

### Procedure

1. Back up the current **workloadUpdateMethods** configuration by running the following command:

```
$ WORKLOAD_UPDATE_METHODS=$(oc get kv kubevirt-kubevirt-hyperconverged -n openshift-cnv -o jsonpath='{.spec.workloadUpdateStrategy.workloadUpdateMethods}')
```

2. Turn off all workload update methods by running the following command:

```
$ oc patch hco kubevirt-hyperconverged -n openshift-cnv --type json -p '[{"op":"replace","path":"/spec/workloadUpdateStrategy/workloadUpdateMethods", "value":[]}]'
```

### Example output

```
hyperconverged.hco.kubevirt.io/kubevirt-hyperconverged patched
```

3. Ensure that the **HyperConverged** Operator is **Upgradeable** before you continue. Enter the following command and monitor the output:

```
$ oc get hco kubevirt-hyperconverged -n openshift-cnv -o json | jq ".status.conditions"
```

### Example 7.1. Example output

```
[
  {
    "lastTransitionTime": "2022-12-09T16:29:11Z",
    "message": "Reconcile completed successfully",
    "observedGeneration": 3,
    "reason": "ReconcileCompleted",
    "status": "True",
    "type": "ReconcileComplete"
  },
  {
    "lastTransitionTime": "2022-12-09T20:30:10Z",
    "message": "Reconcile completed successfully",
    "observedGeneration": 3,
    "reason": "ReconcileCompleted",
    "status": "True",
    "type": "Available"
  },
  {
    "lastTransitionTime": "2022-12-09T20:30:10Z",
    "message": "Reconcile completed successfully",
    "observedGeneration": 3,
    "reason": "ReconcileCompleted",
    "status": "False",
    "type": "Progressing"
  },
  {
    "lastTransitionTime": "2022-12-09T16:39:11Z",
    "message": "Reconcile completed successfully",
    "observedGeneration": 3,
    "reason": "ReconcileCompleted",
    "status": "False",
    "type": "Degraded"
  },
  {
    "lastTransitionTime": "2022-12-09T20:30:10Z",
    "message": "Reconcile completed successfully",
    "observedGeneration": 3,
    "reason": "ReconcileCompleted",
    "status": "True",
    "type": "Upgradeable" ①
  }
]
```

① The OpenShift Virtualization Operator has the **Upgradeable** status.

4. Manually update your cluster from the source EUS version to the next minor version of OpenShift Container Platform:

```
$ oc adm upgrade
```

## Verification

- Check the current version by running the following command:

```
$ oc get clusterversion
```



### NOTE

Updating OpenShift Container Platform to the next version is a prerequisite for updating OpenShift Virtualization. For more details, refer to the "Updating clusters" section of the OpenShift Container Platform documentation.

## 5. Update OpenShift Virtualization.

- With the default **Automatic** approval strategy, OpenShift Virtualization automatically updates to the corresponding version after you update OpenShift Container Platform.
- If you use the **Manual** approval strategy, approve the pending updates by using the web console.

## 6. Monitor the OpenShift Virtualization update by running the following command:

```
$ oc get csv -n openshift-cnv
```

- Update OpenShift Virtualization to every z-stream version that is available for the non-EUS minor version, monitoring each update by running the command shown in the previous step.
- Confirm that OpenShift Virtualization successfully updated to the latest z-stream release of the non-EUS version by running the following command:

```
$ oc get hco kubevirt-hyperconverged -n openshift-cnv -o json | jq ".status.versions"
```

### Example output

```
[  
 {  
   "name": "operator",  
   "version": "4.13.4"  
 }
```

- Wait until the **HyperConverged** Operator has the **Upgradeable** status before you perform the next update. Enter the following command and monitor the output:

```
$ oc get hco kubevirt-hyperconverged -n openshift-cnv -o json | jq ".status.conditions"
```

- Update OpenShift Container Platform to the target EUS version.

- Confirm that the update succeeded by checking the cluster version:

```
$ oc get clusterversion
```

12. Update OpenShift Virtualization to the target EUS version.
  - With the default **Automatic** approval strategy, OpenShift Virtualization automatically updates to the corresponding version after you update OpenShift Container Platform.
  - If you use the **Manual** approval strategy, approve the pending updates by using the web console.

13. Monitor the OpenShift Virtualization update by running the following command:

```
$ oc get csv -n openshift-cnv
```

The update completes when the **VERSION** field matches the target EUS version and the **PHASE** field reads **Succeeded**.

14. Restore the workload update methods configuration that you backed up:

```
$ oc patch hco kubevirt-hyperconverged -n openshift-cnv --type json -p "
[{\\"op\\\":\\"add\\",\\"path\\\":\\"/spec/workloadUpdateStrategy/workloadUpdateMethods\\",
\\"value\\\":\$WORKLOAD_UPDATE_METHODS}]"
```

#### Example output

```
hyperconverged.hco.kubevirt.io/kubevirt-hyperconverged patched
```

#### Verification

- Check the status of VM migration by running the following command:

```
$ oc get vmmim -A
```

#### Next steps

- You can now unpause the worker nodes' machine config pools.

## 7.4. CONFIGURING WORKLOAD UPDATE METHODS

You can configure workload update methods by editing the **HyperConverged** custom resource (CR).

#### Prerequisites

- To use live migration as an update method, you must first enable live migration in the cluster.



#### NOTE

If a **VirtualMachineInstance** CR contains **evictionStrategy: LiveMigrate** and the virtual machine instance (VMI) does not support live migration, the VMI will not update.

#### Procedure

1. To open the **HyperConverged** CR in your default editor, run the following command:

```
$ oc edit hco -n openshift-cnv kubevirt-hyperconverged
```

2. Edit the **workloadUpdateStrategy** stanza of the **HyperConverged** CR. For example:

```
apiVersion: hco.kubevirt.io/v1beta1
kind: HyperConverged
metadata:
  name: kubevirt-hyperconverged
spec:
  workloadUpdateStrategy:
    workloadUpdateMethods: ①
      - LiveMigrate ②
      - Evict ③
    batchEvictionSize: 10 ④
    batchEvictionInterval: "1m0s" ⑤
# ...
```

- 1 The methods that can be used to perform automated workload updates. The available values are **LiveMigrate** and **Evict**. If you enable both options as shown in this example, updates use **LiveMigrate** for VMIs that support live migration and **Evict** for any VMIs that do not support live migration. To disable automatic workload updates, you can either remove the **workloadUpdateStrategy** stanza or set **workloadUpdateMethods: []** to leave the array empty.
- 2 The least disruptive update method. VMIs that support live migration are updated by migrating the virtual machine (VM) guest into a new pod with the updated components enabled. If **LiveMigrate** is the only workload update method listed, VMIs that do not support live migration are not disrupted or updated.
- 3 A disruptive method that shuts down VMI pods during upgrade. **Evict** is the only update method available if live migration is not enabled in the cluster. If a VMI is controlled by a **VirtualMachine** object that has **runStrategy: always** configured, a new VMI is created in a new pod with updated components.
- 4 The number of VMIs that can be forced to be updated at a time by using the **Evict** method. This does not apply to the **LiveMigrate** method.
- 5 The interval to wait before evicting the next batch of workloads. This does not apply to the **LiveMigrate** method.



#### NOTE

You can configure live migration limits and timeouts by editing the **spec.liveMigrationConfig** stanza of the **HyperConverged** CR.

3. To apply your changes, save and exit the editor.

## 7.5. APPROVING PENDING OPERATOR UPDATES

### 7.5.1. Manually approving a pending Operator update

If an installed Operator has the approval strategy in its subscription set to **Manual**, when new updates are released in its current update channel, the update must be manually approved before installation can begin.

## Prerequisites

- An Operator previously installed using Operator Lifecycle Manager (OLM).

## Procedure

1. In the **Administrator** perspective of the OpenShift Container Platform web console, navigate to **Operators → Installed Operators**.
2. Operators that have a pending update display a status with **Upgrade available**. Click the name of the Operator you want to update.
3. Click the **Subscription** tab. Any updates requiring approval are displayed next to **Upgrade status**. For example, it might display **1 requires approval**.
4. Click **1 requires approval**, then click **Preview Install Plan**.
5. Review the resources that are listed as available for update. When satisfied, click **Approve**.
6. Navigate back to the **Operators → Installed Operators** page to monitor the progress of the update. When complete, the status changes to **Succeeded** and **Up to date**.

## 7.6. MONITORING UPDATE STATUS

### 7.6.1. Monitoring OpenShift Virtualization upgrade status

To monitor the status of a OpenShift Virtualization Operator upgrade, watch the cluster service version (CSV) **PHASE**. You can also monitor the CSV conditions in the web console or by running the command provided here.



#### NOTE

The **PHASE** and conditions values are approximations that are based on available information.

## Prerequisites

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

## Procedure

1. Run the following command:

```
$ oc get csv -n openshift-cnv
```
2. Review the output, checking the **PHASE** field. For example:

### Example output

VERSION REPLACES	PHASE
4.9.0 kubevirt-hyperconverged-operator.v4.8.2	Installing
4.9.0 kubevirt-hyperconverged-operator.v4.9.0	Replacing

3. Optional: Monitor the aggregated status of all OpenShift Virtualization component conditions by running the following command:

```
$ oc get hco -n openshift-cnv kubevirt-hyperconverged \
-o=jsonpath='{range .status.conditions[*]}{.type}{"\t"}{.status}{"\t"}{.message}{"\n"}{end}'
```

A successful upgrade results in the following output:

#### Example output

ReconcileComplete	True	Reconcile completed successfully
Available	True	Reconcile completed successfully
Progressing	False	Reconcile completed successfully
Degraded	False	Reconcile completed successfully
Upgradeable	True	Reconcile completed successfully

### 7.6.2. Viewing outdated OpenShift Virtualization workloads

You can view a list of outdated workloads by using the CLI.



#### NOTE

If there are outdated virtualization pods in your cluster, the **OutdatedVirtualMachineInstanceWorkloads** alert fires.

#### Procedure

- To view a list of outdated virtual machine instances (VMIs), run the following command:

```
$ oc get vmi -l kubevirt.io/outdatedLauncherImage --all-namespaces
```



#### NOTE

Configure workload updates to ensure that VMIs update automatically.

## 7.7. ADDITIONAL RESOURCES

- [Preparing to perform an EUS-to-EUS update](#)
- [What are Operators?](#)
- [Operator Lifecycle Manager concepts and resources](#)
- [Cluster service versions \(CSVs\)](#)
- [Virtual machine live migration](#)
- [Configuring virtual machine eviction strategy](#)

- Configuring live migration limits and timeouts

# CHAPTER 8. SECURITY POLICIES

Learn about OpenShift Virtualization security and authorization.

## Key points

- OpenShift Virtualization adheres to the [restricted Kubernetes pod security standards](#) profile, which aims to enforce the current best practices for pod security.
- Virtual machine (VM) workloads run as unprivileged pods.
- [Security context constraints](#) (SCCs) are defined for the **kubevirt-controller** service account.

## 8.1. ABOUT WORKLOAD SECURITY

By default, virtual machine (VM) workloads do not run with root privileges in OpenShift Virtualization, and there are no supported OpenShift Virtualization features that require root privileges.

For each VM, a **virt-launcher** pod runs an instance of **libvirt** in *session mode* to manage the VM process. In session mode, the **libvirt** daemon runs as a non-root user account and only permits connections from clients that are running under the same user identifier (UID). Therefore, VMs run as unprivileged pods, adhering to the security principle of least privilege.

## 8.2. ADDITIONAL OPENSHIFT CONTAINER PLATFORM SECURITY CONTEXT CONSTRAINTS AND LINUX CAPABILITIES FOR THE KUBEVIRT-CONTROLLER SERVICE ACCOUNT

Security context constraints (SCCs) control permissions for pods. These permissions include actions that a pod, a collection of containers, can perform and what resources it can access. You can use SCCs to define a set of conditions that a pod must run with to be accepted into the system.

The **virt-controller** is a cluster controller that creates the **virt-launcher** pods for virtual machines in the cluster. These pods are granted permissions by the **kubevirt-controller** service account.

The **kubevirt-controller** service account is granted additional SCCs and Linux capabilities so that it can create **virt-launcher** pods with the appropriate permissions. These extended permissions allow virtual machines to use OpenShift Virtualization features that are beyond the scope of typical pods.

The **kubevirt-controller** service account is granted the following SCCs:

- **scc.AllowHostDirVolumePlugin = true**  
This allows virtual machines to use the hostpath volume plugin.
- **scc.AllowPrivilegedContainer = false**  
This ensures the virt-launcher pod is not run as a privileged container.
- **scc.AllowedCapabilities = []corev1.Capability{"SYS\_NICE", "NET\_BIND\_SERVICE"}**
  - **SYS\_NICE** allows setting the CPU affinity.
  - **NET\_BIND\_SERVICE** allows DHCP and Slirp operations.

### 8.2.1. Viewing the SCC and RBAC definitions for the kubevirt-controller

You can view the **SecurityContextConstraints** definition for the **kubevirt-controller** by using the **oc** tool:

```
$ oc get scc kubevirt-controller -o yaml
```

You can view the RBAC definition for the **kubevirt-controller** clusterrole by using the **oc** tool:

```
$ oc get clusterrole kubevirt-controller -o yaml
```

## 8.3. AUTHORIZATION

OpenShift Virtualization uses [role-based access control](#) (RBAC) for authorization. For example, an administrator can create an RBAC role that provides the permissions required to launch a virtual machine. The administrator can then restrict access to that feature by binding the role to specific users.

### 8.3.1. Default cluster roles for OpenShift Virtualization

By using cluster role aggregation, OpenShift Virtualization extends the default OpenShift Container Platform cluster roles to include permissions for accessing virtualization objects.

**Table 8.1. OpenShift Virtualization cluster roles**

Default cluster role	OpenShift Virtualization cluster role	OpenShift Virtualization cluster role description
<b>view</b>	<b>kubevirt.io:view</b>	A user that can view all OpenShift Virtualization resources in the cluster but cannot create, delete, modify, or access them. For example, the user can see that a virtual machine (VM) is running but cannot shut it down or gain access to its console.
<b>edit</b>	<b>kubevirt.io:edit</b>	A user that can modify all OpenShift Virtualization resources in the cluster. For example, the user can create VMs, access VM consoles, and delete VMs.
<b>admin</b>	<b>kubevirt.io:admin</b>	A user that has full permissions to all OpenShift Virtualization resources, including the ability to delete collections of resources. The user can also view and modify the OpenShift Virtualization runtime configuration, which is located in the <b>HyperConverged</b> custom resource in the <b>openshift-cnv</b> namespace.

## 8.4. ADDITIONAL RESOURCES

- [Managing security context constraints](#)
- [Using RBAC to define and apply permissions](#)
- [Creating a cluster role](#)
- [Cluster role binding commands](#)
- [Enabling user permissions to clone data volumes across namespaces](#)

# CHAPTER 9. USING THE VIRTCTL AND LIBGUESTFS CLI TOOLS

You can manage OpenShift Virtualization resources by using the **virtctl** command line tool.

You can also deploy a **libguestfs-tools** container by using **virtctl**. **Libguestfs** is a set of tools for accessing and modifying virtual machine (VM) disk images.

## 9.1. INSTALLING VIRTCTL

To install **virtctl** on Linux, Windows, and MacOS operating systems, you download and install the the **virtctl** binary file.

To install **virtctl** on Red Hat Enterprise Linux (RHEL), you enable the OpenShift Virtualization repository and then install the **kubevirt-virtctl** package.

### 9.1.1. Installing virtctl on Linux, Windows, and macOS

Download and install the **virtctl** binary for your operating system.

#### Procedure

1. Navigate to **Virtualization** → **Overview** page in the OpenShift Container Platform web console.
2. Click the **Download virtctl** link to download the **virtctl** binary for your operating system.
3. Install **virtctl**:
  - For Linux:
    - a. Decompress the archive file:

```
$ tar -xvf <virtctl-version-distribution.arch>.tar.gz
```
    - b. Run the following command to make the **virtctl** binary executable:

```
$ chmod +x <path/virtctl-file-name>
```
    - c. Move the **virtctl** binary to a directory in your **PATH** environment variable.  
You can check your path by running the following command:

```
$ echo $PATH
```
    - d. Set the **KUBECONFIG** environment variable:

```
$ export KUBECONFIG=/home/<user>/clusters/current/auth/kubeconfig
```
  - For Windows:
    - a. Decompress the archive file.
    - b. Navigate the extracted folder hierarchy and double-click the **virtctl** executable file to install the client.

- c. Move the **virtctl** binary to a directory in your **PATH** environment variable.

You can check your path by running the following command:

```
C:\> path
```

- For macOS:

- a. Decompress the archive file.

- b. Move the **virtctl** binary to a directory in your **PATH** environment variable.

You can check your path by running the following command:

```
echo $PATH
```

## 9.1.2. Installing virtctl on RHEL

You install the **virtctl** RPM on Red Hat Enterprise Linux (RHEL) by enabling the OpenShift Virtualization repository and installing the **kubevirt-virtctl** package.

### Prerequisites

- Each host in your cluster must be registered with Red Hat Subscription Manager (RHSM) and have an active OpenShift Container Platform subscription.

### Procedure

- Enable the appropriate OpenShift Virtualization repository for your operating system by using the **subscription-manager** CLI tool:

- RHEL 9:

```
# subscription-manager repos --enable cnv-4.13-for-rhel-9-x86_64-rpms
```

- RHEL 8:

```
# subscription-manager repos --enable cnv-4.13-for-rhel-8-x86_64-rpms
```

- Install the **kubevirt-virtctl** package:

```
# yum install kubevirt-virtctl
```

## 9.2. VIRTCTL COMMANDS

The **virtctl** client is a command-line utility for managing OpenShift Virtualization resources.



### NOTE

The virtual machine (VM) commands also apply to virtual machine instances unless otherwise specified.

### 9.2.1. Virtctl information commands

You use **virtctl** information commands to view information about the **virtctl** client.

**Table 9.1. Information commands**

Command	Description
<b>virtctl version</b>	View the <b>virtctl</b> client and server versions.
<b>virtctl help</b>	View a list of <b>virtctl</b> commands.
<b>virtctl &lt;command&gt; -h --help</b>	View a list of options for a specific command.
<b>virtctl options</b>	View a list of global command options for any <b>virtctl</b> command.

### 9.2.2. VM information commands

You can use **virtctl** to view information about VMs and VMIs.

**Table 9.2. VM information commands**

Command	Description
<b>virtctl fslist &lt;vm_name&gt;</b>	View the file systems available on a guest machine.
<b>virtctl guestosinfo &lt;vm_name&gt;</b>	View information about the operating systems on a guest machine.
<b>virtctl userlist &lt;vm_name&gt;</b>	View the logged-in users on a guest machine.

### 9.2.3. VM management commands

You use **virtctl** virtual machine (VM) management commands to manage and migrate VMs and VMIs.

**Table 9.3. VM management commands**

Command	Description
<b>virtctl create -name &lt;vm_name&gt;</b>	Create a <b>VirtualMachine</b> manifest.
<b>virtctl start &lt;vm_name&gt;</b>	Start a VM.
<b>virtctl start --paused &lt;vm_name&gt;</b>	Start a VM in a paused state. This option enables you to interrupt the boot process from the VNC console.
<b>virtctl stop &lt;vm_name&gt;</b>	Stop a VM.
<b>virtctl stop &lt;vm_name&gt; --grace-period 0 --force</b>	Force stop a VM. This option might cause data inconsistency or data loss.

Command	Description
<b>virtctl pause vm &lt;vm_name&gt;</b>	Pause a VM. The machine state is kept in memory.
<b>virtctl unpause vm &lt;vm_name&gt;</b>	Unpause a VM.
<b>virtctl migrate &lt;vm_name&gt;</b>	Migrate a VM.
<b>virtctl restart &lt;vm_name&gt;</b>	Restart a VM.

#### 9.2.4. VM connection commands

You use **virtctl** connection commands to expose ports and connect to VMs and VMIs.

Table 9.4. VM connection commands

Command	Description
<b>virtctl console &lt;vm_name&gt;</b>	Connect to the serial console of a VM.
<b>virtctl expose &lt;vm_name&gt;</b>	Create a service that forwards a designated port of a VM and expose the service on the specified port of the node.
<b>virtctl scp -i &lt;ssh_key&gt; &lt;file_name&gt; &lt;user_name&gt;@&lt;vm_name&gt;</b>	Copy a file from your machine to a VM. This command uses the private key of an SSH key pair. The VM must be configured with the public key.
<b>virtctl scp -i &lt;ssh_key&gt; &lt;user_name&gt;@&lt;vm_name&gt;:&lt;file_name&gt; .</b>	Copy a file from a VM to your machine. This command uses the private key of an SSH key pair. The VM must be configured with the public key.
<b>virtctl ssh -i &lt;ssh_key&gt; &lt;user_name&gt;@&lt;vm_name&gt;</b>	Open an SSH connection with a VM. This command uses the private key of an SSH key pair. The VM must be configured with the public key.
<b>virtctl vnc --kubeconfig=\$KUBECONFIG &lt;vm_name&gt;</b>	Connect to the VNC console of a VM. Accessing the graphical console of a VM through VNC requires a remote viewer on your local machine.
<b>virtctl vnc --kubeconfig=\$KUBECONFIG --proxy-only=true &lt;vm_name&gt;</b>	Display the port number and connect manually to a VM by using any viewer through the VNC connection.
<b>virtctl vnc --kubeconfig=\$KUBECONFIG --port=&lt;port-number&gt; &lt;vm_name&gt;</b>	Specify a port number to run the proxy on the specified port, if that port is available. If a port number is not specified, the proxy runs on a random port.

## 9.2.5. VM export commands

You use **virtctl vmexport** commands to create, download, or delete a volume exported from a VM, VM snapshot, or persistent volume claim (PVC).

**Table 9.5. VM export commands**

Command	Description
<b>virtctl vmexport create &lt;vmexport_name&gt; --vm snapshot pvc= &lt;object_name&gt;</b>	Create a <b>VirtualMachineExport</b> custom resource (CR) to export a volume from a VM, VM snapshot, or PVC. <ul style="list-style-type: none"> <li>• <b>--vm</b>: Exports the PVCs of a VM.</li> <li>• <b>--snapshot</b>: Exports the PVCs contained in a <b>VirtualMachineSnapshot</b> CR.</li> <li>• <b>--pvc</b>: Exports a PVC.</li> <li>• Optional: <b>--ttl=1h</b> specifies the time to live. The default duration is 2 hours.</li> </ul>
<b>virtctl vmexport delete &lt;vmexport_name&gt;</b>	Delete a <b>VirtualMachineExport</b> CR manually.
<b>virtctl vmexport download &lt;vmexport_name&gt; --output= &lt;output_file&gt; --volume= &lt;volume_name&gt;</b>	Download the volume defined in a <b>VirtualMachineExport</b> CR. <ul style="list-style-type: none"> <li>• <b>--output</b> specifies the file format. Example: <b>disk.img.gz</b>.</li> <li>• <b>--volume</b> specifies the volume to download. This flag is optional if only one volume is available.</li> </ul> Optional: <ul style="list-style-type: none"> <li>• <b>--keep-vme</b> retains the <b>VirtualMachineExport</b> CR after download. The default behavior is to delete the <b>VirtualMachineExport</b> CR after download.</li> <li>• <b>--insecure</b> enables an insecure HTTP connection.</li> </ul>
<b>virtctl vmexport download &lt;vmexport_name&gt; --vm snapshot pvc= &lt;object_name&gt; --output= &lt;output_file&gt; --volume= &lt;volume_name&gt;</b>	Create a <b>VirtualMachineExport</b> CR and then download the volume defined in the CR.

## 9.2.6. VM memory dump commands

You can use the **virtctl memory-dump** command to output a VM memory dump on a PVC. You can specify an existing PVC or use the **--create-claim** flag to create a new PVC.

### Prerequisites

- The PVC volume mode must be **FileSystem**.

- The PVC must be large enough to contain the memory dump. The formula for calculating the PVC size is **(VMMemorySize + 100Mi) \* FileSystemOverhead**, where **100Mi** is the memory dump overhead.
- You must enable the hot plug feature gate in the **HyperConverged** custom resource by running the following command:

```
$ oc patch hco kubevirt-hyperconverged -n openshift-cnv \
--type json -p '[{"op": "add", "path": "/spec/featureGates", \
"value": "HotplugVolumes"}]'
```

## Downloading the memory dump

You must use the **virtctl vmexport download** command to download the memory dump:

```
$ virtctl vmexport download <vmexport_name> --vm\|pvc=<object_name> \
--volume=<volume_name> --output=<output_file>
```

**Table 9.6. VM memory dump commands**

Command	Description
<b>virtctl memory-dump get &lt;vm_name&gt; --claim-name=&lt;pvc_name&gt;</b>	<p>Save the memory dump of a VM on a PVC. The memory dump status is displayed in the <b>status</b> section of the <b>VirtualMachine</b> resource.</p> <p>Optional:</p> <ul style="list-style-type: none"> <li>• <b>--create-claim</b> creates a new PVC with the appropriate size. This flag has the following options: <ul style="list-style-type: none"> <li>◦ <b>--storage-class=&lt;storage_class&gt;</b>: Specify a storage class for the PVC.</li> <li>◦ <b>--access-mode=&lt;access_mode&gt;</b>: Specify <b>ReadWriteOnce</b> or <b>ReadWriteMany</b>.</li> </ul> </li> </ul>
<b>virtctl memory-dump get &lt;vm_name&gt;</b>	Rerun the <b>virtctl memory-dump</b> command with the same PVC. This command overwrites the previous memory dump.
<b>virtctl memory-dump remove &lt;vm_name&gt;</b>	<p>Remove a memory dump.</p> <p>You must remove a memory dump manually if you want to change the target PVC.</p> <p>This command removes the association between the VM and the PVC, so that the memory dump is not displayed in the <b>status</b> section of the <b>VirtualMachine</b> resource. The PVC is not affected.</p>

## 9.2.7. Hot plug and hot unplug commands

You use **virtctl** to add or remove resources from running VMs and VMIs.

**Table 9.7. Hot plug and hot unplug commands**

Command	Description
<b>virtctl addvolume</b> <b>&lt;vm_name&gt; --volume-name=</b> <b>&lt;datavolume_or_PVC&gt; [--persist] [-serial=&lt;label&gt;]</b>	Hot plug a data volume or persistent volume claim (PVC). Optional: <ul style="list-style-type: none"><li>• <b>--persist</b> mounts the virtual disk permanently on a VM. This flag does not apply to VMIs.</li><li>• <b>--serial=&lt;label&gt;</b> adds a label to the VM. If you do not specify a label, the default label is the data volume or PVC name.</li></ul>
<b>virtctl removevolume</b> <b>&lt;vm_name&gt; --volume-name=&lt;virtual_disk&gt;</b>	Hot unplug a virtual disk.

### 9.2.8. Image upload commands

You use the **virtctl image-upload** commands to upload a VM image to a data volume.

Table 9.8. Image upload commands

Command	Description
<b>virtctl image-upload dv</b> <b>&lt;datavolume_name&gt; --image-path=</b> <b>&lt;/path/to/image&gt; --no-create</b>	Upload a VM image to a data volume that already exists.
<b>virtctl image-upload dv</b> <b>&lt;datavolume_name&gt; --size=</b> <b>&lt;datavolume_size&gt; --image-path=&lt;/path/to/image&gt;</b>	Upload a VM image to a new data volume of a specified requested size.

## 9.3. USING LIBGUESTFS

### 9.3.1. Deploying a libguestfs-tools container by using virtctl

You can use the **virtctl guestfs** command to deploy an interactive container with **libguestfs-tools** and a persistent volume claim (PVC) attached to it.

#### Procedure

- To deploy a container with **libguestfs-tools**, mount the PVC, and attach a shell to it, run the following command:

```
$ virtctl guestfs -n <namespace> <pvc_name> ①
```

① The PVC name is a required argument. If you do not include it, an error message appears.

### 9.3.2. Libguestfs and virtctl guestfs commands

**Libguestfs** tools help you access and modify virtual machine (VM) disk images. You can use **libguestfs** tools to view and edit files in a guest, clone and build virtual machines, and format and resize disks.

You can also use the **virtctl guestfs** command and its sub-commands to modify, inspect, and debug VM disks on a PVC. To see a complete list of possible sub-commands, enter **virt-** on the command line and press the Tab key. For example:

Command	Description
<b>virt-edit -a /dev/vda /etc/motd</b>	Edit a file interactively in your terminal.
<b>virt-customize -a /dev/vda --ssh-inject root:string:&lt;public key example&gt;</b>	Inject an ssh key into the guest and create a login.
<b>virt-df -a /dev/vda -h</b>	See how much disk space is used by a VM.
<b>virt-customize -a /dev/vda --run-command 'rpm -qa &gt; /rpm-list'</b>	See the full list of all RPMs installed on a guest by creating an output file containing the full list.
<b>virt-cat -a /dev/vda /rpm-list</b>	Display the output file list of all RPMs created using the <b>virt-customize -a /dev/vda --run-command 'rpm -qa &gt; /rpm-list'</b> command in your terminal.
<b>virt-sysprep -a /dev/vda</b>	Seal a virtual machine disk image to be used as a template.

By default, **virtctl guestfs** creates a session with everything needed to manage a VM disk. However, the command also supports several flag options if you want to customize the behavior:

Flag Option	Description
<b>--h or --help</b>	Provides help for <b>guestfs</b> .
<b>-n &lt;namespace&gt;</b> option with a <b>&lt;pvc_name&gt;</b> argument	To use a PVC from a specific namespace.  If you do not use the <b>-n &lt;namespace&gt;</b> option, your current project is used. To change projects, use <b>oc project &lt;namespace&gt;</b> .  If you do not include a <b>&lt;pvc_name&gt;</b> argument, an error message appears.
<b>--image string</b>	Lists the <b>libguestfs-tools</b> container image.  You can configure the container to use a custom image by using the <b>--image</b> option.

Flag Option	Description
<b>--kvm</b>	<p>Indicates that <b>kvm</b> is used by the <b>libguestfs-tools</b> container.</p> <p>By default, <b>virtctl guestfs</b> sets up <b>kvm</b> for the interactive container, which greatly speeds up the <b>libguest-tools</b> execution because it uses QEMU.</p> <p>If a cluster does not have any <b>kvm</b> supporting nodes, you must disable <b>kvm</b> by setting the option <b>--kvm=false</b>.</p> <p>If not set, the <b>libguestfs-tools</b> pod remains pending because it cannot be scheduled on any node.</p>
<b>--pull-policy</b> string	<p>Shows the pull policy for the <b>libguestfs</b> image.</p> <p>You can also overwrite the image's pull policy by setting the <b>pull-policy</b> option.</p>

The command also checks if a PVC is in use by another pod, in which case an error message appears. However, once the **libguestfs-tools** process starts, the setup cannot avoid a new pod using the same PVC. You must verify that there are no active **virtctl guestfs** pods before starting the VM that accesses the same PVC.



#### NOTE

The **virtctl guestfs** command accepts only a single PVC attached to the interactive pod.

# CHAPTER 10. VIRTUAL MACHINES

## 10.1. CREATING VIRTUAL MACHINES

Use one of these procedures to create a virtual machine:

- Quick Start guided tour
- Quick create from the **Catalog**
- Pasting a pre-configured YAML file with the virtual machine wizard
- Using the CLI



### WARNING

Do not create virtual machines in **openshift-\*** namespaces. Instead, create a new namespace or use an existing namespace without the **openshift** prefix.

When you create virtual machines from the web console, select a virtual machine template that is configured with a boot source. Virtual machine templates with a boot source are labeled as **Available boot source** or they display a customized label text. Using templates with an available boot source expedites the process of creating virtual machines.

Templates without a boot source are labeled as **Boot source required**. You can use these templates if you complete the steps for [adding a boot source to the virtual machine](#).



### IMPORTANT

Due to differences in storage behavior, some virtual machine templates are incompatible with single-node OpenShift. To ensure compatibility, do not set the **evictionStrategy** field for any templates or virtual machines that use data volumes or storage profiles.

### 10.1.1. Using a Quick Start to create a virtual machine

The web console provides Quick Starts with instructional guided tours for creating virtual machines. You can access the Quick Starts catalog by selecting the Help menu in the **Administrator** perspective to view the Quick Starts catalog. When you click on a Quick Start tile and begin the tour, the system guides you through the process.

Tasks in a Quick Start begin with selecting a Red Hat template. Then, you can add a boot source and import the operating system image. Finally, you can save the custom template and use it to create a virtual machine.

#### Prerequisites

- Access to the website where you can download the URL link for the operating system image.

#### Procedure

1. In the web console, select **Quick Starts** from the Help menu.
2. Click on a tile in the Quick Starts catalog. For example: **Creating a Red Hat Linux Enterprise Linux virtual machine**.
3. Follow the instructions in the guided tour and complete the tasks for importing an operating system image and creating a virtual machine. The **Virtualization → VirtualMachines** page displays the virtual machine.

### 10.1.2. Quick creating a virtual machine

You can quickly create a virtual machine (VM) by using a template with an available boot source.

#### Procedure

1. Click **Virtualization → Catalog** in the side menu.
2. Click **Boot source available** to filter templates with boot sources.



#### NOTE

By default, the template list will show only **Default Templates**. Click **All Items** when filtering to see all available templates for your chosen filters.

3. Click a template to view its details.
4. Click **Quick Create VirtualMachine** to create a VM from the template.  
The virtual machine **Details** page is displayed with the provisioning status.

#### Verification

1. Click **Events** to view a stream of events as the VM is provisioned.
2. Click **Console** to verify that the VM booted successfully.

### 10.1.3. Creating a virtual machine from a customized template

Some templates require additional parameters, for example, a PVC with a boot source. You can customize select parameters of a template to create a virtual machine (VM).

#### Procedure

1. In the web console, select a template:
  - a. Click **Virtualization → Catalog** in the side menu.
  - b. Optional: Filter the templates by project, keyword, operating system, or workload profile.
  - c. Click the template that you want to customize.
2. Click **Customize VirtualMachine**.
3. Specify parameters for your VM, including its **Name** and **Disk source**. You can optionally specify a data source to clone.

## Verification

1. Click **Events** to view a stream of events as the VM is provisioned.
2. Click **Console** to verify that the VM booted successfully.

Refer to the virtual machine fields section when creating a VM from the web console.

### 10.1.3.1. Networking fields

Name	Description
Name	Name for the network interface controller.
Model	Indicates the model of the network interface controller. Supported values are <b>e1000e</b> and <b>virtio</b> .
Network	List of available network attachment definitions.
Type	List of available binding methods. Select the binding method suitable for the network interface: <ul style="list-style-type: none"> <li>● Default pod network: <b>masquerade</b></li> <li>● Linux bridge network: <b>bridge</b></li> <li>● SR-IOV network: <b>SR-IOV</b></li> </ul>
MAC Address	MAC address for the network interface controller. If a MAC address is not specified, one is assigned automatically.

### 10.1.3.2. Storage fields

Name	Selection	Description
Source	Blank (creates PVC)	Create an empty disk.
	Import via URL (creates PVC)	Import content via URL (HTTP or HTTPS endpoint).
	Use an existing PVC	Use a PVC that is already available in the cluster.
	Clone existing PVC (creates PVC)	Select an existing PVC available in the cluster and clone it.
	Import via Registry (creates PVC)	Import content via container registry.

Name	Selection	Description
	Container (ephemeral)	Upload content from a container located in a registry accessible from the cluster. The container disk should be used only for read-only filesystems such as CD-ROMs or temporary virtual machines.
Name		Name of the disk. The name can contain lowercase letters ( <b>a-z</b> ), numbers ( <b>0-9</b> ), hyphens (-), and periods (.), up to a maximum of 253 characters. The first and last characters must be alphanumeric. The name must not contain uppercase letters, spaces, or special characters.
Size		Size of the disk in GiB.
Type		Type of disk. Example: Disk or CD-ROM
Interface		Type of disk device. Supported interfaces are <b>virtIO</b> , <b>SATA</b> , and <b>SCSI</b> .
Storage Class		The storage class that is used to create the disk.

### Advanced storage settings

The following advanced storage settings are optional and available for **Blank**, **Import via URL**, and **Clone existing PVC** disks. Before OpenShift Virtualization 4.11, if you do not specify these parameters, the system uses the default values from the **kubevirt-storage-class-defaults** config map. In OpenShift Virtualization 4.11 and later, the system uses the default values from the [storage profile](#).



#### NOTE

Use storage profiles to ensure consistent advanced storage settings when provisioning storage for OpenShift Virtualization.

To manually specify **Volume Mode** and **Access Mode**, you must clear the **Apply optimized StorageProfile settings** checkbox, which is selected by default.

Name	Mode description	Parameter	Parameter description

Name	Mode description	Parameter	Parameter description
Volume Mode	Defines whether the persistent volume uses a formatted file system or raw block state. Default is <b>Filesystem</b> .	Filesystem	Stores the virtual disk on a file system-based volume.
		Block	Stores the virtual disk directly on the block volume. Only use <b>Block</b> if the underlying storage supports it.
Access Mode	Access mode of the persistent volume.	ReadWriteOnce (RWO)	Volume can be mounted as read-write by a single node.
		ReadWriteMany (RWX)	Volume can be mounted as read-write by many nodes at one time.
		ReadOnlyMany (ROX)	 <b>NOTE</b> This is required for some features, such as live migration of virtual machines between nodes.

#### 10.1.3.3. Cloud-init fields

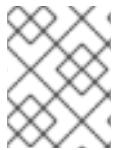
Name	Description
Authorized SSH Keys	The user's public key that is copied to <code>~/.ssh/authorized_keys</code> on the virtual machine.
Custom script	Replaces other options with a field in which you paste a custom cloud-init script.

To configure storage class defaults, use storage profiles. For more information, see [Customizing the storage profile](#).

#### 10.1.3.4. Pasting in a pre-configured YAML file to create a virtual machine

Create a virtual machine by writing or pasting a YAML configuration file. A valid **example** virtual machine configuration is provided by default whenever you open the YAML edit screen.

If your YAML configuration is invalid when you click **Create**, an error message indicates the parameter in which the error occurs. Only one error is shown at a time.



### NOTE

Navigating away from the YAML screen while editing cancels any changes to the configuration you have made.

### Procedure

1. Click **Virtualization** → **VirtualMachines** from the side menu.
2. Click **Create** and select **With YAML**.
3. Write or paste your virtual machine configuration in the editable window.
  - a. Alternatively, use the **example** virtual machine provided by default in the YAML screen.
4. Optional: Click **Download** to download the YAML configuration file in its present state.
5. Click **Create** to create the virtual machine.

The virtual machine is listed on the **VirtualMachines** page.

#### 10.1.4. Using the CLI to create a virtual machine

You can create a virtual machine from a **virtualMachine** manifest.

### Procedure

1. Edit the **VirtualMachine** manifest for your VM. For example, the following manifest configures a Red Hat Enterprise Linux (RHEL) VM:

#### Example 10.1. Example manifest for a RHEL VM

```
apiVersion: kubevirt.io/v1
kind: VirtualMachine
metadata:
  labels:
    app: <vm_name> ①
    name: <vm_name>
spec:
  dataVolumeTemplates:
  - apiVersion: cdi.kubevirt.io/v1beta1
    kind: DataVolume
    metadata:
      name: <vm_name>
    spec:
      sourceRef:
        kind: DataSource
        name: rhel9
        namespace: openshift-virtualization-os-images
      storage:
```

```
resources:
  requests:
    storage: 30Gi
running: false
template:
  metadata:
    labels:
      kubevirt.io/domain: <vm_name>
spec:
  domain:
    cpu:
      cores: 1
      sockets: 2
      threads: 1
    devices:
      disks:
        - disk:
            bus: virtio
            name: rootdisk
        - disk:
            bus: virtio
            name: cloudinitdisk
    interfaces:
      - masquerade: {}
        name: default
      rng: {}
    features:
      smm:
        enabled: true
  firmware:
    bootloader:
      efi: {}
  resources:
    requests:
      memory: 8Gi
  evictionStrategy: LiveMigrate
  networks:
    - name: default
      pod: {}
  volumes:
    - dataVolume:
        name: <vm_name>
        name: rootdisk
    - cloudInitNoCloud:
        userData: |-  
          #cloud-config  
          user: cloud-user  
          password: '<password>' 2  
          chpasswd: { expire: False }
        name: cloudinitdisk
```

- 1** Specify the name of the virtual machine.
- 2** Specify the password for cloud-user.

2. Create a virtual machine by using the manifest file:

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

3. Optional: Start the virtual machine:

```
$ virtctl start <vm_name>
```

### 10.1.5. Virtual machine storage volume types

Storage volume type	Description
ephemeral	A local copy-on-write (COW) image that uses a network volume as a read-only backing store. The backing volume must be a <b>PersistentVolumeClaim</b> . The ephemeral image is created when the virtual machine starts and stores all writes locally. The ephemeral image is discarded when the virtual machine is stopped, restarted, or deleted. The backing volume (PVC) is not mutated in any way.
persistentVolumeClaim	Attaches an available PV to a virtual machine. Attaching a PV allows for the virtual machine data to persist between sessions.  Importing an existing virtual machine disk into a PVC by using CDI and attaching the PVC to a virtual machine instance is the recommended method for importing existing virtual machines into OpenShift Container Platform. There are some requirements for the disk to be used within a PVC.
dataVolume	Data volumes build on the <b>persistentVolumeClaim</b> disk type by managing the process of preparing the virtual machine disk via an import, clone, or upload operation. VMs that use this volume type are guaranteed not to start until the volume is ready.  Specify <b>type: dataVolume</b> or <b>type: ""</b> . If you specify any other value for <b>type</b> , such as <b>persistentVolumeClaim</b> , a warning is displayed, and the virtual machine does not start.
cloudInitNoCloud	Attaches a disk that contains the referenced cloud-init NoCloud data source, providing user data and metadata to the virtual machine. A cloud-init installation is required inside the virtual machine disk.

Storage volume type	Description
containerDisk	<p>References an image, such as a virtual machine disk, that is stored in the container image registry. The image is pulled from the registry and attached to the virtual machine as a disk when the virtual machine is launched.</p> <p>A <b>containerDisk</b> volume is not limited to a single virtual machine and is useful for creating large numbers of virtual machine clones that do not require persistent storage.</p> <p>Only RAW and QCOW2 formats are supported disk types for the container image registry. QCOW2 is recommended for reduced image size.</p> <p> <b>NOTE</b></p> <p>A <b>containerDisk</b> volume is ephemeral. It is discarded when the virtual machine is stopped, restarted, or deleted. A <b>containerDisk</b> volume is useful for read-only file systems such as CD-ROMs or for disposable virtual machines.</p>
emptyDisk	<p>Creates an additional sparse QCOW2 disk that is tied to the life-cycle of the virtual machine interface. The data survives guest-initiated reboots in the virtual machine but is discarded when the virtual machine stops or is restarted from the web console. The empty disk is used to store application dependencies and data that otherwise exceeds the limited temporary file system of an ephemeral disk.</p> <p>The disk <b>capacity</b> size must also be provided.</p>

### 10.1.6. About RunStrategies for virtual machines

A **RunStrategy** for virtual machines determines a virtual machine instance's (VMI) behavior, depending on a series of conditions. The **spec.runStrategy** setting exists in the virtual machine configuration process as an alternative to the **spec.running** setting. The **spec.runStrategy** setting allows greater flexibility for how VMIs are created and managed, in contrast to the **spec.running** setting with only **true** or **false** responses. However, the two settings are mutually exclusive. Only either **spec.running** or **spec.runStrategy** can be used. An error occurs if both are used.

There are four defined RunStrategies.

#### Always

A VMI is always present when a virtual machine is created. A new VMI is created if the original stops for any reason, which is the same behavior as **spec.running: true**.

## RerunOnFailure

A VMI is re-created if the previous instance fails due to an error. The instance is not re-created if the virtual machine stops successfully, such as when it shuts down.

## Manual

The **start**, **stop**, and **restart** virtctl client commands can be used to control the VMI's state and existence.

## Halted

No VMI is present when a virtual machine is created, which is the same behavior as **spec.running: false**.

Different combinations of the **start**, **stop** and **restart** virtctl commands affect which **RunStrategy** is used.

The following table follows a VM's transition from different states. The first column shows the VM's initial **RunStrategy**. Each additional column shows a virtctl command and the new **RunStrategy** after that command is run.

Initial RunStrategy	start	stop	restart
Always	-	Halted	Always
RerunOnFailure	-	Halted	RerunOnFailure
Manual	Manual	Manual	Manual
Halted	Always	-	-



### NOTE

In OpenShift Virtualization clusters installed using installer-provisioned infrastructure, when a node fails the MachineHealthCheck and becomes unavailable to the cluster, VMs with a RunStrategy of **Always** or **RerunOnFailure** are rescheduled on a new node.

```
apiVersion: kubevirt.io/v1
kind: VirtualMachine
spec:
  RunStrategy: Always ①
  template:
    # ...
```

- ① The VMI's current **RunStrategy** setting.

### 10.1.7. Additional resources

- The **VirtualMachineSpec** definition in the [KubeVirt v0.59.0 API Reference](#) provides broader context for the parameters and hierarchy of the virtual machine specification.



## NOTE

The KubeVirt API Reference is the upstream project reference and might contain parameters that are not supported in OpenShift Virtualization.

- Enable the [CPU Manager](#) to use the high-performance workload profile.
- See [Prepare a container disk](#) before adding it to a virtual machine as a **containerDisk** volume.
- See [Deploying machine health checks](#) for further details on deploying and enabling machine health checks.
- See [Installer-provisioned infrastructure overview](#) for further details on installer-provisioned infrastructure.
- [Customizing the storage profile](#)

## 10.2. EDITING VIRTUAL MACHINES

You can update a virtual machine configuration using either the YAML editor in the web console or the OpenShift CLI on the command line. You can also update a subset of the parameters in the **Virtual Machine Details** screen.

### 10.2.1. Editing a virtual machine in the web console

You can edit a virtual machine by using the OpenShift Container Platform web console or the command line interface.

#### Procedure

1. Navigate to **Virtualization** → **VirtualMachines** in the web console.
2. Select a virtual machine to open the **VirtualMachine details** page.
3. Click any field that has the pencil icon, which indicates that the field is editable. For example, click the current **Boot mode** setting, such as BIOS or UEFI, to open the **Boot mode** window and select an option from the list.
4. Click **Save**.



## NOTE

If the virtual machine is running, changes to **Boot Order** or **Flavor** will not take effect until you restart the virtual machine.

You can view pending changes by clicking **View Pending Changes** on the right side of the relevant field. The **Pending Changes** banner at the top of the page displays a list of all changes that will be applied when the virtual machine restarts.

### 10.2.2. Editing a virtual machine YAML configuration using the web console

You can edit the YAML configuration of a virtual machine in the web console. Some parameters cannot be modified. If you click **Save** with an invalid configuration, an error message indicates the parameter that cannot be changed.

**NOTE**

Navigating away from the YAML screen while editing cancels any changes to the configuration you have made.

**Procedure**

1. Click **Virtualization** → **VirtualMachines** from the side menu.
2. Select a virtual machine.
3. Click the **YAML** tab to display the editable configuration.
4. Optional: You can click **Download** to download the YAML file locally in its current state.
5. Edit the file and click **Save**.

A confirmation message shows that the modification has been successful and includes the updated version number for the object.

### 10.2.3. Editing a virtual machine YAML configuration using the CLI

Use this procedure to edit a virtual machine YAML configuration using the CLI.

**Prerequisites**

- You configured a virtual machine with a YAML object configuration file.
- You installed the **oc** CLI.

**Procedure**

1. Run the following command to update the virtual machine configuration:

```
$ oc edit <object_type> <object_ID>
```

2. Open the object configuration.
3. Edit the YAML.
4. If you edit a running virtual machine, you need to do one of the following:
  - Restart the virtual machine.
  - Run the following command for the new configuration to take effect:

```
$ oc apply <object_type> <object_ID>
```

### 10.2.4. Adding a virtual disk to a virtual machine

Use this procedure to add a virtual disk to a virtual machine.

**Procedure**

1. Click **Virtualization** → **VirtualMachines** from the side menu.

2. Select a virtual machine to open the **VirtualMachine details** page.
3. On the **Configuration → Disks** tab, click **Add disk**.
4. Specify the **Source**, **Name**, **Size**, **Type**, **Interface**, and **Storage Class**.
  - a. Optional: You can enable preallocation if you use a blank disk source and require maximum write performance when creating data volumes. To do so, select the **Enable preallocation** checkbox.
  - b. Optional: You can clear **Apply optimized StorageProfile settings** to change the **Volume Mode** and **Access Mode** for the virtual disk. If you do not specify these parameters, the system uses the default values from the **kubevirt-storage-class-defaults** config map.
5. Click **Add**.



#### NOTE

If the virtual machine is running, the new disk is in the **pending restart** state and will not be attached until you restart the virtual machine.

The **Pending Changes** banner at the top of the page displays a list of all changes that will be applied when the virtual machine restarts.

To configure storage class defaults, use storage profiles. For more information, see [Customizing the storage profile](#).

#### 10.2.4.1. Storage fields

Name	Selection	Description
Source	Blank (creates PVC)	Create an empty disk.
	Import via URL (creates PVC)	Import content via URL (HTTP or HTTPS endpoint).
	Use an existing PVC	Use a PVC that is already available in the cluster.
	Clone existing PVC (creates PVC)	Select an existing PVC available in the cluster and clone it.
	Import via Registry (creates PVC)	Import content via container registry.
	Container (ephemeral)	Upload content from a container located in a registry accessible from the cluster. The container disk should be used only for read-only filesystems such as CD-ROMs or temporary virtual machines.

Name	Selection	Description
Name		Name of the disk. The name can contain lowercase letters ( <b>a-z</b> ), numbers ( <b>0-9</b> ), hyphens (-), and periods (.), up to a maximum of 253 characters. The first and last characters must be alphanumeric. The name must not contain uppercase letters, spaces, or special characters.
Size		Size of the disk in GiB.
Type		Type of disk. Example: Disk or CD-ROM
Interface		Type of disk device. Supported interfaces are <b>virtIO</b> , <b>SATA</b> , and <b>SCSI</b> .
Storage Class		The storage class that is used to create the disk.

### Advanced storage settings

The following advanced storage settings are optional and available for **Blank**, **Import via URL**, and **Clone existing PVC** disks. Before OpenShift Virtualization 4.11, if you do not specify these parameters, the system uses the default values from the **kubevirt-storage-class-defaults** config map. In OpenShift Virtualization 4.11 and later, the system uses the default values from the [storage profile](#).



#### NOTE

Use storage profiles to ensure consistent advanced storage settings when provisioning storage for OpenShift Virtualization.

To manually specify **Volume Mode** and **Access Mode**, you must clear the **Apply optimized StorageProfile settings** checkbox, which is selected by default.

Name	Mode description	Parameter	Parameter description
Volume Mode	Defines whether the persistent volume uses a formatted file system or raw block state. Default is <b>Filesystem</b> .	Filesystem	Stores the virtual disk on a file system-based volume.
		Block	Stores the virtual disk directly on the block volume. Only use <b>Block</b> if the underlying storage supports it.

Name	Mode description	Parameter	Parameter description
Access Mode	Access mode of the persistent volume.	ReadWriteOnce (RWO)	Volume can be mounted as read-write by a single node.
		ReadWriteMany (RWX)	Volume can be mounted as read-write by many nodes at one time.
		ReadOnlyMany (ROX)	 <b>NOTE</b> This is required for some features, such as live migration of virtual machines between nodes.

### 10.2.5. Adding a secret, config map, or service account to a virtual machine

You add a secret, config map, or service account to a virtual machine by using the OpenShift Container Platform web console.

These resources are added to the virtual machine as disks. You then mount the secret, config map, or service account as you would mount any other disk.

If the virtual machine is running, changes do not take effect until you restart the virtual machine. The newly added resources are marked as pending changes at the top of the page.

#### Prerequisites

- The secret, config map, or service account that you want to add must exist in the same namespace as the target virtual machine.

#### Procedure

- Click **Virtualization** → **VirtualMachines** from the side menu.
- Select a virtual machine to open the **VirtualMachine details** page.
- Click **Configuration** → **Environment**.
- Click **Add Config Map, Secret or Service Account**
- Click **Select a resource** and select a resource from the list. A six character serial number is automatically generated for the selected resource.

6. Optional: Click **Reload** to revert the environment to its last saved state.

7. Click **Save**.

## Verification

1. On the **VirtualMachine details** page, click **Configuration → Disks** and verify that the resource is displayed in the list of disks.
2. Restart the virtual machine by clicking **Actions → Restart**.

You can now mount the secret, config map, or service account as you would mount any other disk.

## Additional resources for config maps, secrets, and service accounts

- [Understanding config maps](#)
- [Providing sensitive data to pods](#)
- [Understanding and creating service accounts](#)

### 10.2.6. Adding a network interface to a virtual machine

Use this procedure to add a network interface to a virtual machine.

#### Procedure

1. Click **Virtualization → VirtualMachines** from the side menu.
2. Select a virtual machine to open the **VirtualMachine details** page.
3. On the **Configuration → Network interfaces** tab, click **Add Network Interface**.
4. In the **Add Network Interface** window, specify the **Name**, **Model**, **Network**, **Type**, and **MAC Address** of the network interface.
5. Click **Add**.



#### NOTE

If the virtual machine is running, the new network interface is in the **pending restart** state and changes will not take effect until you restart the virtual machine.

The **Pending Changes** banner at the top of the page displays a list of all changes that will be applied when the virtual machine restarts.

#### 10.2.6.1. Networking fields

Name	Description
Name	Name for the network interface controller.
Model	Indicates the model of the network interface controller. Supported values are <b>e1000e</b> and <b>virtio</b> .

Name	Description
Network	List of available network attachment definitions.
Type	List of available binding methods. Select the binding method suitable for the network interface: <ul style="list-style-type: none"> <li>● Default pod network: <b>masquerade</b></li> <li>● Linux bridge network: <b>bridge</b></li> <li>● SR-IOV network: <b>SR-IOV</b></li> </ul>
MAC Address	MAC address for the network interface controller. If a MAC address is not specified, one is assigned automatically.

## 10.3. EDITING BOOT ORDER

You can update the values for a boot order list by using the web console or the CLI.

With **Boot Order** in the [Virtual Machine Overview](#) page, you can:

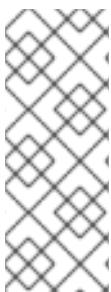
- Select a disk or network interface controller (NIC) and add it to the boot order list.
- Edit the order of the disks or NICs in the boot order list.
- Remove a disk or NIC from the boot order list, and return it back to the inventory of bootable sources.

### 10.3.1. Adding items to a boot order list in the web console

Add items to a boot order list by using the web console.

#### Procedure

1. Click **Virtualization** → **VirtualMachines** from the side menu.
2. Select a virtual machine to open the **VirtualMachine details** page.
3. Click the **Details** tab.
4. Click the pencil icon that is located on the right side of **Boot Order**. If a YAML configuration does not exist, or if this is the first time that you are creating a boot order list, the following message displays: **No resource selected. VM will attempt to boot from disks by order of appearance in YAML file.**
5. Click **Add Source** and select a bootable disk or network interface controller (NIC) for the virtual machine.
6. Add any additional disks or NICs to the boot order list.
7. Click **Save**.

**NOTE**

If the virtual machine is running, changes to **Boot Order** will not take effect until you restart the virtual machine.

You can view pending changes by clicking **View Pending Changes** on the right side of the **Boot Order** field. The **Pending Changes** banner at the top of the page displays a list of all changes that will be applied when the virtual machine restarts.

### 10.3.2. Editing a boot order list in the web console

Edit the boot order list in the web console.

**Procedure**

1. Click **Virtualization** → **VirtualMachines** from the side menu.
2. Select a virtual machine to open the **VirtualMachine details** page.
3. Click the **Details** tab.
4. Click the pencil icon that is located on the right side of **Boot Order**.
5. Choose the appropriate method to move the item in the boot order list:
  - If you do not use a screen reader, hover over the arrow icon next to the item that you want to move, drag the item up or down, and drop it in a location of your choice.
  - If you use a screen reader, press the Up Arrow key or Down Arrow key to move the item in the boot order list. Then, press the **Tab** key to drop the item in a location of your choice.
6. Click **Save**.

**NOTE**

If the virtual machine is running, changes to the boot order list will not take effect until you restart the virtual machine.

You can view pending changes by clicking **View Pending Changes** on the right side of the **Boot Order** field. The **Pending Changes** banner at the top of the page displays a list of all changes that will be applied when the virtual machine restarts.

### 10.3.3. Editing a boot order list in the YAML configuration file

Edit the boot order list in a YAML configuration file by using the CLI.

**Procedure**

1. Open the YAML configuration file for the virtual machine by running the following command:
 

`$ oc edit vm example`
2. Edit the YAML file and modify the values for the boot order associated with a disk or network interface controller (NIC). For example:

```

disks:
- bootOrder: 1 ①
disk:
  bus: virtio
  name: containerdisk
- disk:
  bus: virtio
  name: cloudinitdisk
- cdrom:
  bus: virtio
  name: cd-drive-1
interfaces:
- boot Order: 2 ②
  macAddress: '02:96:c4:00:00'
  masquerade: {}
  name: default

```

- ① The boot order value specified for the disk.
- ② The boot order value specified for the network interface controller.

3. Save the YAML file.
4. Click **reload the content** to apply the updated boot order values from the YAML file to the boot order list in the web console.

#### 10.3.4. Removing items from a boot order list in the web console

Remove items from a boot order list by using the web console.

##### Procedure

1. Click **Virtualization** → **VirtualMachines** from the side menu.
2. Select a virtual machine to open the **VirtualMachine details** page.
3. Click the **Details** tab.
4. Click the pencil icon that is located on the right side of **Boot Order**.
5. Click the **Remove** icon ⓧ next to the item. The item is removed from the boot order list and saved in the list of available boot sources. If you remove all items from the boot order list, the following message displays: **No resource selected. VM will attempt to boot from disks by order of appearance in YAML file.**



##### NOTE

If the virtual machine is running, changes to **Boot Order** will not take effect until you restart the virtual machine.

You can view pending changes by clicking **View Pending Changes** on the right side of the **Boot Order** field. The **Pending Changes** banner at the top of the page displays a list of all changes that will be applied when the virtual machine restarts.

## 10.4. DELETING VIRTUAL MACHINES

You can delete a virtual machine from the web console or by using the **oc** command line interface.

### 10.4.1. Deleting a virtual machine using the web console

Deleting a virtual machine permanently removes it from the cluster.

#### Procedure

1. In the OpenShift Container Platform console, click **Virtualization** → **VirtualMachines** from the side menu.
2. Click the Options menu  beside a virtual machine and select **Delete**. Alternatively, click the virtual machine name to open the **VirtualMachine details** page and click **Actions** → **Delete**.
3. Optional: Select **With grace period** or clear **Delete disks**.
4. Click **Delete** to permanently delete the virtual machine.

### 10.4.2. Deleting a virtual machine by using the CLI

You can delete a virtual machine by using the **oc** command line interface (CLI). The **oc** client enables you to perform actions on multiple virtual machines.

#### Prerequisites

- Identify the name of the virtual machine that you want to delete.

#### Procedure

- Delete the virtual machine by running the following command:

```
$ oc delete vm <vm_name>
```



#### NOTE

This command only deletes a VM in the current project. Specify the **-n <project\_name>** option if the VM you want to delete is in a different project or namespace.

## 10.5. EXPORTING VIRTUAL MACHINES

You can export a virtual machine (VM) and its associated disks in order to import a VM into another cluster or to analyze the volume for forensic purposes.

You create a **VirtualMachineExport** custom resource (CR) by using the command line interface.

Alternatively, you can use the **virtctl vmexport** command to create a **VirtualMachineExport** CR and to download exported volumes.

## 10.5.1. Creating a **VirtualMachineExport** custom resource

You can create a **VirtualMachineExport** custom resource (CR) to export the following objects:

- Virtual machine (VM): Exports the persistent volume claims (PVCs) of a specified VM.
- VM snapshot: Exports PVCs contained in a **VirtualMachineSnapshot** CR.
- PVC: Exports a PVC. If the PVC is used by another pod, such as the **virt-launcher** pod, the export remains in a **Pending** state until the PVC is no longer in use.

The **VirtualMachineExport** CR creates internal and external links for the exported volumes. Internal links are valid within the cluster. External links can be accessed by using an **Ingress** or **Route**.

The export server supports the following file formats:

- **raw**: Raw disk image file.
- **gzip**: Compressed disk image file.
- **dir**: PVC directory and files.
- **tar.gz**: Compressed PVC file.

### Prerequisites

- The VM must be shut down for a VM export.

### Procedure

- 1 Create a **VirtualMachineExport** manifest to export a volume from a **VirtualMachine**, **VirtualMachineSnapshot**, or **PersistentVolumeClaim** CR according to the following example and save it as **example-export.yaml**:

#### **VirtualMachineExport** example

```
apiVersion: export.kubevirt.io/v1alpha1
kind: VirtualMachineExport
metadata:
  name: example-export
spec:
  source:
    apiGroup: "kubevirt.io" ①
    kind: VirtualMachine ②
    name: example-vm
    ttlDuration: 1h ③
```

- 1 Specify the appropriate API group:

- "**kubevirt.io**" for **VirtualMachine**.
- "**snapshot.kubevirt.io**" for **VirtualMachineSnapshot**.
- "" for **PersistentVolumeClaim**.

- 2** Specify **VirtualMachine**, **VirtualMachineSnapshot**, or **PersistentVolumeClaim**.
- 3** Optional. The default duration is 2 hours.

2. Create the **VirtualMachineExport** CR:

```
$ oc create -f example-export.yaml
```

3. Get the **VirtualMachineExport** CR:

```
$ oc get vmexport example-export -o yaml
```

The internal and external links for the exported volumes are displayed in the **status** stanza:

### Output example

```
apiVersion: export.kubevirt.io/v1alpha1
kind: VirtualMachineExport
metadata:
  name: example-export
  namespace: example
spec:
  source:
    apiGroup: ""
    kind: PersistentVolumeClaim
    name: example-pvc
    tokenSecretRef: example-token
status:
  conditions:
    - lastProbeTime: null
      lastTransitionTime: "2022-06-21T14:10:09Z"
      reason: podReady
      status: "True"
      type: Ready
    - lastProbeTime: null
      lastTransitionTime: "2022-06-21T14:09:02Z"
      reason: pvcBound
      status: "True"
      type: PVCReady
  links:
    external: 1
    cert: |-  
-----BEGIN CERTIFICATE-----  
...  
-----END CERTIFICATE-----  
  volumes:  
    - formats:  
      - format: raw  
        url: https://vmexport-  
proxy.test.net/api/export.kubevirt.io/v1alpha1/namespaces/example/virtualmachineexports/exam-  
ple-export/volumes/example-disk/disk.img  
      - format: gzip  
        url: https://vmexport-  
proxy.test.net/api/export.kubevirt.io/v1alpha1/namespaces/example/virtualmachineexports/exam-
```

```

ple-export/volumes/example-disk/disk.img.gz
  name: example-disk
  internal: ②
  cert: |-  

    -----BEGIN CERTIFICATE-----  

    ...  

    -----END CERTIFICATE-----  

  volumes:  

    - formats:  

      - format: raw  

        url: https://virt-export-example-export.example.svc/volumes/example-disk/disk.img  

      - format: gzip  

        url: https://virt-export-example-export.example.svc/volumes/example-disk/disk.img.gz  

        name: example-disk
  phase: Ready
  serviceName: virt-export-example-export

```

- ① External links are accessible from outside the cluster by using an **Ingress** or **Route**.
- ② Internal links are only valid inside the cluster.

### 10.5.2. Accessing exported virtual machine manifests

After you export a virtual machine (VM) or snapshot, you can get the **VirtualMachine** manifest and related information from the export server.

#### Prerequisites

- You exported a virtual machine or VM snapshot by creating a **VirtualMachineExport** custom resource (CR).



#### NOTE

**VirtualMachineExport** objects that have the **spec.source.kind: PersistentVolumeClaim** parameter do not generate virtual machine manifests.

#### Procedure

1. To access the manifests, you must first copy the certificates from the source cluster to the target cluster.
  - a. Log in to the source cluster.
  - b. Save the certificates to the **cacert.crt** file by running the following command:

```
$ oc get vmexport <export_name> -o jsonpath={.status.links.external.cert} > cacert.crt
```

①

- ① Replace **<export\_name>** with the **metadata.name** value from the **VirtualMachineExport** object.

- c. Copy the **cacert.crt** file to the target cluster.

2. Decode the token in the source cluster and save it to the **token\_decode** file by running the following command:

```
$ oc get secret export-token-<export_name> -o jsonpath={.data.token} | base64 --decode > token_decode ①
```

- 1 Replace **<export\_name>** with the **metadata.name** value from the **VirtualMachineExport** object.

3. Copy the **token\_decode** file to the target cluster.

4. Get the **VirtualMachineExport** custom resource by running the following command:

```
$ oc get vmexport <export_name> -o yaml
```

5. Review the **status.links** stanza, which is divided into **external** and **internal** sections. Note the **manifests.url** fields within each section:

### Example output

```
apiVersion: export.kubevirt.io/v1alpha1
kind: VirtualMachineExport
metadata:
  name: example-export
spec:
  source:
    apiGroup: "kubevirt.io"
    kind: VirtualMachine
    name: example-vm
    tokenSecretRef: example-token
  status:
#...
  links:
    external:
#...
    manifests:
      - type: all
        url: https://vmexport-
proxy.test.net/api/export.kubevirt.io/v1alpha1/namespaces/example/virtualmachineexports/example-export/external/manifests/all ①
        - type: auth-header-secret
          url: https://vmexport-
proxy.test.net/api/export.kubevirt.io/v1alpha1/namespaces/example/virtualmachineexports/example-export/external/manifests/secret ②
        internal:
#...
        manifests:
          - type: all
            url: https://virt-export-export-pvc.default.svc/internal/manifests/all ③
          - type: auth-header-secret
            url: https://virt-export-export-pvc.default.svc/internal/manifests/secret
  phase: Ready
  serviceName: virt-export-example-export
```

- 1 Contains the **VirtualMachine** manifest, **DataVolume** manifest, if present, and a **ConfigMap** manifest that contains the public certificate for the external URL's ingress or route.
- 2 Contains a secret containing a header that is compatible with Containerized Data Importer (CDI). The header contains a text version of the export token.
- 3 Contains the **VirtualMachine** manifest, **DataVolume** manifest, if present, and a **ConfigMap** manifest that contains the certificate for the internal URL's export server.

6. Log in to the target cluster.
7. Get the **Secret** manifest by running the following command:

```
$ curl --cacert cacert.crt <secret_manifest_url> -H \ ①
  "x-kubevirt-export-token:token_decode" -H \ ②
  "Accept:application/yaml"
```

- 1 Replace **<secret\_manifest\_url>** with an **auth-header-secret** URL from the **VirtualMachineExport** YAML output.
- 2 Reference the **token\_decode** file that you created earlier.

For example:

```
$ curl --cacert cacert.crt https://vmexport-
proxy.test.net/api/export.kubevirt.io/v1alpha1/namespaces/example/virtualmachineexports/exam-
ple-export/external/manifests/secret -H "x-kubevirt-export-token:token_decode" -H
"Accept:application/yaml"
```

8. Get the manifests of **type: all**, such as the **ConfigMap** and **VirtualMachine** manifests, by running the following command:

```
$ curl --cacert cacert.crt <all_manifest_url> -H \ ①
  "x-kubevirt-export-token:token_decode" -H \ ②
  "Accept:application/yaml"
```

- 1 Replace **<all\_manifest\_url>** with a URL from the **VirtualMachineExport** YAML output.
- 2 Reference the **token\_decode** file that you created earlier.

For example:

```
$ curl --cacert cacert.crt https://vmexport-
proxy.test.net/api/export.kubevirt.io/v1alpha1/namespaces/example/virtualmachineexports/exam-
ple-export/external/manifests/all -H "x-kubevirt-export-token:token_decode" -H
"Accept:application/yaml"
```

## Next steps

- You can now create the **ConfigMap** and **VirtualMachine** objects on the target cluster by using the exported manifests.

### 10.5.3. Additional resources

- [Importing virtual machine images with data volumes](#)

## 10.6. MANAGING VIRTUAL MACHINE INSTANCES

If you have standalone virtual machine instances (VMIs) that were created independently outside of the OpenShift Virtualization environment, you can manage them by using the web console or by using **oc** or **virtctl** commands from the command-line interface (CLI).

The **virtctl** command provides more virtualization options than the **oc** command. For example, you can use **virtctl** to pause a VM or expose a port.

### 10.6.1. About virtual machine instances

A virtual machine instance (VMI) is a representation of a running virtual machine (VM). When a VMI is owned by a VM or by another object, you manage it through its owner in the web console or by using the **oc** command-line interface (CLI).

A standalone VMI is created and started independently with a script, through automation, or by using other methods in the CLI. In your environment, you might have standalone VMIs that were developed and started outside of the OpenShift Virtualization environment. You can continue to manage those standalone VMIs by using the CLI. You can also use the web console for specific tasks associated with standalone VMIs:

- List standalone VMIs and their details.
- Edit labels and annotations for a standalone VMI.
- Delete a standalone VMI.

When you delete a VM, the associated VMI is automatically deleted. You delete a standalone VMI directly because it is not owned by VMs or other objects.



#### NOTE

Before you uninstall OpenShift Virtualization, list and view the standalone VMIs by using the CLI or the web console. Then, delete any outstanding VMIs.

### 10.6.2. Listing all virtual machine instances using the CLI

You can list all virtual machine instances (VMIs) in your cluster, including standalone VMIs and those owned by virtual machines, by using the **oc** command-line interface (CLI).

#### Procedure

- List all VMIs by running the following command:

```
$ oc get vmis -A
```

### 10.6.3. Listing standalone virtual machine instances using the web console

Using the web console, you can list and view standalone virtual machine instances (VMIs) in your cluster that are not owned by virtual machines (VMs).



## NOTE

VMIs that are owned by VMs or other objects are not displayed in the web console. The web console displays only standalone VMIs. If you want to list all VMIs in your cluster, you must use the CLI.

### Procedure

- Click **Virtualization** → **VirtualMachines** from the side menu.  
You can identify a standalone VMI by a dark colored badge next to its name.

## 10.6.4. Editing a standalone virtual machine instance using the web console

You can edit the annotations and labels of a standalone virtual machine instance (VMI) using the web console. Other fields are not editable.

### Procedure

1. In the OpenShift Container Platform console, click **Virtualization** → **VirtualMachines** from the side menu.
2. Select a standalone VMI to open the **VirtualMachineInstance** details page.
3. On the **Details** tab, click the pencil icon beside **Annotations** or **Labels**.
4. Make the relevant changes and click **Save**.

## 10.6.5. Deleting a standalone virtual machine instance using the CLI

You can delete a standalone virtual machine instance (VMI) by using the **oc** command-line interface (CLI).

### Prerequisites

- Identify the name of the VMI that you want to delete.

### Procedure

- Delete the VMI by running the following command:

```
$ oc delete vmi <vmi_name>
```

## 10.6.6. Deleting a standalone virtual machine instance using the web console

Delete a standalone virtual machine instance (VMI) from the web console.

### Procedure

1. In the OpenShift Container Platform web console, click **Virtualization** → **VirtualMachines** from the side menu.
2. Click **Actions** → **Delete VirtualMachineInstance**.
3. In the confirmation pop-up window, click **Delete** to permanently delete the standalone VMI.

## 10.7. CONTROLLING VIRTUAL MACHINE STATES

You can stop, start, restart, and unpause virtual machines from the web console.

You can use **virtctl** to manage virtual machine states and perform other actions from the CLI. For example, you can use **virtctl** to force stop a VM or expose a port.

### 10.7.1. Starting a virtual machine

You can start a virtual machine from the web console.

#### Procedure

1. Click **Virtualization** → **VirtualMachines** from the side menu.
2. Find the row that contains the virtual machine that you want to start.
3. Navigate to the appropriate menu for your use case:
  - To stay on this page, where you can perform actions on multiple virtual machines:
    - a. Click the Options menu  located at the far right end of the row.
  - To view comprehensive information about the selected virtual machine before you start it:
    - a. Access the **VirtualMachine details** page by clicking the name of the virtual machine.
    - b. Click **Actions**.
4. Select **Restart**.
5. In the confirmation window, click **Start** to start the virtual machine.



#### NOTE

When you start virtual machine that is provisioned from a **URL** source for the first time, the virtual machine has a status of **Importing** while OpenShift Virtualization imports the container from the URL endpoint. Depending on the size of the image, this process might take several minutes.

### 10.7.2. Restarting a virtual machine

You can restart a running virtual machine from the web console.



#### IMPORTANT

To avoid errors, do not restart a virtual machine while it has a status of **Importing**.

#### Procedure

1. Click **Virtualization** → **VirtualMachines** from the side menu.
2. Find the row that contains the virtual machine that you want to restart.

3. Navigate to the appropriate menu for your use case:

- To stay on this page, where you can perform actions on multiple virtual machines:



- a. Click the Options menu located at the far right end of the row.

- To view comprehensive information about the selected virtual machine before you restart it:

- a. Access the **VirtualMachine details** page by clicking the name of the virtual machine.
- b. Click **Actions → Restart**.

4. In the confirmation window, click **Restart** to restart the virtual machine.

### 10.7.3. Stopping a virtual machine

You can stop a virtual machine from the web console.

#### Procedure

1. Click **Virtualization → VirtualMachines** from the side menu.

2. Find the row that contains the virtual machine that you want to stop.

3. Navigate to the appropriate menu for your use case:

- To stay on this page, where you can perform actions on multiple virtual machines:



- a. Click the Options menu located at the far right end of the row.

- To view comprehensive information about the selected virtual machine before you stop it:

- a. Access the **VirtualMachine details** page by clicking the name of the virtual machine.
- b. Click **Actions → Stop**.

4. In the confirmation window, click **Stop** to stop the virtual machine.

### 10.7.4. Unpausing a virtual machine

You can unpause a paused virtual machine from the web console.

#### Prerequisites

- At least one of your virtual machines must have a status of **Paused**.



#### NOTE

You can pause virtual machines by using the **virtctl** client.

#### Procedure

1. Click **Virtualization → VirtualMachines** from the side menu.

2. Find the row that contains the virtual machine that you want to unpause.
3. Navigate to the appropriate menu for your use case:
  - To stay on this page, where you can perform actions on multiple virtual machines:
    - a. In the **Status** column, click **Paused**.
  - To view comprehensive information about the selected virtual machine before you unpause it:
    - a. Access the **VirtualMachine details** page by clicking the name of the virtual machine.
    - b. Click the pencil icon that is located on the right side of **Status**.
4. In the confirmation window, click **Unpause** to unpause the virtual machine.

## 10.8. ACCESSING VIRTUAL MACHINE CONSOLES

OpenShift Virtualization provides different virtual machine consoles that you can use to accomplish different product tasks. You can access these consoles through the OpenShift Container Platform web console and by using CLI commands.

### 10.8.1. Accessing virtual machine consoles in the OpenShift Container Platform web console

You can connect to virtual machines by using the serial console or the VNC console in the OpenShift Container Platform web console.

You can connect to Windows virtual machines by using the desktop viewer console, which uses RDP (remote desktop protocol), in the OpenShift Container Platform web console.

#### 10.8.1.1. Connecting to the serial console

Connect to the serial console of a running virtual machine from the **Console** tab on the **VirtualMachine details** page of the web console.

#### Procedure

1. In the OpenShift Container Platform console, click **Virtualization** → **VirtualMachines** from the side menu.
2. Select a virtual machine to open the **VirtualMachine details** page.
3. Click the **Console** tab. The VNC console opens by default.
4. Click **Disconnect** to ensure that only one console session is open at a time. Otherwise, the VNC console session remains active in the background.
5. Click the **VNC Console** drop-down list and select **Serial Console**.
6. Click **Disconnect** to end the console session.
7. Optional: Open the serial console in a separate window by clicking **Open Console in New Window**.

### 10.8.1.2. Connecting to the VNC console

Connect to the VNC console of a running virtual machine from the **Console** tab on the **VirtualMachine details** page of the web console.

#### Procedure

1. In the OpenShift Container Platform console, click **Virtualization** → **VirtualMachines** from the side menu.
2. Select a virtual machine to open the **VirtualMachine details** page.
3. Click the **Console** tab. The VNC console opens by default.
4. Optional: Open the VNC console in a separate window by clicking **Open Console in New Window**.
5. Optional: Send key combinations to the virtual machine by clicking **Send Key**.
6. Click outside the console window and then click **Disconnect** to end the session.

### 10.8.1.3. Connecting to a Windows virtual machine with RDP

The **Desktop viewer** console, which utilizes the Remote Desktop Protocol (RDP), provides a better console experience for connecting to Windows virtual machines.

To connect to a Windows virtual machine with RDP, download the **console.rdp** file for the virtual machine from the **Console** tab on the **VirtualMachine details** page of the web console and supply it to your preferred RDP client.

#### Prerequisites

- A running Windows virtual machine with the QEMU guest agent installed. The **qemu-guest-agent** is included in the VirtIO drivers.
- An RDP client installed on a machine on the same network as the Windows virtual machine.

#### Procedure

1. In the OpenShift Container Platform console, click **Virtualization** → **VirtualMachines** from the side menu.
2. Click a Windows virtual machine to open the **VirtualMachine details** page.
3. Click the **Console** tab.
4. From the list of consoles, select **Desktop viewer**.
5. Click **Launch Remote Desktop** to download the **console.rdp** file.
6. Reference the **console.rdp** file in your preferred RDP client to connect to the Windows virtual machine.

### 10.8.1.4. Switching between virtual machine displays

If your Windows virtual machine (VM) has a vGPU attached, you can switch between the default display and the vGPU display by using the web console.

## Prerequisites

- The mediated device is configured in the **HyperConverged** custom resource and assigned to the VM.
- The VM is running.

## Procedure

1. In the OpenShift Container Platform console, click **Virtualization** → **VirtualMachines**
2. Select a Windows virtual machine to open the **Overview** screen.
3. Click the **Console** tab.
4. From the list of consoles, select **VNC console**.
5. Choose the appropriate key combination from the **Send Key** list:
  - a. To access the default VM display, select **Ctl + Alt+ 1**.
  - b. To access the vGPU display, select **Ctl + Alt + 2**.

## Additional resources

- [Configuring mediated devices](#)

### 10.8.1.5. Copying the SSH command using the web console

Copy the command to connect to a virtual machine (VM) terminal via SSH.

## Procedure

1. In the OpenShift Container Platform console, click **Virtualization** → **VirtualMachines** from the side menu.
2. Click the **Options** menu  for your virtual machine and select **Copy SSH command**.
3. Paste it in the terminal to access the VM.

### 10.8.2. Accessing virtual machine consoles by using CLI commands

#### 10.8.2.1. Accessing a virtual machine via SSH by using virtctl

You can use the **virtctl ssh** command to forward SSH traffic to a virtual machine (VM) by using your local SSH client. If you have previously configured SSH key authentication with the VM, skip to step 2 of the procedure because step 1 is not required.



## NOTE

Heavy SSH traffic on the control plane can slow down the API server. If you regularly need a large number of connections, use a dedicated Kubernetes **Service** object to access the virtual machine.

### Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have installed the **virtctl** client.
- The virtual machine you want to access is running.
- You are in the same project as the VM.

### Procedure

1. Configure SSH key authentication:
  - a. Use the **ssh-keygen** command to generate an SSH public key pair:
 

```
$ ssh-keygen -f <key_file> ①
```

① Specify the file in which to store the keys.
  - b. Create an SSH authentication secret which contains the SSH public key to access the VM:
 

```
$ oc create secret generic my-pub-key --from-file=key1=<key_file>.pub
```
  - c. Add a reference to the secret in the **VirtualMachine** manifest. For example:

```
apiVersion: kubevirt.io/v1
kind: VirtualMachine
metadata:
  name: testvm
spec:
  running: true
  template:
    spec:
      accessCredentials:
        - sshPublicKey:
            source:
              secret:
                secretName: my-pub-key ①
      propagationMethod:
        configDrive: {} ②
# ...
```

- ① Reference to the SSH authentication **Secret** object.
- ② The SSH public key is injected into the VM as cloud-init metadata using the **configDrive** provider.

- d. Restart the VM to apply your changes.
2. Connect to the VM via SSH:
    - a. Run the following command to access the VM via SSH:
- ```
$ virtctl ssh -i <key_file> <vm_username>@<vm_name>
```
- b. Optional: To securely transfer files to or from the VM, use the following commands:

#### **Copy a file from your machine to the VM**

```
$ virtctl scp -i <key_file> <filename> <vm_username>@<vm_name>:
```

#### **Copy a file from the VM to your machine**

```
$ virtctl scp -i <key_file> <vm_username>@<vm_name>:<filename> .
```

### Additional resources

- [Creating a service to expose a virtual machine](#)
- [Understanding secrets](#)

#### 10.8.2.2. Using OpenSSH and `virtctl port-forward`

You can use your local OpenSSH client and the **virtctl port-forward** command to connect to a running virtual machine (VM). You can use this method with Ansible to automate the configuration of VMs.

This method is recommended for low-traffic applications because port-forwarding traffic is sent over the control plane. This method is not recommended for high-traffic applications such as Rsync or Remote Desktop Protocol because it places a heavy burden on the API server.

### Prerequisites

- You have installed the **virtctl** client.
- The virtual machine you want to access is running.
- The environment where you installed the **virtctl** tool has the cluster permissions required to access the VM. For example, you ran **oc login** or you set the **KUBECONFIG** environment variable.

### Procedure

1. Add the following text to the `~/.ssh/config` file on your client machine:

```
Host vm/*
ProxyCommand virtctl port-forward --stdio=true %h %p
```

2. Connect to the VM by running the following command:

```
$ ssh <user>@vm/<vm_name>.<namespace>
```

### 10.8.2.3. Accessing the serial console of a virtual machine instance

The **virtctl console** command opens a serial console to the specified virtual machine instance.

#### Prerequisites

- The **virt-viewer** package must be installed.
- The virtual machine instance you want to access must be running.

#### Procedure

- Connect to the serial console with **virtctl**:

```
$ virtctl console <VMI>
```

### 10.8.2.4. Accessing the graphical console of a virtual machine instances with VNC

The **virtctl** client utility can use the **remote-viewer** function to open a graphical console to a running virtual machine instance. This capability is included in the **virt-viewer** package.

#### Prerequisites

- The **virt-viewer** package must be installed.
- The virtual machine instance you want to access must be running.



#### NOTE

If you use **virtctl** via SSH on a remote machine, you must forward the X session to your machine.

#### Procedure

1. Connect to the graphical interface with the **virtctl** utility:

```
$ virtctl vnc <VMI>
```

2. If the command failed, try using the **-v** flag to collect troubleshooting information:

```
$ virtctl vnc <VMI> -v 4
```

### 10.8.2.5. Connecting to a Windows virtual machine with an RDP console

Create a Kubernetes **Service** object to connect to a Windows virtual machine (VM) by using your local Remote Desktop Protocol (RDP) client.

#### Prerequisites

- A running Windows virtual machine with the QEMU guest agent installed. The **qemu-guest-agent** object is included in the VirtIO drivers.
- An RDP client installed on your local machine.

## Procedure

1. Edit the **VirtualMachine** manifest to add the label for service creation:

```
apiVersion: kubevirt.io/v1
kind: VirtualMachine
metadata:
  name: vm-ephemeral
  namespace: example-namespace
spec:
  running: false
  template:
    metadata:
      labels:
        special: key 1
# ...
```

- 1 Add the label **special: key** in the **spec.template.metadata.labels** section.



### NOTE

Labels on a virtual machine are passed through to the pod. The **special: key** label must match the label in the **spec.selector** attribute of the **Service** manifest.

- 2 Save the **VirtualMachine** manifest file to apply your changes.
- 3 Create a **Service** manifest to expose the VM:

```
apiVersion: v1
kind: Service
metadata:
  name: rdpservice 1
  namespace: example-namespace 2
spec:
  ports:
    - targetPort: 3389 3
      protocol: TCP
  selector:
    special: key 4
  type: NodePort 5
# ...
```

- 1 The name of the **Service** object.
- 2 The namespace where the **Service** object resides. This must match the **metadata.namespace** field of the **VirtualMachine** manifest.
- 3 The VM port to be exposed by the service. It must reference an open port if a port list is defined in the VM manifest.
- 4 The reference to the label that you added in the **spec.template.metadata.labels** stanza of the **VirtualMachine** manifest.

- 5 The type of service.

4. Save the **Service** manifest file.
5. Create the service by running the following command:

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

6. Start the VM. If the VM is already running, restart it.
7. Query the **Service** object to verify that it is available:

```
$ oc get service -n example-namespace
```

#### Example output for NodePort service

| NAME       | TYPE     | CLUSTER-IP    | EXTERNAL-IP | PORT(S)        | AGE |
|------------|----------|---------------|-------------|----------------|-----|
| rdpservice | NodePort | 172.30.232.73 | <none>      | 3389:30000/TCP | 5m  |

8. Run the following command to obtain the IP address for the node:

```
$ oc get node <node_name> -o wide
```

#### Example output

| NAME   | STATUS | ROLES  | AGE   | VERSION | INTERNAL-IP    | EXTERNAL-IP |
|--------|--------|--------|-------|---------|----------------|-------------|
| node01 | Ready  | worker | 6d22h | v1.24.0 | 192.168.55.101 | <none>      |

9. Specify the node IP address and the assigned port in your preferred RDP client.
10. Enter the user name and password to connect to the Windows virtual machine.

## 10.9. AUTOMATING WINDOWS INSTALLATION WITH SYSPREP

You can use Microsoft DVD images and **sysprep** to automate the installation, setup, and software provisioning of Windows virtual machines.

### 10.9.1. Using a Windows DVD to create a VM disk image

Microsoft does not provide disk images for download, but you can create a disk image using a Windows DVD. This disk image can then be used to create virtual machines.

#### Procedure

1. In the OpenShift Virtualization web console, click **Storage** → **PersistentVolumeClaims** → **Create PersistentVolumeClaim With Data upload** form
2. Select the intended project.
3. Set the **Persistent Volume Claim Name**

4. Upload the VM disk image from the Windows DVD. The image is now available as a boot source to create a new Windows VM.

### 10.9.2. Using a disk image to install Windows

You can use a disk image to install Windows on your virtual machine.

#### Prerequisites

- You must create a disk image using a Windows DVD.
- You must create an **autounattend.xml** answer file. See the [Microsoft documentation](#) for details.

#### Procedure

1. In the OpenShift Container Platform console, click **Virtualization** → **Catalog** from the side menu.
2. Select a Windows template and click **Customize VirtualMachine**.
3. Select **Upload (Upload a new file to a PVC)** from the **Disk source** list and browse to the DVD image.
4. Click **Review and create VirtualMachine**.
5. Clear **Clone available operating system source to this Virtual Machine**
6. Clear **Start this VirtualMachine after creation**
7. On the **Sysprep** section of the **Scripts** tab, click **Edit**.
8. Browse to the **autounattend.xml** answer file and click **Save**.
9. Click **Create VirtualMachine**.
10. On the **YAML** tab, replace **running:false** with **runStrategy: RerunOnFailure** and click **Save**.

The VM will start with the **sysprep** disk containing the **autounattend.xml** answer file.

### 10.9.3. Generalizing a Windows VM using sysprep

Generalizing an image allows that image to remove all system-specific configuration data when the image is deployed on a virtual machine (VM).

Before generalizing the VM, you must ensure the **sysprep** tool cannot detect an answer file after the unattended Windows installation.

#### Prerequisites

- A running Windows virtual machine with the QEMU guest agent installed.

#### Procedure

1. In the OpenShift Container Platform console, click **Virtualization** → **VirtualMachines**.
2. Select a Windows VM to open the **VirtualMachine details** page.

3. Click **Configuration** → **Disk**s.

4. Click the Options menu  beside the **sysprep** disk and select **Detach**.

5. Click **Detach**.

6. Rename **C:\Windows\Panther\unattend.xml** to avoid detection by the **sysprep** tool.

7. Start the **sysprep** program by running the following command:

```
%WINDIR%\System32\Sysprep\sysprep.exe /generalize /shutdown /oobe /mode:vm
```

8. After the **sysprep** tool completes, the Windows VM shuts down. The disk image of the VM is now available to use as an installation image for Windows VMs.

You can now specialize the VM.

#### 10.9.4. Specializing a Windows virtual machine

Specializing a virtual machine (VM) configures the computer-specific information from a generalized Windows image onto the VM.

##### Prerequisites

- You must have a generalized Windows disk image.
- You must create an **unattend.xml** answer file. See the [Microsoft documentation](#) for details.

##### Procedure

1. In the OpenShift Container Platform console, click **Virtualization** → **Catalog**.
2. Select a Windows template and click **Customize VirtualMachine**.
3. Select **PVC (clone PVC)** from the **Disk source** list.
4. Specify the **Persistent Volume Claim project** and **Persistent Volume Claim name** of the generalized Windows image.
5. Click **Review and create VirtualMachine**.
6. Click the **Scripts** tab.
7. In the **Sysprep** section, click **Edit**, browse to the **unattend.xml** answer file, and click **Save**.
8. Click **Create VirtualMachine**.

During the initial boot, Windows uses the **unattend.xml** answer file to specialize the VM. The VM is now ready to use.

#### 10.9.5. Additional resources

- [Creating virtual machines](#)

- Installing the QEMU guest agent and VirtIO drivers
- Microsoft, Sysprep (Generalize) a Windows installation
- Microsoft, generalize
- Microsoft, specialize

## 10.10. TRIGGERING VIRTUAL MACHINE FAILOVER BY RESOLVING A FAILED NODE

If a node fails and [machine health checks](#) are not deployed on your cluster, virtual machines (VMs) with **RunStrategy: Always** configured are not automatically relocated to healthy nodes. To trigger VM failover, you must manually delete the **Node** object.



### NOTE

If you installed your cluster by using [installer-provisioned infrastructure](#) and you properly configured machine health checks:

- Failed nodes are automatically recycled.
- Virtual machines with **RunStrategy** set to **Always** or **RerunOnFailure** are automatically scheduled on healthy nodes.

### 10.10.1. Prerequisites

- A node where a virtual machine was running has the **NotReady** condition.
- The virtual machine that was running on the failed node has **RunStrategy** set to **Always**.
- You have installed the OpenShift CLI (**oc**).

### 10.10.2. Deleting nodes from a bare metal cluster

When you delete a node using the CLI, the node object is deleted in Kubernetes, but the pods that exist on the node are not deleted. Any bare pods not backed by a replication controller become inaccessible to OpenShift Container Platform. Pods backed by replication controllers are rescheduled to other available nodes. You must delete local manifest pods.

#### Procedure

Delete a node from an OpenShift Container Platform cluster running on bare metal by completing the following steps:

1. Mark the node as unschedulable:

```
$ oc adm cordon <node_name>
```

2. Drain all pods on the node:

```
$ oc adm drain <node_name> --force=true
```

This step might fail if the node is offline or unresponsive. Even if the node does not respond, it might still be running a workload that writes to shared storage. To avoid data corruption, power down the physical hardware before you proceed.

3. Delete the node from the cluster:

```
$ oc delete node <node_name>
```

Although the node object is now deleted from the cluster, it can still rejoin the cluster after reboot or if the kubelet service is restarted. To permanently delete the node and all its data, you must [decommission the node](#).

4. If you powered down the physical hardware, turn it back on so that the node can rejoin the cluster.

### 10.10.3. Verifying virtual machine failover

After all resources are terminated on the unhealthy node, a new virtual machine instance (VMI) is automatically created on a healthy node for each relocated VM. To confirm that the VMI was created, view all VMIs by using the **oc** CLI.

#### 10.10.3.1. Listing all virtual machine instances using the CLI

You can list all virtual machine instances (VMIs) in your cluster, including standalone VMIs and those owned by virtual machines, by using the **oc** command-line interface (CLI).

#### Procedure

- List all VMIs by running the following command:

```
$ oc get vmis -A
```

## 10.11. INSTALLING THE QEMU GUEST AGENT AND VIRTIO DRIVERS

The [QEMU guest agent](#) is a daemon that runs on the virtual machine and passes information to the host about the virtual machine, users, file systems, and secondary networks.

### 10.11.1. Installing the QEMU guest agent

#### 10.11.1.1. Installing QEMU guest agent on a Linux virtual machine

The **qemu-guest-agent** is widely available and available by default in Red Hat Enterprise Linux (RHEL) virtual machines (VMs). Install the agent and start the service.



## NOTE

To create snapshots of an online (Running state) VM with the highest integrity, install the QEMU guest agent.

The QEMU guest agent takes a consistent snapshot by attempting to quiesce the VM's file system as much as possible, depending on the system workload. This ensures that in-flight I/O is written to the disk before the snapshot is taken. If the guest agent is not present, quiescing is not possible and a best-effort snapshot is taken. The conditions under which the snapshot was taken are reflected in the snapshot indications that are displayed in the web console or CLI.

## Procedure

1. Access the virtual machine command line through one of the consoles or by SSH.
2. Install the QEMU guest agent on the virtual machine:

```
$ yum install -y qemu-guest-agent
```

3. Ensure the service is persistent and start it:

```
$ systemctl enable --now qemu-guest-agent
```

## Verification

1. Run the following command to verify that **AgentConnected** is listed in the VM spec:

```
$ oc get vm <vm_name>
```

### 10.11.1.2. Installing QEMU guest agent on a Windows virtual machine

For Windows virtual machines, the QEMU guest agent is included in the VirtIO drivers. Install the drivers on an existing or a new Windows installation.



## NOTE

To create snapshots of an online (Running state) VM with the highest integrity, install the QEMU guest agent.

The QEMU guest agent takes a consistent snapshot by attempting to quiesce the VM's file system as much as possible, depending on the system workload. This ensures that in-flight I/O is written to the disk before the snapshot is taken. If the guest agent is not present, quiescing is not possible and a best-effort snapshot is taken. The conditions under which the snapshot was taken are reflected in the snapshot indications that are displayed in the web console or CLI.

## Procedure

1. In the Windows Guest Operating System (OS), use the **File Explorer** to navigate to the **guest-agent** directory in the **virtio-win** CD drive.
2. Run the **qemu-ga-x86\_64.msi** installer.

## Verification

- Run the following command to verify that the output contains the **QEMU Guest Agent**:

```
$ net start
```

### 10.11.2. Installing VirtIO drivers

#### 10.11.2.1. Supported VirtIO drivers for Microsoft Windows virtual machines

**Table 10.1. Supported drivers**

| Driver name | Hardware ID                            | Description                                                                                                                                              |
|-------------|----------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| viostor     | VEN_1AF4&DEV_1001<br>VEN_1AF4&DEV_1042 | The block driver. Sometimes displays as an <b>SCSI Controller</b> in the <b>Other devices</b> group.                                                     |
| viornrg     | VEN_1AF4&DEV_1005<br>VEN_1AF4&DEV_1044 | The entropy source driver. Sometimes displays as a <b>PCI Device</b> in the <b>Other devices</b> group.                                                  |
| NetKVM      | VEN_1AF4&DEV_1000<br>VEN_1AF4&DEV_1041 | The network driver. Sometimes displays as an <b>Ethernet Controller</b> in the <b>Other devices</b> group. Available only if a VirtIO NIC is configured. |

#### 10.11.2.2. About VirtIO drivers

VirtIO drivers are paravirtualized device drivers required for Microsoft Windows virtual machines to run in OpenShift Virtualization. The supported drivers are available in the **container-native-virtualization/virtio-win** container disk of the [Red Hat Ecosystem Catalog](#).

The **container-native-virtualization/virtio-win** container disk must be attached to the virtual machine as a SATA CD drive to enable driver installation. You can install VirtIO drivers during Windows installation on the virtual machine or added to an existing Windows installation.

After the drivers are installed, the **container-native-virtualization/virtio-win** container disk can be removed from the virtual machine.

#### 10.11.2.3. Installing VirtIO drivers on an existing Windows virtual machine

Install the VirtIO drivers from the attached SATA CD drive to an existing Windows virtual machine.



#### NOTE

This procedure uses a generic approach to adding drivers to Windows. The process might differ slightly between versions of Windows. See the installation documentation for your version of Windows for specific installation steps.

## Procedure

1. Start the virtual machine and connect to a graphical console.
2. Log in to a Windows user session.
3. Open **Device Manager** and expand **Other devices** to list any **Unknown device**.
  - a. Open the **Device Properties** to identify the unknown device. Right-click the device and select **Properties**.
  - b. Click the **Details** tab and select **Hardware IDs** in the **Property** list.
  - c. Compare the **Value** for the **Hardware IDs** with the supported VirtIO drivers.
4. Right-click the device and select **Update Driver Software**.
5. Click **Browse my computer for driver software** and browse to the attached SATA CD drive, where the VirtIO drivers are located. The drivers are arranged hierarchically according to their driver type, operating system, and CPU architecture.
6. Click **Next** to install the driver.
7. Repeat this process for all the necessary VirtIO drivers.
8. After the driver installs, click **Close** to close the window.
9. Reboot the virtual machine to complete the driver installation.

### 10.11.2.4. Installing VirtIO drivers during Windows installation

Install the **virtio** drivers during or after Windows installation.



#### NOTE

This procedure uses a generic approach to the Windows installation and the installation method might differ between versions of Windows. See the documentation for the version of Windows that you are installing.

## Prerequisites

- A storage device containing the **virtio** drivers must be attached to the VM.

## Procedure

1. In the Windows Guest OS, use the **File Explorer** to navigate to the **virtio-win** CD drive.
2. Double-click to run the appropriate installer for your VM:
  - a. For a 64-bit vCPU, use the **virtio-win-gt-x64** installer. 32-bit vCPUs are no longer supported.
3. Optional: During the **Custom Setup** step of the installer, select the device drivers you want to install. The recommended driver set is selected by default.
4. After the installation is complete, select **Finish**.

5. Reboot the VM.

## Verification

1. Open the system disk on the PC. This is typically **C:**.
2. Navigate to **Program Files → Virtio-Win**.

If the **Virtio-Win** directory is present and contains a sub-directory for each driver, the installation was successful.

### 10.11.2.5. Adding VirtIO drivers container disk to a virtual machine

OpenShift Virtualization distributes VirtIO drivers for Microsoft Windows as a container disk, which is available from the [Red Hat Ecosystem Catalog](#). To install these drivers to a Windows virtual machine, attach the **container-native-virtualization/virtio-win** container disk to the virtual machine as a SATA CD drive in the virtual machine configuration file.

#### Prerequisites

- Download the **container-native-virtualization/virtio-win** container disk from the [Red Hat Ecosystem Catalog](#). This is not mandatory, because the container disk will be downloaded from the Red Hat registry if it is not already present in the cluster, but it can reduce installation time.

#### Procedure

1. Add the **container-native-virtualization/virtio-win** container disk as a **cdrom** disk in the Windows virtual machine configuration file. The container disk will be downloaded from the registry if it is not already present in the cluster.

```
spec:
domain:
devices:
disks:
- name: virtiocontainerdisk
  bootOrder: 2 1
cdrom:
bus: sata
volumes:
- containerDisk:
  image: container-native-virtualization/virtio-win
  name: virtiocontainerdisk
```

- 1** 1 OpenShift Virtualization boots virtual machine disks in the order defined in the **VirtualMachine** configuration file. You can either define other disks for the virtual machine before the **container-native-virtualization/virtio-win** container disk or use the optional **bootOrder** parameter to ensure the virtual machine boots from the correct disk. If you specify the **bootOrder** for a disk, it must be specified for all disks in the configuration.

2. The disk is available once the virtual machine has started:

- If you add the container disk to a running virtual machine, use **oc apply -f <vm.yaml>** in the CLI or reboot the virtual machine for the changes to take effect.

- If the virtual machine is not running, use **virtctl start <vm>**.

After the virtual machine has started, the VirtIO drivers can be installed from the attached SATA CD drive.

## 10.12. VIEWING THE QEMU GUEST AGENT INFORMATION FOR VIRTUAL MACHINES

When the QEMU guest agent runs on the virtual machine, you can use the web console to view information about the virtual machine, users, file systems, and secondary networks.

If the QEMU guest agent is not installed, the **Overview** and the **Details** tabs display information about the operating system that was specified when the virtual machine was created.

### 10.12.1. Viewing the QEMU guest agent information in the web console

You can use the web console to view information for virtual machines that is passed by the QEMU guest agent to the host.

#### Prerequisites

- Install the QEMU guest agent on the virtual machine.

#### Procedure

1. Click **Virtualization** → **VirtualMachines** from the side menu.
2. Select a virtual machine name to open the **VirtualMachine details** page.
3. Click the **Details** tab to view active users.
4. Click the **Configuration** → **Disk** tab to view information about the file systems.

## 10.13. USING VIRTUAL TRUSTED PLATFORM MODULE DEVICES

Add a virtual Trusted Platform Module (vTPM) device to a new or existing virtual machine by editing the **VirtualMachine** (VM) or **VirtualMachineInstance** (VMI) manifest.

### 10.13.1. About vTPM devices

A virtual Trusted Platform Module (vTPM) device functions like a physical Trusted Platform Module (TPM) hardware chip.

You can use a vTPM device with any operating system, but Windows 11 requires the presence of a TPM chip to install or boot. A vTPM device allows VMs created from a Windows 11 image to function without a physical TPM chip.

If you do not enable vTPM, then the VM does not recognize a TPM device, even if the node has one.

vTPM devices also protect virtual machines by temporarily storing secrets without physical hardware. However, using vTPM for persistent secret storage is not currently supported. vTPM discards stored secrets after a VM shuts down.

### 10.13.2. Adding a vTPM device to a virtual machine

Adding a virtual Trusted Platform Module (vTPM) device to a virtual machine (VM) allows you to run a VM created from a Windows 11 image without a physical TPM device. A vTPM device also temporarily stores secrets for that VM.

#### Procedure

1. Run the following command to update the VM configuration:

```
$ oc edit vm <vm_name>
```

2. Edit the VM **spec** so that it includes the **tpm: {}** line. For example:

```
apiVersion: kubevirt.io/v1
kind: VirtualMachine
metadata:
  name: example-vm
spec:
  template:
    spec:
      domain:
        devices:
          tpm: {} ①
# ...
```

① Adds the TPM device to the VM.

3. To apply your changes, save and exit the editor.
4. Optional: If you edited a running virtual machine, you must restart it for the changes to take effect.

## 10.14. MANAGING VIRTUAL MACHINES WITH OPENSHIFT PIPELINES

[Red Hat OpenShift Pipelines](#) is a Kubernetes-native CI/CD framework that allows developers to design and run each step of the CI/CD pipeline in its own container.

The Tekton Tasks Operator (TTO) integrates OpenShift Virtualization with OpenShift Pipelines. TTO includes cluster tasks and example pipelines that allow you to:

- Create and manage virtual machines (VMs), persistent volume claims (PVCs), and data volumes
- Run commands in VMs
- Manipulate disk images with **libguestfs** tools



## IMPORTANT

Managing virtual machines with Red Hat OpenShift Pipelines 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](#).

### 10.14.1. Prerequisites

- You have access to an OpenShift Container Platform cluster with **cluster-admin** permissions.
- You have installed the OpenShift CLI (**oc**).
- You have [installed OpenShift Pipelines](#).

### 10.14.2. Deploying the Tekton Tasks Operator resources

The Tekton Tasks Operator (TTO) cluster tasks and example pipelines are not deployed by default when you install OpenShift Virtualization. To deploy TTO resources, enable the **deployTektonTaskResources** feature gate in the **HyperConverged** custom resource (CR).

#### Procedure

1. Open the **HyperConverged** CR in your default editor by running the following command:

```
$ oc edit hco -n openshift-cnv kubevirt-hyperconverged
```

2. Set the **spec.featureGates.deployTektonTaskResources** field to **true**.

```
apiVersion: hco.kubevirt.io/v1beta1
kind: HyperConverged
metadata:
  name: kubevirt-hyperconverged
  namespace: kubevirt-hyperconverged
spec:
  tektonPipelinesNamespace: <user_namespace> 1
  featureGates:
    deployTektonTaskResources: true 2
# ...
```

- 1** The namespace where the pipelines are to be run.
- 2** The feature gate to be enabled to deploy TTO resources.



## NOTE

The cluster tasks and example pipelines remain available even if you disable the feature gate later.

3. Save your changes and exit the editor.

### 10.14.3. Virtual machine tasks supported by the Tekton Tasks Operator

The following table shows the cluster tasks that are included as part of the Tekton Tasks Operator.

**Table 10.2. Virtual machine tasks supported by the Tekton Tasks Operator**

| Task                           | Description                                                                                       |
|--------------------------------|---------------------------------------------------------------------------------------------------|
| <b>create-vm-from-template</b> | Create a virtual machine from a template.                                                         |
| <b>copy-template</b>           | Copy a virtual machine template.                                                                  |
| <b>modify-vm-template</b>      | Modify a virtual machine template.                                                                |
| <b>modify-data-object</b>      | Create or delete data volumes or data sources.                                                    |
| <b>cleanup-vm</b>              | Run a script or a command in a virtual machine and stop or delete the virtual machine afterward.  |
| <b>disk-virt-customize</b>     | Use the <b>virt-customize</b> tool to run a customization script on a target PVC.                 |
| <b>disk-virt-sysprep</b>       | Use the <b>virt-sysprep</b> tool to run a sysprep script on a target PVC.                         |
| <b>wait-for-vmi-status</b>     | Wait for a specific status of a virtual machine instance and fail or succeed based on the status. |

### 10.14.4. Example pipelines

The Tekton Tasks Operator includes the following example **Pipeline** manifests. You can run the example pipelines by using the web console or CLI.

You might have to run more than one installer pipeline if you need multiple versions of Windows. If you run more than one installer pipeline, each one requires unique parameters, such as the **autounattend** config map and base image name. For example, if you need Windows 10 and Windows 11 or Windows Server 2022 images, you have to run both the Windows efi installer pipeline and the Windows bios installer pipeline. However, if you need Windows 11 and Windows Server 2022 images, you have to run only the Windows efi installer pipeline.

#### Windows EFI installer pipeline

This pipeline installs Windows 11 or Windows Server 2022 into a new data volume from a Windows installation image (ISO file). A custom answer file is used to run the installation process.

#### Windows BIOS installer pipeline

This pipeline installs Windows 10 into a new data volume from a Windows installation image, also called an ISO file. A custom answer file is used to run the installation process.

#### Windows customize pipeline

This pipeline clones the data volume of a basic Windows 10, 11, or Windows Server 2022 installation, customizes it by installing Microsoft SQL Server Express or Microsoft Visual Studio Code, and then creates a new image and template.

#### 10.14.4.1. Running the example pipelines using the web console

You can run the example pipelines from the **Pipelines** menu in the web console.

##### Procedure

1. Click **Pipelines** → **Pipelines** in the side menu.
2. Select a pipeline to open the **Pipeline details** page.
3. From the **Actions** list, select **Start**. The **Start Pipeline** dialog is displayed.
4. Keep the default values for the parameters and then click **Start** to run the pipeline. The **Details** tab tracks the progress of each task and displays the pipeline status.

#### 10.14.4.2. Running the example pipelines using the CLI

Use a **PipelineRun** resource to run the example pipelines. A **PipelineRun** object is the running instance of a pipeline. It instantiates a pipeline for execution with specific inputs, outputs, and execution parameters on a cluster. It also creates a **TaskRun** object for each task in the pipeline.

##### Procedure

1. To run the Windows 10 installer pipeline, create the following **PipelineRun** manifest:

```
apiVersion: tekton.dev/v1beta1
kind: PipelineRun
metadata:
  generateName: windows10-installer-run-
  labels:
    pipelinerun: windows10-installer-run
spec:
  params:
    - name: winImageDownloadURL
      value: <link_to_windows_10_iso> ①
  pipelineRef:
    name: windows10-installer
  taskRunSpecs:
    - pipelineTaskName: copy-template
      taskServiceAccountName: copy-template-task
    - pipelineTaskName: modify-vm-template
      taskServiceAccountName: modify-vm-template-task
    - pipelineTaskName: create-vm-from-template
      taskServiceAccountName: create-vm-from-template-task
    - pipelineTaskName: wait-for-vmi-status
      taskServiceAccountName: wait-for-vmi-status-task
    - pipelineTaskName: create-base-dv
      taskServiceAccountName: modify-data-object-task
    - pipelineTaskName: cleanup-vm
      taskServiceAccountName: cleanup-vm-task
status: {}
```

- 1 Specify the URL for the Windows 10 64-bit ISO file. The product language must be English (United States).

2. Apply the **PipelineRun** manifest:

```
$ oc apply -f windows10-installer-run.yaml
```

3. To run the Windows 10 customize pipeline, create the following **PipelineRun** manifest:

```
apiVersion: tekton.dev/v1beta1
kind: PipelineRun
metadata:
  generateName: windows10-customize-run-
  labels:
    pipelinerun: windows10-customize-run
spec:
  params:
    - name: allowReplaceGoldenTemplate
      value: true
    - name: allowReplaceCustomizationTemplate
      value: true
  pipelineRef:
    name: windows10-customize
  taskRunSpecs:
    - pipelineTaskName: copy-template-customize
      taskServiceAccountName: copy-template-task
    - pipelineTaskName: modify-vm-template-customize
      taskServiceAccountName: modify-vm-template-task
    - pipelineTaskName: create-vm-from-template
      taskServiceAccountName: create-vm-from-template-task
    - pipelineTaskName: wait-for-vmi-status
      taskServiceAccountName: wait-for-vmi-status-task
    - pipelineTaskName: create-base-dv
      taskServiceAccountName: modify-data-object-task
    - pipelineTaskName: cleanup-vm
      taskServiceAccountName: cleanup-vm-task
    - pipelineTaskName: copy-template-golden
      taskServiceAccountName: copy-template-task
    - pipelineTaskName: modify-vm-template-golden
      taskServiceAccountName: modify-vm-template-task
  status: {}
```

4. Apply the **PipelineRun** manifest:

```
$ oc apply -f windows10-customize-run.yaml
```

#### 10.14.5. Additional resources

- [Creating CI/CD solutions for applications using Red Hat OpenShift Pipelines](#)

### 10.15. ADVANCED VIRTUAL MACHINE MANAGEMENT

## 10.15.1. Working with resource quotas for virtual machines

Create and manage resource quotas for virtual machines.

### 10.15.1.1. Setting resource quota limits for virtual machines

Resource quotas that only use requests automatically work with virtual machines (VMs). If your resource quota uses limits, you must manually set resource limits on VMs. Resource limits must be at least 100 MiB larger than resource requests.

#### Procedure

- Set limits for a VM by editing the **VirtualMachine** manifest. For example:

```
apiVersion: kubevirt.io/v1
kind: VirtualMachine
metadata:
  name: with-limits
spec:
  running: false
  template:
    spec:
      domain:
# ...
      resources:
        requests:
          memory: 128Mi
        limits:
          memory: 256Mi ①
```

- ① This configuration is supported because the **limits.memory** value is at least **100Mi** larger than the **requests.memory** value.

- Save the **VirtualMachine** manifest.

### 10.15.1.2. Additional resources

- [Resource quotas per project](#)
- [Resource quotas across multiple projects](#)

## 10.15.2. Specifying nodes for virtual machines

You can place virtual machines (VMs) on specific nodes by using node placement rules.

### 10.15.2.1. About node placement for virtual machines

To ensure that virtual machines (VMs) run on appropriate nodes, you can configure node placement rules. You might want to do this if:

- You have several VMs. To ensure fault tolerance, you want them to run on different nodes.
- You have two chatty VMs. To avoid redundant inter-node routing, you want the VMs to run on the same node.

- Your VMs require specific hardware features that are not present on all available nodes.
- You have a pod that adds capabilities to a node, and you want to place a VM on that node so that it can use those capabilities.



### NOTE

Virtual machine placement relies on any existing node placement rules for workloads. If workloads are excluded from specific nodes on the component level, virtual machines cannot be placed on those nodes.

You can use the following rule types in the **spec** field of a **VirtualMachine** manifest:

#### **nodeSelector**

Allows virtual machines to be scheduled on nodes that are labeled with the key-value pair or pairs that you specify in this field. The node must have labels that exactly match all listed pairs.

#### **affinity**

Enables you to use more expressive syntax to set rules that match nodes with virtual machines. For example, you can specify that a rule is a preference, rather than a hard requirement, so that virtual machines are still scheduled if the rule is not satisfied. Pod affinity, pod anti-affinity, and node affinity are supported for virtual machine placement. Pod affinity works for virtual machines because the **VirtualMachine** workload type is based on the **Pod** object.



### NOTE

Affinity rules only apply during scheduling. OpenShift Container Platform does not reschedule running workloads if the constraints are no longer met.

#### **tolerations**

Allows virtual machines to be scheduled on nodes that have matching taints. If a taint is applied to a node, that node only accepts virtual machines that tolerate the taint.

### 10.15.2.2. Node placement examples

The following example YAML file snippets use **nodePlacement**, **affinity**, and **tolerations** fields to customize node placement for virtual machines.

#### 10.15.2.2.1. Example: VM node placement with **nodeSelector**

In this example, the virtual machine requires a node that has metadata containing both **example-key-1 = example-value-1** and **example-key-2 = example-value-2** labels.



### WARNING

If there are no nodes that fit this description, the virtual machine is not scheduled.

### Example VM manifest

```

metadata:
  name: example-vm-node-selector
  apiVersion: kubevirt.io/v1
  kind: VirtualMachine
spec:
  template:
    spec:
      nodeSelector:
        example-key-1: example-value-1
        example-key-2: example-value-2
# ...

```

#### 10.15.2.2. Example: VM node placement with pod affinity and pod anti-affinity

In this example, the VM must be scheduled on a node that has a running pod with the label **example-key-1 = example-value-1**. If there is no such pod running on any node, the VM is not scheduled.

If possible, the VM is not scheduled on a node that has any pod with the label **example-key-2 = example-value-2**. However, if all candidate nodes have a pod with this label, the scheduler ignores this constraint.

#### Example VM manifest

```

metadata:
  name: example-vm-pod-affinity
  apiVersion: kubevirt.io/v1
  kind: VirtualMachine
spec:
  template:
    spec:
      affinity:
        podAffinity:
          requiredDuringSchedulingIgnoredDuringExecution: ①
            - labelSelector:
                matchExpressions:
                  - key: example-key-1
                    operator: In
                    values:
                      - example-value-1
          topologyKey: kubernetes.io/hostname
        podAntiAffinity:
          preferredDuringSchedulingIgnoredDuringExecution: ②
            - weight: 100
              podAffinityTerm:
                labelSelector:
                  matchExpressions:
                    - key: example-key-2
                      operator: In
                      values:
                        - example-value-2
          topologyKey: kubernetes.io/hostname
# ...

```

- 1 If you use the **requiredDuringSchedulingIgnoredDuringExecution** rule type, the VM is not scheduled if the constraint is not met.
- 2 If you use the **preferredDuringSchedulingIgnoredDuringExecution** rule type, the VM is still scheduled if the constraint is not met, as long as all required constraints are met.

#### 10.15.2.2.3. Example: VM node placement with node affinity

In this example, the VM must be scheduled on a node that has the label **example.io/example-key = example-value-1** or the label **example.io/example-key = example-value-2**. The constraint is met if only one of the labels is present on the node. If neither label is present, the VM is not scheduled.

If possible, the scheduler avoids nodes that have the label **example-node-label-key = example-node-label-value**. However, if all candidate nodes have this label, the scheduler ignores this constraint.

#### Example VM manifest

```
metadata:
  name: example-vm-node-affinity
  apiVersion: kubevirt.io/v1
  kind: VirtualMachine
  spec:
    template:
      spec:
        affinity:
          nodeAffinity:
            requiredDuringSchedulingIgnoredDuringExecution: ①
              nodeSelectorTerms:
                - matchExpressions:
                    - key: example.io/example-key
                      operator: In
                      values:
                        - example-value-1
                        - example-value-2
            preferredDuringSchedulingIgnoredDuringExecution: ②
              - weight: 1
                preference:
                  matchExpressions:
                    - key: example-node-label-key
                      operator: In
                      values:
                        - example-node-label-value
# ...
```

- 1 If you use the **requiredDuringSchedulingIgnoredDuringExecution** rule type, the VM is not scheduled if the constraint is not met.
- 2 If you use the **preferredDuringSchedulingIgnoredDuringExecution** rule type, the VM is still scheduled if the constraint is not met, as long as all required constraints are met.

#### 10.15.2.2.4. Example: VM node placement with tolerations

In this example, nodes that are reserved for virtual machines are already labeled with the **key=virtualization:NoSchedule** taint. Because this virtual machine has matching **tolerations**, it can schedule onto the tainted nodes.



### NOTE

A virtual machine that tolerates a taint is not required to schedule onto a node with that taint.

### Example VM manifest

```
metadata:
  name: example-vm-tolerations
  apiVersion: kubevirt.io/v1
  kind: VirtualMachine
spec:
  tolerations:
    - key: "key"
      operator: "Equal"
      value: "virtualization"
      effect: "NoSchedule"
  # ...
```

### 10.15.2.3. Additional resources

- [Specifying nodes for virtualization components](#)
- [Placing pods on specific nodes using node selectors](#)
- [Controlling pod placement on nodes using node affinity rules](#)
- [Controlling pod placement using node taints](#)

### 10.15.3. Configuring certificate rotation

Configure certificate rotation parameters to replace existing certificates.

#### 10.15.3.1. Configuring certificate rotation

You can do this during OpenShift Virtualization installation in the web console or after installation in the **HyperConverged** custom resource (CR).

#### Procedure

1. Open the **HyperConverged** CR by running the following command:

```
$ oc edit hco -n openshift-cnv kubevirt-hyperconverged
```

2. Edit the **spec.certConfig** fields as shown in the following example. To avoid overloading the system, ensure that all values are greater than or equal to 10 minutes. Express all values as strings that comply with the [golang ParseDuration format](#).

```
apiVersion: hco.kubevirt.io/v1beta1
```

```

kind: HyperConverged
metadata:
  name: kubevirt-hyperconverged
  namespace: openshift-cnv
spec:
  certConfig:
    ca:
      duration: 48h0m0s
      renewBefore: 24h0m0s 1
    server:
      duration: 24h0m0s 2
      renewBefore: 12h0m0s 3

```

- 1** The value of **ca.renewBefore** must be less than or equal to the value of **ca.duration**.
- 2** The value of **server.duration** must be less than or equal to the value of **ca.duration**.
- 3** The value of **server.renewBefore** must be less than or equal to the value of **server.duration**.

3. Apply the YAML file to your cluster.

#### 10.15.3.2. Troubleshooting certificate rotation parameters

Deleting one or more **certConfig** values causes them to revert to the default values, unless the default values conflict with one of the following conditions:

- The value of **ca.renewBefore** must be less than or equal to the value of **ca.duration**.
- The value of **server.duration** must be less than or equal to the value of **ca.duration**.
- The value of **server.renewBefore** must be less than or equal to the value of **server.duration**.

If the default values conflict with these conditions, you will receive an error.

If you remove the **server.duration** value in the following example, the default value of **24h0m0s** is greater than the value of **ca.duration**, conflicting with the specified conditions.

#### Example

```

certConfig:
  ca:
    duration: 4h0m0s
    renewBefore: 1h0m0s
  server:
    duration: 4h0m0s
    renewBefore: 4h0m0s

```

This results in the following error message:

```

error: hyperconvergeds.hco.kubevirt.io "kubevirt-hyperconverged" could not be patched: admission
webhook "validate-hco.kubevirt.io" denied the request: spec.certConfig: ca.duration is smaller than
server.duration

```

The error message only mentions the first conflict. Review all certConfig values before you proceed.

#### 10.15.4. Configuring the default CPU model

Use the **defaultCPUModel** setting in the **HyperConverged** custom resource (CR) to define a cluster-wide default CPU model.

The virtual machine (VM) CPU model depends on the availability of CPU models within the VM and the cluster.

- If the VM does not have a defined CPU model:
  - The **defaultCPUModel** is automatically set using the CPU model defined at the cluster-wide level.
- If both the VM and the cluster have a defined CPU model:
  - The VM’s CPU model takes precedence.
- If neither the VM nor the cluster have a defined CPU model:
  - The host-model is automatically set using the CPU model defined at the host level.

##### 10.15.4.1. Configuring the default CPU model

Configure the **defaultCPUModel** by updating the **HyperConverged** custom resource (CR). You can change the **defaultCPUModel** while OpenShift Virtualization is running.



#### NOTE

The **defaultCPUModel** is case sensitive.

#### Prerequisites

- Install the OpenShift CLI (oc).

#### Procedure

1. Open the **HyperConverged** CR by running the following command:

```
$ oc edit hco -n openshift-cnv kubevirt-hyperconverged
```

2. Add the **defaultCPUModel** field to the CR and set the value to the name of a CPU model that exists in the cluster:

```
apiVersion: hco.kubevirt.io/v1beta1
kind: HyperConverged
metadata:
  name: kubevirt-hyperconverged
  namespace: openshift-cnv
spec:
  defaultCPUModel: "EPYC"
```

3. Apply the YAML file to your cluster.

## 10.15.5. Using UEFI mode for virtual machines

You can boot a virtual machine (VM) in Unified Extensible Firmware Interface (UEFI) mode.

### 10.15.5.1. About UEFI mode for virtual machines

Unified Extensible Firmware Interface (UEFI), like legacy BIOS, initializes hardware components and operating system image files when a computer starts. UEFI supports more modern features and customization options than BIOS, enabling faster boot times.

It stores all the information about initialization and startup in a file with a **.efi** extension, which is stored on a special partition called EFI System Partition (ESP). The ESP also contains the boot loader programs for the operating system that is installed on the computer.

### 10.15.5.2. Booting virtual machines in UEFI mode

You can configure a virtual machine to boot in UEFI mode by editing the **VirtualMachine** manifest.

#### Prerequisites

- Install the OpenShift CLI (**oc**).

#### Procedure

1. Edit or create a **VirtualMachine** manifest file. Use the **spec.firmware.bootloader** stanza to configure UEFI mode:

#### Bootin in UEFI mode with secure boot active

```
apiVersion: kubevirt.io/v1
kind: VirtualMachine
metadata:
  labels:
    special: vm-secureboot
  name: vm-secureboot
spec:
  template:
    metadata:
      labels:
        special: vm-secureboot
    spec:
      domain:
        devices:
          disks:
            - disk:
                bus: virtio
                name: containerdisk
      features:
        acpi: {}
        smm:
          enabled: true 1
      firmware:
        bootloader:
```

```
efi:  
  secureBoot: true 2  
# ...
```

- 1 OpenShift Virtualization requires System Management Mode (**SMM**) to be enabled for Secure Boot in UEFI mode to occur.
- 2 OpenShift Virtualization supports a VM with or without Secure Boot when using UEFI mode. If Secure Boot is enabled, then UEFI mode is required. However, UEFI mode can be enabled without using Secure Boot.

2. Apply the manifest to your cluster by running the following command:

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

## 10.15.6. Configuring PXE booting for virtual machines

PXE booting, or network booting, is available in OpenShift Virtualization. Network booting allows a computer to boot and load an operating system or other program without requiring a locally attached storage device. For example, you can use it to choose your desired OS image from a PXE server when deploying a new host.

### 10.15.6.1. Prerequisites

- A Linux bridge must be [connected](#).
- The PXE server must be connected to the same VLAN as the bridge.

### 10.15.6.2. PXE booting with a specified MAC address

As an administrator, you can boot a client over the network by first creating a **NetworkAttachmentDefinition** object for your PXE network. Then, reference the network attachment definition in your virtual machine instance configuration file before you start the virtual machine instance. You can also specify a MAC address in the virtual machine instance configuration file, if required by the PXE server.

#### Prerequisites

- A Linux bridge must be connected.
- The PXE server must be connected to the same VLAN as the bridge.

#### Procedure

1. Configure a PXE network on the cluster:
  - a. Create the network attachment definition file for PXE network **pxe-net-conf**:

```
apiVersion: "k8s.cni.cncf.io/v1"  
kind: NetworkAttachmentDefinition  
metadata:  
  name: pxe-net-conf  
spec:
```

```
config: {
  "cniVersion": "0.3.1",
  "name": "pxe-net-conf",
  "plugins": [
    {
      "type": "cnv-bridge",
      "bridge": "br1",
      "vlan": 1 1
    },
    {
      "type": "cnv-tuning" 2
    }
  ]
}'
```

**1** Optional: The VLAN tag.

**2** The **cnv-tuning** plugin provides support for custom MAC addresses.



#### NOTE

The virtual machine instance will be attached to the bridge **br1** through an access port with the requested VLAN.

2. Create the network attachment definition by using the file you created in the previous step:

```
$ oc create -f pxe-net-conf.yaml
```

3. Edit the virtual machine instance configuration file to include the details of the interface and network.

- a. Specify the network and MAC address, if required by the PXE server. If the MAC address is not specified, a value is assigned automatically.

Ensure that **bootOrder** is set to **1** so that the interface boots first. In this example, the interface is connected to a network called **<pxe-net>**:

```
interfaces:
- masquerade: {}
  name: default
- bridge: {}
  name: pxe-net
  macAddress: de:00:00:00:00:de
  bootOrder: 1
```



#### NOTE

Boot order is global for interfaces and disks.

- b. Assign a boot device number to the disk to ensure proper booting after operating system provisioning.

Set the disk **bootOrder** value to **2**:

```

devices:
disks:
- disk:
  bus: virtio
  name: containerdisk
bootOrder: 2

```

- c. Specify that the network is connected to the previously created network attachment definition. In this scenario, <pxe-net> is connected to the network attachment definition called <pxe-net-conf>:

```

networks:
- name: default
  pod: {}
- name: pxe-net
  multus:
    networkName: pxe-net-conf

```

4. Create the virtual machine instance:

```
$ oc create -f vmi-pxe-boot.yaml
```

### Example output

```
virtualmachineinstance.kubevirt.io "vmi-pxe-boot" created
```

1. Wait for the virtual machine instance to run:

```
$ oc get vmi vmi-pxe-boot -o yaml | grep -i phase
phase: Running
```

2. View the virtual machine instance using VNC:

```
$ virtctl vnc vmi-pxe-boot
```

3. Watch the boot screen to verify that the PXE boot is successful.

4. Log in to the virtual machine instance:

```
$ virtctl console vmi-pxe-boot
```

5. Verify the interfaces and MAC address on the virtual machine and that the interface connected to the bridge has the specified MAC address. In this case, we used **eth1** for the PXE boot, without an IP address. The other interface, **eth0**, got an IP address from OpenShift Container Platform.

```
$ ip addr
```

### Example output

```
...
3. eth1: <BROADCAST,MULTICAST> mtu 1500 qdisc noop state DOWN group default qlen 1000
   link/ether de:00:00:00:00:de brd ff:ff:ff:ff:ff:ff
```

### 10.15.6.3. OpenShift Virtualization networking glossary

OpenShift Virtualization provides advanced networking functionality by using custom resources and plugins.

The following terms are used throughout OpenShift Virtualization documentation:

#### Container Network Interface (CNI)

a [Cloud Native Computing Foundation](#) project, focused on container network connectivity.

OpenShift Virtualization uses CNI plugins to build upon the basic Kubernetes networking functionality.

#### Multus

a "meta" CNI plugin that allows multiple CNIs to exist so that a pod or virtual machine can use the interfaces it needs.

#### Custom resource definition (CRD)

a [Kubernetes](#) API resource that allows you to define custom resources, or an object defined by using the CRD API resource.

#### Network attachment definition (NAD)

a CRD introduced by the Multus project that allows you to attach pods, virtual machines, and virtual machine instances to one or more networks.

#### Node network configuration policy (NNCP)

a description of the requested network configuration on nodes. You update the node network configuration, including adding and removing interfaces, by applying a

**NodeNetworkConfigurationPolicy** manifest to the cluster.

#### Preboot eXecution Environment (PXE)

an interface that enables an administrator to boot a client machine from a server over the network. Network booting allows you to remotely load operating systems and other software onto the client.

### 10.15.7. Using huge pages with virtual machines

You can use huge pages as backing memory for virtual machines in your cluster.

#### 10.15.7.1. Prerequisites

- Nodes must have [pre-allocated huge pages configured](#).

#### 10.15.7.2. What huge pages do

Memory is managed in blocks known as pages. On most systems, a page is 4Ki. 1Mi of memory is equal to 256 pages; 1Gi of memory is 256,000 pages, and so on. CPUs have a built-in memory management unit that manages a list of these pages in hardware. The Translation Lookaside Buffer (TLB) is a small hardware cache of virtual-to-physical page mappings. If the virtual address passed in a hardware instruction can be found in the TLB, the mapping can be determined quickly. If not, a TLB miss occurs, and the system falls back to slower, software-based address translation, resulting in performance issues. Since the size of the TLB is fixed, the only way to reduce the chance of a TLB miss is to increase the page size.

A huge page is a memory page that is larger than 4Ki. On x86\_64 architectures, there are two common huge page sizes: 2Mi and 1Gi. Sizes vary on other architectures. To use huge pages, code must be written so that applications are aware of them. Transparent Huge Pages (THP) attempt to automate the management of huge pages without application knowledge, but they have limitations. In particular, they are limited to 2Mi page sizes. THP can lead to performance degradation on nodes with high memory utilization or fragmentation due to defragmenting efforts of THP, which can lock memory pages. For this reason, some applications may be designed to (or recommend) usage of pre-allocated huge pages instead of THP.

In OpenShift Virtualization, virtual machines can be configured to consume pre-allocated huge pages.

### 10.15.7.3. Configuring huge pages for virtual machines

You can configure virtual machines to use pre-allocated huge pages by including the **memory.hugepages.pageSize** and **resources.requests.memory** parameters in your virtual machine configuration.

The memory request must be divisible by the page size. For example, you cannot request **500Mi** memory with a page size of **1Gi**.



#### NOTE

The memory layouts of the host and the guest OS are unrelated. Huge pages requested in the virtual machine manifest apply to QEMU. Huge pages inside the guest can only be configured based on the amount of available memory of the virtual machine instance.

If you edit a running virtual machine, the virtual machine must be rebooted for the changes to take effect.

#### Prerequisites

- Nodes must have pre-allocated huge pages configured.

#### Procedure

- In your virtual machine configuration, add the **resources.requests.memory** and **memory.hugepages.pageSize** parameters to the **spec.domain**. The following configuration snippet is for a virtual machine that requests a total of **4Gi** memory with a page size of **1Gi**:

```
kind: VirtualMachine
# ...
spec:
  domain:
    resources:
      requests:
        memory: "4Gi" 1
      memory:
        hugepages:
          pageSize: "1Gi" 2
# ...
```

- The total amount of memory requested for the virtual machine. This value must be divisible by the page size.

- 2 The size of each huge page. Valid values for x86\_64 architecture are **1Gi** and **2Mi**. The page size must be smaller than the requested memory.

2. Apply the virtual machine configuration:

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

## 10.15.8. Enabling dedicated resources for virtual machines

To improve performance, you can dedicate node resources, such as CPU, to a virtual machine.

### 10.15.8.1. About dedicated resources

When you enable dedicated resources for your virtual machine, your virtual machine's workload is scheduled on CPUs that will not be used by other processes. By using dedicated resources, you can improve the performance of the virtual machine and the accuracy of latency predictions.

### 10.15.8.2. Prerequisites

- The [CPU Manager](#) must be configured on the node. Verify that the node has the **cpumanager = true** label before scheduling virtual machine workloads.
- The virtual machine must be powered off.

### 10.15.8.3. Enabling dedicated resources for a virtual machine

You enable dedicated resources for a virtual machine in the **Details** tab. Virtual machines that were created from a Red Hat template can be configured with dedicated resources.

#### Procedure

- In the OpenShift Container Platform console, click **Virtualization** → **VirtualMachines** from the side menu.
- Select a virtual machine to open the **VirtualMachine details** page.
- On the **Configuration** → **Scheduling** tab, click the edit icon beside **Dedicated Resources**.
- Select **Schedule this workload with dedicated resources (guaranteed policy)**
- Click **Save**.

## 10.15.9. Scheduling virtual machines

You can schedule a virtual machine (VM) on a node by ensuring that the VM's CPU model and policy attribute are matched for compatibility with the CPU models and policy attributes supported by the node.

### 10.15.9.1. Policy attributes

You can schedule a virtual machine (VM) by specifying a policy attribute and a CPU feature that is matched for compatibility when the VM is scheduled on a node. A policy attribute specified for a VM determines how that VM is scheduled on a node.

| Policy attribute | Description                                                                                                                                                                                                                                                                                                                                                                                                       |
|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| force            | The VM is forced to be scheduled on a node. This is true even if the host CPU does not support the VM's CPU.                                                                                                                                                                                                                                                                                                      |
| require          | Default policy that applies to a VM if the VM is not configured with a specific CPU model and feature specification. If a node is not configured to support CPU node discovery with this default policy attribute or any one of the other policy attributes, VMs are not scheduled on that node. Either the host CPU must support the VM's CPU or the hypervisor must be able to emulate the supported CPU model. |
| optional         | The VM is added to a node if that VM is supported by the host's physical machine CPU.                                                                                                                                                                                                                                                                                                                             |
| disable          | The VM cannot be scheduled with CPU node discovery.                                                                                                                                                                                                                                                                                                                                                               |
| forbid           | The VM is not scheduled even if the feature is supported by the host CPU and CPU node discovery is enabled.                                                                                                                                                                                                                                                                                                       |

### 10.15.9.2. Setting a policy attribute and CPU feature

You can set a policy attribute and CPU feature for each virtual machine (VM) to ensure that it is scheduled on a node according to policy and feature. The CPU feature that you set is verified to ensure that it is supported by the host CPU or emulated by the hypervisor.

#### Procedure

- Edit the **domain** spec of your VM configuration file. The following example sets the CPU feature and the **require** policy for a virtual machine (VM):

```
apiVersion: kubevirt.io/v1
kind: VirtualMachine
metadata:
  name: myvm
spec:
  template:
    spec:
      domain:
        cpu:
          features:
            - name: apic 1
          policy: require 2
```

- 1 Name of the CPU feature for the VM.
- 2 Policy attribute for the VM.

### 10.15.9.3. Scheduling virtual machines with the supported CPU model

You can configure a CPU model for a virtual machine (VM) to schedule it on a node where its CPU model is supported.

### Procedure

- Edit the **domain** spec of your virtual machine configuration file. The following example shows a specific CPU model defined for a VM:

```
apiVersion: kubevirt.io/v1
kind: VirtualMachine
metadata:
  name: myvm
spec:
  template:
    spec:
      domain:
        cpu:
          model: Conroe ①
```

① CPU model for the VM.

#### 10.15.9.4. Scheduling virtual machines with the host model

When the CPU model for a virtual machine (VM) is set to **host-model**, the VM inherits the CPU model of the node where it is scheduled.

### Procedure

- Edit the **domain** spec of your VM configuration file. The following example shows **host-model** being specified for the virtual machine:

```
apiVersion: kubevirt/v1alpha3
kind: VirtualMachine
metadata:
  name: myvm
spec:
  template:
    spec:
      domain:
        cpu:
          model: host-model ①
```

① The VM that inherits the CPU model of the node where it is scheduled.

#### 10.15.10. Configuring PCI passthrough

The Peripheral Component Interconnect (PCI) passthrough feature enables you to access and manage hardware devices from a virtual machine. When PCI passthrough is configured, the PCI devices function as if they were physically attached to the guest operating system.

Cluster administrators can expose and manage host devices that are permitted to be used in the cluster by using the **oc** command-line interface (CLI).

### 10.15.10.1. About preparing a host device for PCI passthrough

To prepare a host device for PCI passthrough by using the CLI, create a **MachineConfig** object and add kernel arguments to enable the Input-Output Memory Management Unit (IOMMU). Bind the PCI device to the Virtual Function I/O (VFIO) driver and then expose it in the cluster by editing the **permittedHostDevices** field of the **HyperConverged** custom resource (CR). The **permittedHostDevices** list is empty when you first install the OpenShift Virtualization Operator.

To remove a PCI host device from the cluster by using the CLI, delete the PCI device information from the **HyperConverged** CR.

#### 10.15.10.1.1. Adding kernel arguments to enable the IOMMU driver

To enable the IOMMU (Input-Output Memory Management Unit) driver in the kernel, create the **MachineConfig** object and add the kernel arguments.

#### Prerequisites

- Administrative privilege to a working OpenShift Container Platform cluster.
- Intel or AMD CPU hardware.
- Intel Virtualization Technology for Directed I/O extensions or AMD IOMMU in the BIOS (Basic Input/Output System) is enabled.

#### Procedure

1. Create a **MachineConfig** object that identifies the kernel argument. The following example shows a kernel argument for an Intel CPU.

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker 1
  name: 100-worker-iommu 2
spec:
  config:
    ignition:
      version: 3.2.0
    kernelArguments:
      - intel_iommu=on 3
# ...
```

- 1 Applies the new kernel argument only to worker nodes.
- 2 The **name** indicates the ranking of this kernel argument (100) among the machine configs and its purpose. If you have an AMD CPU, specify the kernel argument as **amd\_iommu=on**.
- 3 Identifies the kernel argument as **intel\_iommu** for an Intel CPU.

2. Create the new **MachineConfig** object:

```
$ oc create -f 100-worker-kernel-arg-iommu.yaml
```

## Verification

- Verify that the new **MachineConfig** object was added.

```
$ oc get MachineConfig
```

### 10.15.10.1.2. Binding PCI devices to the VFIO driver

To bind PCI devices to the VFIO (Virtual Function I/O) driver, obtain the values for **vendor-ID** and **device-ID** from each device and create a list with the values. Add this list to the **MachineConfig** object. The **MachineConfig** Operator generates the **/etc/modprobe.d/vfio.conf** on the nodes with the PCI devices, and binds the PCI devices to the VFIO driver.

## Prerequisites

- You added kernel arguments to enable IOMMU for the CPU.

## Procedure

- Run the **lspci** command to obtain the **vendor-ID** and the **device-ID** for the PCI device.

```
$ lspci -nnv | grep -i nvidia
```

### Example output

```
02:01.0 3D controller [0302]: NVIDIA Corporation GV100GL [Tesla V100 PCIe 32GB]
[10de:1eb8] (rev a1)
```

- Create a Butane config file, **100-worker-vfiopci.bu**, binding the PCI device to the VFIO driver.



### NOTE

See "Creating machine configs with Butane" for information about Butane.

### Example

```
variant: openshift
version: 4.13.0
metadata:
  name: 100-worker-vfiopci
  labels:
    machineconfiguration.openshift.io/role: worker ①
storage:
  files:
    - path: /etc/modprobe.d/vfio.conf
      mode: 0644
      overwrite: true
      contents:
        inline: |
          options vfio-pci ids=10de:1eb8 ②
    - path: /etc/modules-load.d/vfio-pci.conf ③
      mode: 0644
```

```
  overwrite: true
  contents:
    inline: vfio-pci
```

- 1 Applies the new kernel argument only to worker nodes.
  - 2 Specify the previously determined **vendor-ID** value (**10de**) and the **device-ID** value (**1eb8**) to bind a single device to the VFIO driver. You can add a list of multiple devices with their vendor and device information.
  - 3 The file that loads the vfio-pci kernel module on the worker nodes.
3. Use Butane to generate a **MachineConfig** object file, **100-worker-vfiopci.yaml**, containing the configuration to be delivered to the worker nodes:

```
$ butane 100-worker-vfiopci.bu -o 100-worker-vfiopci.yaml
```

4. Apply the **MachineConfig** object to the worker nodes:

```
$ oc apply -f 100-worker-vfiopci.yaml
```

5. Verify that the **MachineConfig** object was added.

```
$ oc get MachineConfig
```

### Example output

| NAME                             | GENERATEDBYCONTROLLER                    | IGNITIONVERSION |
|----------------------------------|------------------------------------------|-----------------|
| AGE                              |                                          |                 |
| 00-master                        | d3da910bfa9f4b599af4ed7f5ac270d55950a3a1 | 3.2.0 25h       |
| 00-worker                        | d3da910bfa9f4b599af4ed7f5ac270d55950a3a1 | 3.2.0 25h       |
| 01-master-container-runtime      | d3da910bfa9f4b599af4ed7f5ac270d55950a3a1 | 3.2.0 25h       |
| 01-master-kubelet                | d3da910bfa9f4b599af4ed7f5ac270d55950a3a1 | 3.2.0 25h       |
| 01-worker-container-runtime      | d3da910bfa9f4b599af4ed7f5ac270d55950a3a1 | 3.2.0 25h       |
| 01-worker-kubelet                | d3da910bfa9f4b599af4ed7f5ac270d55950a3a1 | 3.2.0 25h       |
| 100-worker-iommu                 |                                          | 3.2.0 30s       |
| 100-worker-vfiopci-configuration |                                          | 3.2.0 30s       |

### Verification

- Verify that the VFIO driver is loaded.

```
$ lspci -nnk -d 10de:
```

The output confirms that the VFIO driver is being used.

### Example output

```
04:00.0 3D controller [0302]: NVIDIA Corporation GP102GL [Tesla P40] [10de:1eb8] (rev a1)
  Subsystem: NVIDIA Corporation Device [10de:1eb8]
  Kernel driver in use: vfio-pci
  Kernel modules: nouveau
```

#### 10.15.10.1.3. Exposing PCI host devices in the cluster using the CLI

To expose PCI host devices in the cluster, add details about the PCI devices to the **spec.permittedHostDevices.pciHostDevices** array of the **HyperConverged** custom resource (CR).

#### Procedure

1. Edit the **HyperConverged** CR in your default editor by running the following command:

```
$ oc edit hyperconverged kubevirt-hyperconverged -n openshift-cnv
```

2. Add the PCI device information to the **spec.permittedHostDevices.pciHostDevices** array. For example:

#### Example configuration file

```
apiVersion: hco.kubevirt.io/v1
kind: HyperConverged
metadata:
  name: kubevirt-hyperconverged
  namespace: openshift-cnv
spec:
  permittedHostDevices: ①
    pciHostDevices: ②
      - pciDeviceSelector: "10DE:1DB6" ③
        resourceName: "nvidia.com/GV100GL_Tesla_V100" ④
      - pciDeviceSelector: "10DE:1EB8"
        resourceName: "nvidia.com/TU104GL_Tesla_T4"
      - pciDeviceSelector: "8086:6F54"
        resourceName: "intel.com/qat"
        externalResourceProvider: true ⑤
    # ...
```

- ① The host devices that are permitted to be used in the cluster.
- ② The list of PCI devices available on the node.
- ③ The **vendor-ID** and the **device-ID** required to identify the PCI device.
- ④ The name of a PCI host device.
- ⑤ Optional: Setting this field to **true** indicates that the resource is provided by an external device plugin. OpenShift Virtualization allows the usage of this device in the cluster but leaves the allocation and monitoring to an external device plugin.

**NOTE**

The above example snippet shows two PCI host devices that are named **nvidia.com/GV100GL\_Tesla\_V100** and **nvidia.com/TU104GL\_Tesla\_T4** added to the list of permitted host devices in the **HyperConverged** CR. These devices have been tested and verified to work with OpenShift Virtualization.

3. Save your changes and exit the editor.

**Verification**

- Verify that the PCI host devices were added to the node by running the following command. The example output shows that there is one device each associated with the **nvidia.com/GV100GL\_Tesla\_V100**, **nvidia.com/TU104GL\_Tesla\_T4**, and **intel.com/qat** resource names.

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

**Example output**

```
Capacity:
cpu:          64
devices.kubevirt.io/kvm:    110
devices.kubevirt.io/tun:    110
devices.kubevirt.io/vhost-net: 110
ephemeral-storage: 915128Mi
hugepages-1Gi:      0
hugepages-2Mi:      0
memory:           131395264Ki
nvidia.com/GV100GL_Tesla_V100  1
nvidia.com/TU104GL_Tesla_T4   1
intel.com/qat:       1
pods:             250

Allocatable:
cpu:          63500m
devices.kubevirt.io/kvm:    110
devices.kubevirt.io/tun:    110
devices.kubevirt.io/vhost-net: 110
ephemeral-storage: 863623130526
hugepages-1Gi:      0
hugepages-2Mi:      0
memory:           130244288Ki
nvidia.com/GV100GL_Tesla_V100  1
nvidia.com/TU104GL_Tesla_T4   1
intel.com/qat:       1
pods:             250
```

**10.15.10.1.4. Removing PCI host devices from the cluster using the CLI**

To remove a PCI host device from the cluster, delete the information for that device from the **HyperConverged** custom resource (CR).

**Procedure**

1. Edit the **HyperConverged** CR in your default editor by running the following command:

```
$ oc edit hyperconverged kubevirt-hyperconverged -n openshift-cnv
```

2. Remove the PCI device information from the **spec.permittedHostDevices.pciHostDevices** array by deleting the **pciDeviceSelector**, **resourceName** and **externalResourceProvider** (if applicable) fields for the appropriate device. In this example, the **intel.com/qat** resource has been deleted.

### Example configuration file

```
apiVersion: hco.kubevirt.io/v1
kind: HyperConverged
metadata:
  name: kubevirt-hyperconverged
  namespace: openshift-cnv
spec:
  permittedHostDevices:
    pciHostDevices:
      - pciDeviceSelector: "10DE:1DB6"
        resourceName: "nvidia.com/GV100GL_Tesla_V100"
      - pciDeviceSelector: "10DE:1EB8"
        resourceName: "nvidia.com/TU104GL_Tesla_T4"
    # ...
```

3. Save your changes and exit the editor.

### Verification

- Verify that the PCI host device was removed from the node by running the following command. The example output shows that there are zero devices associated with the **intel.com/qat** resource name.

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

### Example output

```
Capacity:
cpu: 64
devices.kubevirt.io/kvm: 110
devices.kubevirt.io/tun: 110
devices.kubevirt.io/vhost-net: 110
ephemeral-storage: 915128Mi
hugepages-1Gi: 0
hugepages-2Mi: 0
memory: 131395264Ki
nvidia.com/GV100GL_Tesla_V100 1
nvidia.com/TU104GL_Tesla_T4 1
intel.com/qat: 0
pods: 250
Allocatable:
cpu: 63500m
devices.kubevirt.io/kvm: 110
devices.kubevirt.io/tun: 110
```

```

devices.kubevirt.io/vhost-net: 110
ephemeral-storage: 863623130526
hugepages-1Gi: 0
hugepages-2Mi: 0
memory: 130244288Ki
nvidia.com/GV100GL_Tesla_V100 1
nvidia.com/TU104GL_Tesla_T4 1
intel.com/qat: 0
pods: 250

```

### 10.15.10.2. Configuring virtual machines for PCI passthrough

After the PCI devices have been added to the cluster, you can assign them to virtual machines. The PCI devices are now available as if they are physically connected to the virtual machines.

#### 10.15.10.2.1. Assigning a PCI device to a virtual machine

When a PCI device is available in a cluster, you can assign it to a virtual machine and enable PCI passthrough.

#### Procedure

- Assign the PCI device to a virtual machine as a host device.

#### Example

```

apiVersion: kubevirt.io/v1
kind: VirtualMachine
spec:
  domain:
    devices:
      hostDevices:
        - deviceName: nvidia.com/TU104GL_Tesla_T4 ①
          name: hostdevices1

```

- ① The name of the PCI device that is permitted on the cluster as a host device. The virtual machine can access this host device.

#### Verification

- Use the following command to verify that the host device is available from the virtual machine.

```
$ lspci -nnk | grep NVIDIA
```

#### Example output

```
$ 02:01.0 3D controller [0302]: NVIDIA Corporation GV100GL [Tesla V100 PCIe 32GB]
[10de:1eb8] (rev a1)
```

### 10.15.10.3. Additional resources

- [Enabling Intel VT-X and AMD-V Virtualization Hardware Extensions in BIOS](#)

- [Managing file permissions](#)
- [Post-installation machine configuration tasks](#)

## 10.15.11. Configuring vGPU passthrough

Your virtual machines can access a virtual GPU (vGPU) hardware. Assigning a vGPU to your virtual machine allows you do the following:

- Access a fraction of the underlying hardware's GPU to achieve high performance benefits in your virtual machine.
- Streamline resource-intensive I/O operations.



### IMPORTANT

vGPU passthrough can only be assigned to devices that are connected to clusters running in a bare metal environment.

#### 10.15.11.1. Assigning vGPU passthrough devices to a virtual machine

Use the OpenShift Container Platform web console to assign vGPU passthrough devices to your virtual machine.

#### Prerequisites

- The virtual machine must be stopped.

#### Procedure

1. In the OpenShift Container Platform web console, click **Virtualization** → **VirtualMachines** from the side menu.
2. Select the virtual machine to which you want to assign the device.
3. On the **Details** tab, click **GPU devices**.  
If you add a vGPU device as a host device, you cannot access the device with the VNC console.
4. Click **Add GPU device**, enter the **Name** and select the device from the **Device name** list.
5. Click **Save**.
6. Click the **YAML** tab to verify that the new devices have been added to your cluster configuration in the **hostDevices** section.



### NOTE

You can add hardware devices to virtual machines created from customized templates or a YAML file. You cannot add devices to pre-supplied boot source templates for specific operating systems, such as Windows 10 or RHEL 7.

To display resources that are connected to your cluster, click **Compute** → **Hardware Devices** from the side menu.

### 10.15.11.2. Additional resources

- [Creating virtual machines](#)
- [Creating virtual machine templates](#)

### 10.15.12. Configuring mediated devices

OpenShift Virtualization automatically creates mediated devices, such as virtual GPUs (vGPUs), if you provide a list of devices in the **HyperConverged** custom resource (CR).



#### IMPORTANT

Declarative configuration of mediated devices 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](#).

#### 10.15.12.1. About using the NVIDIA GPU Operator

The NVIDIA GPU Operator manages NVIDIA GPU resources in a OpenShift Container Platform cluster and automates tasks related to bootstrapping GPU nodes. Because the GPU is a special resource in the cluster, you must install some components before you can deploy application workloads to the GPU. These components include the NVIDIA drivers that enable the compute unified device architecture (CUDA), Kubernetes device plugin, container runtime, and other features such as automatic node labeling, monitoring, and more.



#### NOTE

The NVIDIA GPU Operator is supported only by NVIDIA. For more information about obtaining support from NVIDIA, see [Obtaining Support from NVIDIA](#).

There are two ways to enable GPUs with OpenShift Container Platform OpenShift Virtualization: the OpenShift Container Platform-native way described here and by using the NVIDIA GPU Operator.

The NVIDIA GPU Operator is a Kubernetes Operator that uses OpenShift Container Platform OpenShift Virtualization to provision GPUs for virtualized workloads running on OpenShift Container Platform. With the Operator, you can easily provision and manage GPU-enabled virtual machines to run complex artificial intelligence/machine learning (AI/ML) workloads on the same platform as their other workloads. The Operator also provides an easy way to scale the GPU capacity of their infrastructure, enabling rapid growth of GPU-based workloads.

For more information about using the NVIDIA GPU Operator to provision worker nodes for running GPU-accelerated VMs, see [NVIDIA GPU Operator with OpenShift Virtualization](#).

#### 10.15.12.2. About using virtual GPUs with OpenShift Virtualization

Some graphics processing unit (GPU) cards support the creation of virtual GPUs (vGPUs). OpenShift Virtualization can automatically create vGPUs and other mediated devices if an administrator provides

configuration details in the **HyperConverged** custom resource (CR). This automation is especially useful for large clusters.



## NOTE

Refer to your hardware vendor's documentation for functionality and support details.

### Mediated device

A physical device that is divided into one or more virtual devices. A vGPU is a type of mediated device (mdev); the performance of the physical GPU is divided among the virtual devices. You can assign mediated devices to one or more virtual machines (VMs), but the number of guests must be compatible with your GPU. Some GPUs do not support multiple guests.

#### 10.15.12.2.1. Prerequisites

- If your hardware vendor provides drivers, you installed them on the nodes where you want to create mediated devices.
  - If you use NVIDIA cards, you [installed the NVIDIA GRID driver](#).

#### 10.15.12.2.2. Configuration overview

When configuring mediated devices, an administrator must complete the following tasks:

- Create the mediated devices.
- Expose the mediated devices to the cluster.

The **HyperConverged** CR includes APIs that accomplish both tasks.

### Creating mediated devices

```
# ...
spec:
  mediatedDevicesConfiguration:
    mediatedDevicesTypes: ①
      - <device_type>
    nodeMediatedDeviceTypes: ②
      - mediatedDevicesTypes: ③
        - <device_type>
      nodeSelector: ④
        <node_selector_key>: <node_selector_value>
# ...
```

- ① Required: Configures global settings for the cluster.
- ② Optional: Overrides the global configuration for a specific node or group of nodes. Must be used with the global **mediatedDevicesTypes** configuration.
- ③ Required if you use **nodeMediatedDeviceTypes**. Overrides the global **mediatedDevicesTypes** configuration for the specified nodes.
- ④ Required if you use **nodeMediatedDeviceTypes**. Must include a **key:value** pair.

## Exposing mediated devices to the cluster

```
# ...
permittedHostDevices:
  mediatedDevices:
    - mdevNameSelector: GRID T4-2Q ①
      resourceName: nvidia.com/GRID_T4-2Q ②
# ...
```

- ① Exposes the mediated devices that map to this value on the host.



### NOTE

You can see the mediated device types that your device supports by viewing the contents of `/sys/bus/pci/devices/<slot>:<bus>:<domain>`.

`<function>/mdev_supported_types/<type>/name`, substituting the correct values for your system.

For example, the name file for the **nvidia-231** type contains the selector string **GRID T4-2Q**. Using **GRID T4-2Q** as the **mdevNameSelector** value allows nodes to use the **nvidia-231** type.

- ② The **resourceName** should match that allocated on the node. Find the **resourceName** by using the following command:

```
$ oc get $NODE -o json \
| jq '.status.allocatable' \
| with_entries(select(.key | startswith("nvidia.com/")))\ \
| with_entries(select(.value != "0"))'
```

### 10.15.12.2.3. How vGPUs are assigned to nodes

For each physical device, OpenShift Virtualization configures the following values:

- A single mdev type.
- The maximum number of instances of the selected **mdev** type.

The cluster architecture affects how devices are created and assigned to nodes.

### Large cluster with multiple cards per node

On nodes with multiple cards that can support similar vGPU types, the relevant device types are created in a round-robin manner. For example:

```
# ...
mediatedDevicesConfiguration:
  mediatedDevicesTypes:
    - nvidia-222
    - nvidia-228
    - nvidia-105
    - nvidia-108
# ...
```

In this scenario, each node has two cards, both of which support the following vGPU types:

```
nvidia-105
# ...
nvidia-108
nvidia-217
nvidia-299
# ...
```

On each node, OpenShift Virtualization creates the following vGPUs:

- 16 vGPUs of type nvidia-105 on the first card.
- 2 vGPUs of type nvidia-108 on the second card.

#### One node has a single card that supports more than one requested vGPU type

OpenShift Virtualization uses the supported type that comes first on the **mediatedDevicesTypes** list.

For example, the card on a node card supports **nvidia-223** and **nvidia-224**. The following **mediatedDevicesTypes** list is configured:

```
# ...
mediatedDevicesConfiguration:
  mediatedDevicesTypes:
    - nvidia-22
    - nvidia-223
    - nvidia-224
# ...
```

In this example, OpenShift Virtualization uses the **nvidia-223** type.

#### 10.15.12.2.4. About changing and removing mediated devices

The cluster's mediated device configuration can be updated with OpenShift Virtualization by:

- Editing the **HyperConverged** CR and change the contents of the **mediatedDevicesTypes** stanza.
- Changing the node labels that match the **nodeMediatedDeviceTypes** node selector.
- Removing the device information from the **spec.mediatedDevicesConfiguration** and **spec.permittedHostDevices** stanzas of the **HyperConverged** CR.



#### NOTE

If you remove the device information from the **spec.permittedHostDevices** stanza without also removing it from the **spec.mediatedDevicesConfiguration** stanza, you cannot create a new mediated device type on the same node. To properly remove mediated devices, remove the device information from both stanzas.

Depending on the specific changes, these actions cause OpenShift Virtualization to reconfigure mediated devices or remove them from the cluster nodes.

### 10.15.12.2.5. Preparing hosts for mediated devices

You must enable the Input-Output Memory Management Unit (IOMMU) driver before you can configure mediated devices.

#### 10.15.12.2.5.1. Adding kernel arguments to enable the IOMMU driver

To enable the IOMMU (Input-Output Memory Management Unit) driver in the kernel, create the **MachineConfig** object and add the kernel arguments.

#### Prerequisites

- Administrative privilege to a working OpenShift Container Platform cluster.
- Intel or AMD CPU hardware.
- Intel Virtualization Technology for Directed I/O extensions or AMD IOMMU in the BIOS (Basic Input/Output System) is enabled.

#### Procedure

- 1 Create a **MachineConfig** object that identifies the kernel argument. The following example shows a kernel argument for an Intel CPU.

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker 1
  name: 100-worker-iommu 2
spec:
  config:
    ignition:
      version: 3.2.0
  kernelArguments:
    - intel_iommu=on 3
# ...
```

- 1 Applies the new kernel argument only to worker nodes.
- 2 The **name** indicates the ranking of this kernel argument (100) among the machine configs and its purpose. If you have an AMD CPU, specify the kernel argument as **amd\_iommu=on**.
- 3 Identifies the kernel argument as **intel\_iommu** for an Intel CPU.

- 2 Create the new **MachineConfig** object:

```
$ oc create -f 100-worker-kernel-arg-iommu.yaml
```

#### Verification

- Verify that the new **MachineConfig** object was added.

```
$ oc get MachineConfig
```

### 10.15.12.2.6. Adding and removing mediated devices

You can add or remove mediated devices.

#### 10.15.12.2.6.1. Creating and exposing mediated devices

You can expose and create mediated devices such as virtual GPUs (vGPUs) by editing the **HyperConverged** custom resource (CR).

#### Prerequisites

- You enabled the IOMMU (Input-Output Memory Management Unit) driver.

#### Procedure

1. Edit the **HyperConverged** CR in your default editor by running the following command:

```
$ oc edit hyperconverged kubevirt-hyperconverged -n openshift-cnv
```

2. Add the mediated device information to the **HyperConverged** CR **spec**, ensuring that you include the **mediatedDevicesConfiguration** and **permittedHostDevices** stanzas. For example:

#### Example configuration file

```
apiVersion: hco.kubevirt.io/v1
kind: HyperConverged
metadata:
  name: kubevirt-hyperconverged
  namespace: openshift-cnv
spec:
  mediatedDevicesConfiguration: <.>
  mediatedDevicesTypes: <.>
  - nvidia-231
  nodeMediatedDeviceTypes: <.>
  - mediatedDevicesTypes: <.>
    - nvidia-233
  nodeSelector:
    kubernetes.io/hostname: node-11.redhat.com
  permittedHostDevices: <.>
    mediatedDevices:
    - mdevNameSelector: GRID T4-2Q
      resourceName: nvidia.com/GRID_T4-2Q
    - mdevNameSelector: GRID T4-8Q
      resourceName: nvidia.com/GRID_T4-8Q
# ...
```

<.> Creates mediated devices. <.> Required: Global **mediatedDevicesTypes** configuration. <.> Optional: Overrides the global configuration for specific nodes. <.> Required if you use **nodeMediatedDeviceTypes**. <.> Exposes mediated devices to the cluster.

3. Save your changes and exit the editor.

#### Verification

- You can verify that a device was added to a specific node by running the following command:

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

### 10.15.12.2.6.2. Removing mediated devices from the cluster using the CLI

To remove a mediated device from the cluster, delete the information for that device from the **HyperConverged** custom resource (CR).

#### Procedure

1. Edit the **HyperConverged** CR in your default editor by running the following command:

```
$ oc edit hyperconverged kubevirt-hyperconverged -n openshift-cnv
```

2. Remove the device information from the **spec.mediatedDevicesConfiguration** and **spec.permittedHostDevices** stanzas of the **HyperConverged** CR. Removing both entries ensures that you can later create a new mediated device type on the same node. For example:

#### Example configuration file

```
apiVersion: hco.kubevirt.io/v1
kind: HyperConverged
metadata:
  name: kubevirt-hyperconverged
  namespace: openshift-cnv
spec:
  mediatedDevicesConfiguration:
    mediatedDevicesTypes: ①
      - nvidia-231
  permittedHostDevices:
    mediatedDevices: ②
      - mdevNameSelector: GRID T4-2Q
      resourceName: nvidia.com/GRID_T4-2Q
```

- 1 To remove the **nvidia-231** device type, delete it from the **mediatedDevicesTypes** array.
  - 2 To remove the **GRID T4-2Q** device, delete the **mdevNameSelector** field and its corresponding **resourceName** field.
3. Save your changes and exit the editor.

### 10.15.12.3. Using mediated devices

A vGPU is a type of mediated device; the performance of the physical GPU is divided among the virtual devices. You can assign mediated devices to one or more virtual machines.

#### 10.15.12.3.1. Assigning a mediated device to a virtual machine

Assign mediated devices such as virtual GPUs (vGPUs) to virtual machines.

#### Prerequisites

- The mediated device is configured in the **HyperConverged** custom resource.

## Procedure

- Assign the mediated device to a virtual machine (VM) by editing the **spec.domain.devices.gpus** stanza of the **VirtualMachine** manifest:

### Example virtual machine manifest

```
apiVersion: kubevirt.io/v1
kind: VirtualMachine
spec:
  domain:
    devices:
      gpus:
        - deviceName: nvidia.com/TU104GL_Tesla_T4 ①
          name: gpu1 ②
        - deviceName: nvidia.com/GRID_T4-1Q
          name: gpu2
```

- ① The resource name associated with the mediated device.
- ② A name to identify the device on the VM.

## Verification

- To verify that the device is available from the virtual machine, run the following command, substituting **<device\_name>** with the **deviceName** value from the **VirtualMachine** manifest:

```
$ lspci -nnk | grep <device_name>
```

### 10.15.12.4. Additional resources

- [Enabling Intel VT-X and AMD-V Virtualization Hardware Extensions in BIOS](#)

### 10.15.13. Enabling descheduler evictions on virtual machines

You can use the descheduler to evict pods so that the pods can be rescheduled onto more appropriate nodes. If the pod is a virtual machine, the pod eviction causes the virtual machine to be live migrated to another node.



#### IMPORTANT

Descheduler eviction for virtual machines 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](#).

### 10.15.13.1. Descheduler profiles

Use the Technology Preview **DevPreviewLongLifecycle** profile to enable the descheduler on a virtual machine. This is the only descheduler profile currently available for OpenShift Virtualization. To ensure proper scheduling, create VMs with CPU and memory requests for the expected load.

#### DevPreviewLongLifecycle

This profile balances resource usage between nodes and enables the following strategies:

- **RemovePodsHavingTooManyRestarts**: removes pods whose containers have been restarted too many times and pods where the sum of restarts over all containers (including Init Containers) is more than 100. Restarting the VM guest operating system does not increase this count.
- **LowNodeUtilization**: evicts pods from overutilized nodes when there are any underutilized nodes. The destination node for the evicted pod will be determined by the scheduler.
  - A node is considered underutilized if its usage is below 20% for all thresholds (CPU, memory, and number of pods).
  - A node is considered overutilized if its usage is above 50% for any of the thresholds (CPU, memory, and number of pods).

### 10.15.13.2. Installing the descheduler

The descheduler is not available by default. To enable the descheduler, you must install the Kube Descheduler Operator from OperatorHub and enable one or more descheduler profiles.

By default, the descheduler runs in predictive mode, which means that it only simulates pod evictions. You must change the mode to automatic for the descheduler to perform the pod evictions.



#### IMPORTANT

If you have enabled hosted control planes in your cluster, set a custom priority threshold to lower the chance that pods in the hosted control plane namespaces are evicted. Set the priority threshold class name to **hypershift-control-plane**, because it has the lowest priority value (**100000000**) of the hosted control plane priority classes.

#### Prerequisites

- Cluster administrator privileges.
- Access to the OpenShift Container Platform web console.

#### Procedure

1. Log in to the OpenShift Container Platform web console.
2. Create the required namespace for the Kube Descheduler Operator.
  - a. Navigate to **Administration** → **Namespaces** and click **Create Namespace**.
  - b. Enter **openshift-kube-descheduler-operator** in the **Name** field, enter **openshift.io/cluster-monitoring=true** in the **Labels** field to enable descheduler metrics, and click **Create**.

3. Install the Kube Descheduler Operator.
  - a. Navigate to **Operators** → **OperatorHub**.
  - b. Type **Kube Descheduler Operator** into the filter box.
  - c. Select the **Kube Descheduler Operator** and click **Install**.
  - d. On the **Install Operator** page, select **A specific namespace on the cluster** Select **openshift-kube-descheduler-operator** from the drop-down menu.
  - e. Adjust the values for the **Update Channel** and **Approval Strategy** to the desired values.
  - f. Click **Install**.
4. Create a descheduler instance.
  - a. From the **Operators** → **Installed Operators** page, click the **Kube Descheduler Operator**.
  - b. Select the **Kube Descheduler** tab and click **Create KubeDescheduler**.
  - c. Edit the settings as necessary.
    - i. To evict pods instead of simulating the evictions, change the **Mode** field to **Automatic**.
    - ii. Expand the **Profiles** section and select **DevPreviewLongLifecycle**. The **AffinityAndTaints** profile is enabled by default.



### IMPORTANT

The only profile currently available for OpenShift Virtualization is **DevPreviewLongLifecycle**.

You can also configure the profiles and settings for the descheduler later using the OpenShift CLI (**oc**).

#### 10.15.13.3. Enabling descheduler evictions on a virtual machine (VM)

After the descheduler is installed, you can enable descheduler evictions on your VM by adding an annotation to the **VirtualMachine** custom resource (CR).

##### Prerequisites

- Install the descheduler in the OpenShift Container Platform web console or OpenShift CLI (**oc**).
- Ensure that the VM is not running.

##### Procedure

1. Before starting the VM, add the **descheduler.alpha.kubernetes.io/evict** annotation to the **VirtualMachine** CR:

```
apiVersion: kubevirt.io/v1
kind: VirtualMachine
spec:
  template:
```

```

metadata:
  annotations:
    descheduler.alpha.kubernetes.io/evict: "true"

```

- If you did not already set the **DevPreviewLongLifecycle** profile in the web console during installation, specify the **DevPreviewLongLifecycle** in the **spec.profile** section of the **KubeDescheduler** object:

```

apiVersion: operator.openshift.io/v1
kind: KubeDescheduler
metadata:
  name: cluster
  namespace: openshift-kube-descheduler-operator
spec:
  deschedulingIntervalSeconds: 3600
  profiles:
  - DevPreviewLongLifecycle
  mode: Predictive ①

```

- By default, the descheduler does not evict pods. To evict pods, set **mode** to **Automatic**.

The descheduler is now enabled on the VM.

#### 10.15.13.4. Additional resources

- [Evicting pods using the descheduler](#)

## 10.16. IMPORTING VIRTUAL MACHINES

### 10.16.1. TLS certificates for data volume imports

TLS certificates for registry or HTTPS endpoints must be added to a config map to import data from these sources. This config map must be present in the namespace of the destination data volume.

Create the config map by referencing the relative file path for the TLS certificate.

#### Procedure

- Ensure you are in the correct namespace. The config map can only be referenced by data volumes if it is in the same namespace.

```
$ oc get ns
```

- Create the config map:

```
$ oc create configmap <configmap-name> --from-file=</path/to/file/ca.pem>
```

### 10.16.1.2. Example: Config map created from a TLS certificate

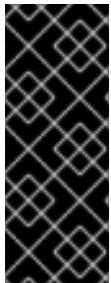
The following example is of a config map created from **ca.pem** TLS certificate.

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: tls-certs
data:
  ca.pem: |
    -----BEGIN CERTIFICATE-----
    ... <base64 encoded cert> ...
    -----END CERTIFICATE-----
```

## 10.16.2. Importing virtual machine images with data volumes

You can import an existing virtual machine image into your OpenShift Container Platform cluster storage. Using the Containerized Data Importer (CDI), you can import the image into a persistent volume claim (PVC) by using a data volume. OpenShift Virtualization uses one or more data volumes to automate the data import and the creation of an underlying PVC. You can attach a data volume to a virtual machine for persistent storage.

The virtual machine image can be hosted at an HTTP or HTTPS endpoint, or built into a container disk and stored in a container registry.



### IMPORTANT

When you import a disk image into a PVC, the disk image is expanded to use the full storage capacity that is requested in the PVC. To use this space, the disk partitions and file system(s) in the virtual machine might need to be expanded.

The resizing procedure varies based on the operating system installed on the virtual machine. See the operating system documentation for details.

### 10.16.2.1. Prerequisites

- If the endpoint requires a TLS certificate, the certificate must be [included in a config map](#) in the same namespace as the data volume and referenced in the data volume configuration.
- To import a container disk:
  - You might need to [prepare a container disk from a virtual machine image](#) and store it in your container registry before importing it.
  - If the container registry does not have TLS, you must [add the registry to the \*\*insecureRegistries\*\* field of the \*\*HyperConverged\*\* custom resource](#) before you can import a container disk from it.
- You might need to [define a storage class or prepare CDI scratch space](#) for this operation to complete successfully.

If you intend to import a virtual machine image into block storage with a data volume, you must have an available [local block persistent volume](#).

### 10.16.2.2. CDI supported operations matrix

This matrix shows the supported CDI operations for content types against endpoints, and which of these operations requires scratch space.

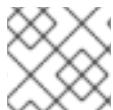
| Content types       | HTTP                      | HTTPS                       | HTTP basic auth           | Registry                 | Upload                     |
|---------------------|---------------------------|-----------------------------|---------------------------|--------------------------|----------------------------|
| KubeVirt<br>(QCOW2) | ✓ QCOW2<br>✓ GZ*<br>✓ XZ* | ✓ QCOW2**<br>✓ GZ*<br>✓ XZ* | ✓ QCOW2<br>✓ GZ*<br>✓ XZ* | ✓ QCOW2*<br>□ GZ<br>□ XZ | ✓ QCOW2*<br>✓ GZ*<br>✓ XZ* |
| KubeVirt<br>(RAW)   | ✓ RAW<br>✓ GZ<br>✓ XZ     | ✓ RAW<br>✓ GZ<br>✓ XZ       | ✓ RAW<br>✓ GZ<br>✓ XZ     | ✓ RAW*<br>□ GZ<br>□ XZ   | ✓ RAW*<br>✓ GZ*<br>✓ XZ*   |

✓ Supported operation

□ Unsupported operation

\* Requires scratch space

\*\* Requires scratch space if a custom certificate authority is required



### NOTE

CDI now uses the OpenShift Container Platform [cluster-wide proxy configuration](#).

#### 10.16.2.3. About data volumes

**DataVolume** objects are custom resources that are provided by the Containerized Data Importer (CDI) project. Data volumes orchestrate import, clone, and upload operations that are associated with an underlying persistent volume claim (PVC). You can create a data volume as either a standalone resource or by using the **dataVolumeTemplate** field in the virtual machine (VM) specification.



### NOTE

- VM disk PVCs that are prepared by using standalone data volumes maintain an independent lifecycle from the VM. If you use the **dataVolumeTemplate** field in the VM specification to prepare the PVC, the PVC shares the same lifecycle as the VM.

#### 10.16.2.4. Local block persistent volumes

If you intend to import a virtual machine image into block storage with a data volume, you must have an available local block persistent volume.

##### 10.16.2.4.1. About block persistent volumes

A block persistent volume (PV) is a PV that is backed by a raw block device. These volumes do not have a file system and can provide performance benefits for virtual machines by reducing overhead.

Raw block volumes are provisioned by specifying **volumeMode: Block** in the PV and persistent volume claim (PVC) specification.

#### 10.16.2.4.2. Creating a local block persistent volume

If you intend to import a virtual machine image into block storage with a data volume, you must have an available local block persistent volume.

Create a local block persistent volume (PV) on a node by populating a file and mounting it as a loop device. You can then reference this loop device in a PV manifest as a **Block** volume and use it as a block device for a virtual machine image.

#### Procedure

1. Log in as **root** to the node on which to create the local PV. This procedure uses **node01** for its examples.

2. Create a file and populate it with null characters so that it can be used as a block device. The following example creates a file **loop10** with a size of 2Gb (20 100Mb blocks):

```
$ dd if=/dev/zero of=<loop10> bs=100M count=20
```

3. Mount the **loop10** file as a loop device.

```
$ losetup </dev/loop10>d3 <loop10> ① ②
```

- ① File path where the loop device is mounted.
- ② The file created in the previous step to be mounted as the loop device.

4. Create a **PersistentVolume** manifest that references the mounted loop device.

```
kind: PersistentVolume
apiVersion: v1
metadata:
  name: <local-block-pv10>
  annotations:
spec:
  local:
    path: </dev/loop10> ①
    capacity:
      storage: <2Gi>
    volumeMode: Block ②
    storageClassName: local ③
  accessModes:
    - ReadWriteOnce
  persistentVolumeReclaimPolicy: Delete
  nodeAffinity:
    required:
      nodeSelectorTerms:
        - matchExpressions:
          - key: kubernetes.io/hostname
            operator: In
            values:
              - <node01> ④
```

- ① The path of the loop device on the node.

- 2 Specifies it is a block PV.
- 3 Optional: Set a storage class for the PV. If you omit it, the cluster default is used.
- 4 The node on which the block device was mounted.

5. Create the block PV.

```
# oc create -f <local-block-pv10.yaml> ①
```

- 1 The file name of the persistent volume created in the previous step.

#### 10.16.2.5. Importing a virtual machine image into storage by using a data volume

You can import a virtual machine image into storage by using a data volume.

The virtual machine image can be hosted at an HTTP or HTTPS endpoint or the image can be built into a container disk and stored in a container registry.

You specify the data source for the image in a **VirtualMachine** configuration file. When the virtual machine is created, the data volume with the virtual machine image is imported into storage.

#### Prerequisites

- To import a virtual machine image you must have the following:
  - A virtual machine disk image in RAW, ISO, or QCOW2 format, optionally compressed by using **xz** or **gz**.
  - An HTTP or HTTPS endpoint where the image is hosted, along with any authentication credentials needed to access the data source.
- To import a container disk, you must have a virtual machine image built into a container disk and stored in a container registry, along with any authentication credentials needed to access the data source.
- If the virtual machine must communicate with servers that use self-signed certificates or certificates not signed by the system CA bundle, you must create a config map in the same namespace as the data volume.

#### Procedure

1. If your data source requires authentication, create a **Secret** manifest, specifying the data source credentials, and save it as **endpoint-secret.yaml**:

```
apiVersion: v1
kind: Secret
metadata:
  name: endpoint-secret ①
  labels:
    app: containerized-data-importer
    type: Opaque
```

```
data:
  accessKeyId: "" ②
  secretKey: "" ③
```

- 1 Specify the name of the **Secret**.
- 2 Specify the Base64-encoded key ID or user name.
- 3 Specify the Base64-encoded secret key or password.

2. Apply the **Secret** manifest:

```
$ oc apply -f endpoint-secret.yaml
```

3. Edit the **VirtualMachine** manifest, specifying the data source for the virtual machine image you want to import, and save it as **vm-fedora-datavolume.yaml**:

```
apiVersion: kubevirt.io/v1
kind: VirtualMachine
metadata:
  creationTimestamp: null
  labels:
    kubevirt.io/vm: vm-fedora-datavolume
  name: vm-fedora-datavolume ①
spec:
  dataVolumeTemplates:
  - metadata:
      creationTimestamp: null
      name: fedora-dv ②
    spec:
      storage:
        volumeMode: Block ③
      resources:
        requests:
          storage: 10Gi
      storageClassName: local
      source: ④
        http:
          url: "https://mirror.arizona.edu/fedora/linux/releases/35/Cloud/x86_64/images/Fedora-Cloud-Base-35-1.2.x86_64.qcow2" ⑤
        secretRef: endpoint-secret ⑥
        certConfigMap: "" ⑦
      # To use a registry source, uncomment the following lines and delete the preceding
      # HTTP source block
      # registry:
      #   url: "docker://kubevirt/fedora-cloud-container-disk-demo:latest"
      #   secretRef: registry-secret ⑧
      #   certConfigMap: "" ⑨
    status: {}
  running: true
  template:
    metadata:
      creationTimestamp: null
```

```

labels:
  kubevirt.io/vm: vm-fedora-datavolume
spec:
  domain:
    devices:
      disks:
        - disk:
            bus: virtio
            name: datavolumedisk1
  machine:
    type: ""
  resources:
    requests:
      memory: 1.5Gi
  terminationGracePeriodSeconds: 180
  volumes:
    - dataVolume:
        name: fedora-dv
        name: datavolumedisk1
status: {}

```

- 1 Specify the name of the virtual machine.
- 2 Specify the name of the data volume.
- 3 The volume and access mode are detected automatically for known storage provisioners. Alternatively, you can specify **Block**.
- 4 5 Specify either the URL or the registry endpoint of the virtual machine image you want to import using the comment block. For example, if you want to use a registry source, you can comment out or delete the HTTP or HTTPS source block. Ensure that you replace the example values shown here with your own values.
- 6 8 Specify the **Secret** name if you created a **Secret** for the data source.
- 7 9 Optional: Specify a CA certificate config map.

#### 4. Create the virtual machine:

```
$ oc create -f vm-fedora-datavolume.yaml
```



#### NOTE

The **oc create** command creates the data volume and the virtual machine. The CDI controller creates an underlying PVC with the correct annotation and the import process begins. When the import is complete, the data volume status changes to **Succeeded**. You can start the virtual machine.

Data volume provisioning happens in the background, so there is no need to monitor the process.

#### Verification

1 2 3 4 5 6 7 8 9

- The importer pod downloads the virtual machine image or container disk from the specified URL and stores it on the provisioned PV. View the status of the importer pod by running the following command:

```
$ oc get pods
```

- Monitor the data volume until its status is **Succeeded** by running the following command:

```
$ oc describe dv fedora-dv 1
```

- 1 Specify the data volume name that you defined in the **VirtualMachine** manifest.

- Verify that provisioning is complete and that the virtual machine has started by accessing its serial console:

```
$ virtctl console vm-fedora-datavolume
```

#### 10.16.2.6. Additional resources

- [Configure preallocation mode](#) to improve write performance for data volume operations.

### 10.17. CLONING VIRTUAL MACHINES

#### 10.17.1. Enabling user permissions to clone data volumes across namespaces

The isolating nature of namespaces means that users cannot by default clone resources between namespaces.

To enable a user to clone a virtual machine to another namespace, a user with the **cluster-admin** role must create a new cluster role. Bind this cluster role to a user to enable them to clone virtual machines to the destination namespace.

##### 10.17.1.1. Prerequisites

- Only a user with the **cluster-admin** role can create cluster roles.

##### 10.17.1.2. About data volumes

**DataVolume** objects are custom resources that are provided by the Containerized Data Importer (CDI) project. Data volumes orchestrate import, clone, and upload operations that are associated with an underlying persistent volume claim (PVC). You can create a data volume as either a standalone resource or by using the **dataVolumeTemplate** field in the virtual machine (VM) specification.



##### NOTE

- VM disk PVCs that are prepared by using standalone data volumes maintain an independent lifecycle from the VM. If you use the **dataVolumeTemplate** field in the VM specification to prepare the PVC, the PVC shares the same lifecycle as the VM.

##### 10.17.1.3. Creating RBAC resources for cloning data volumes

Create a new cluster role that enables permissions for all actions for the **datavolumes** resource.

## Procedure

1. Create a **ClusterRole** manifest:

```
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRole
metadata:
  name: <datavolume-cloner> ①
rules:
- apiGroups: ["cdi.kubevirt.io"]
  resources: ["datavolumes/source"]
  verbs: ["*"]
```

- 1 Unique name for the cluster role.

2. Create the cluster role in the cluster:

```
$ oc create -f <datavolume-cloner.yaml> ①
```

- 1 The file name of the **ClusterRole** manifest created in the previous step.

3. Create a **RoleBinding** manifest that applies to both the source and destination namespaces and references the cluster role created in the previous step.

```
apiVersion: rbac.authorization.k8s.io/v1
kind: RoleBinding
metadata:
  name: <allow-clone-to-user> ①
  namespace: <Source namespace> ②
subjects:
- kind: ServiceAccount
  name: default
  namespace: <Destination namespace> ③
roleRef:
  kind: ClusterRole
  name: datavolume-cloner ④
  apiGroup: rbac.authorization.k8s.io
```

- 1 Unique name for the role binding.
- 2 The namespace for the source data volume.
- 3 The namespace to which the data volume is cloned.
- 4 The name of the cluster role created in the previous step.

4. Create the role binding in the cluster:

```
$ oc create -f <datavolume-cloner.yaml> ①
```

- 1 The file name of the **RoleBinding** manifest created in the previous step.

### 10.17.2. Cloning a virtual machine disk into a new data volume

You can clone the persistent volume claim (PVC) of a virtual machine disk into a new data volume by referencing the source PVC in your data volume configuration file.



#### WARNING

Cloning operations between different volume modes are supported, such as cloning from a persistent volume (PV) with **volumeMode: Block** to a PV with **volumeMode: Filesystem**.

However, you can only clone between different volume modes if they are of the **contentType: kubevirt**.

#### TIP

When you enable preallocation globally, or for a single data volume, the Containerized Data Importer (CDI) preallocates disk space during cloning. Preallocation enhances write performance. For more information, see [Using preallocation for data volumes](#).

#### 10.17.2.1. Prerequisites

- Users need [additional permissions](#) to clone the PVC of a virtual machine disk into another namespace.

#### 10.17.2.2. About data volumes

**DataVolume** objects are custom resources that are provided by the Containerized Data Importer (CDI) project. Data volumes orchestrate import, clone, and upload operations that are associated with an underlying persistent volume claim (PVC). You can create a data volume as either a standalone resource or by using the **dataVolumeTemplate** field in the virtual machine (VM) specification.



#### NOTE

- VM disk PVCs that are prepared by using standalone data volumes maintain an independent lifecycle from the VM. If you use the **dataVolumeTemplate** field in the VM specification to prepare the PVC, the PVC shares the same lifecycle as the VM.

#### 10.17.2.3. Cloning the persistent volume claim of a virtual machine disk into a new data volume

You can clone a persistent volume claim (PVC) of an existing virtual machine disk into a new data volume. The new data volume can then be used for a new virtual machine.



## NOTE

When a data volume is created independently of a virtual machine, the lifecycle of the data volume is independent of the virtual machine. If the virtual machine is deleted, neither the data volume nor its associated PVC is deleted.

### Prerequisites

- Determine the PVC of an existing virtual machine disk to use. You must power down the virtual machine that is associated with the PVC before you can clone it.
- Install the OpenShift CLI (**oc**).

### Procedure

1. Examine the virtual machine disk you want to clone to identify the name and namespace of the associated PVC.
2. Create a YAML file for a data volume that specifies the name of the new data volume, the name and namespace of the source PVC, and the size of the new data volume.

For example:

```
apiVersion: cdi.kubevirt.io/v1beta1
kind: DataVolume
metadata:
  name: <cloner-datavolume> ①
spec:
  source:
    pvc:
      namespace: "<source-namespace>" ②
      name: "<my-favorite-vm-disk>" ③
  pvc:
    accessModes:
      - ReadWriteOnce
    resources:
      requests:
        storage: <2Gi> ④
```

- 1 The name of the new data volume.
- 2 The namespace where the source PVC exists.
- 3 The name of the source PVC.
- 4 The size of the new data volume. You must allocate enough space, or the cloning operation fails. The size must be the same as or larger than the source PVC.

3. Start cloning the PVC by creating the data volume:

```
$ oc create -f <cloner-datavolume>.yaml
```

**NOTE**

Data volumes prevent a virtual machine from starting before the PVC is prepared, so you can create a virtual machine that references the new data volume while the PVC clones.

**10.17.2.4. CDI supported operations matrix**

This matrix shows the supported CDI operations for content types against endpoints, and which of these operations requires scratch space.

| Content types       | HTTP                      | HTTPS                       | HTTP basic auth           | Registry                 | Upload                     |
|---------------------|---------------------------|-----------------------------|---------------------------|--------------------------|----------------------------|
| KubeVirt<br>(QCOW2) | ✓ QCOW2<br>✓ GZ*<br>✓ XZ* | ✓ QCOW2**<br>✓ GZ*<br>✓ XZ* | ✓ QCOW2<br>✓ GZ*<br>✓ XZ* | ✓ QCOW2*<br>□ GZ<br>□ XZ | ✓ QCOW2*<br>✓ GZ*<br>✓ XZ* |
| KubeVirt<br>(RAW)   | ✓ RAW<br>✓ GZ<br>✓ XZ     | ✓ RAW<br>✓ GZ<br>✓ XZ       | ✓ RAW<br>✓ GZ<br>✓ XZ     | ✓ RAW*<br>□ GZ<br>□ XZ   | ✓ RAW*<br>✓ GZ*<br>✓ XZ*   |

✓ Supported operation

□ Unsupported operation

\* Requires scratch space

\*\* Requires scratch space if a custom certificate authority is required

**10.17.3. Cloning a virtual machine by using a data volume template**

You can create a new virtual machine by cloning the persistent volume claim (PVC) of an existing VM. By including a **dataVolumeTemplate** in your virtual machine configuration file, you create a new data volume from the original PVC.

**WARNING**

Cloning operations between different volume modes are supported, such as cloning from a persistent volume (PV) with **volumeMode: Block** to a PV with **volumeMode: Filesystem**.

However, you can only clone between different volume modes if they are of the **contentType: kubevirt**.

**TIP**

When you enable preallocation globally, or for a single data volume, the Containerized Data Importer (CDI) preallocates disk space during cloning. Preallocation enhances write performance. For more information, see [Using preallocation for data volumes](#).

**10.17.3.1. Prerequisites**

- Users need [additional permissions](#) to clone the PVC of a virtual machine disk into another namespace.

**10.17.3.2. About data volumes**

**DataVolume** objects are custom resources that are provided by the Containerized Data Importer (CDI) project. Data volumes orchestrate import, clone, and upload operations that are associated with an underlying persistent volume claim (PVC). You can create a data volume as either a standalone resource or by using the **dataVolumeTemplate** field in the virtual machine (VM) specification.

**NOTE**

- VM disk PVCs that are prepared by using standalone data volumes maintain an independent lifecycle from the VM. If you use the **dataVolumeTemplate** field in the VM specification to prepare the PVC, the PVC shares the same lifecycle as the VM.

**10.17.3.3. Creating a new virtual machine from a cloned persistent volume claim by using a data volume template**

You can create a virtual machine that clones the persistent volume claim (PVC) of an existing virtual machine into a data volume. Reference a **dataVolumeTemplate** in the virtual machine manifest and the **source** PVC is cloned to a data volume, which is then automatically used for the creation of the virtual machine.

**NOTE**

When a data volume is created as part of the data volume template of a virtual machine, the lifecycle of the data volume is then dependent on the virtual machine. If the virtual machine is deleted, the data volume and associated PVC are also deleted.

**Prerequisites**

- Determine the PVC of an existing virtual machine disk to use. You must power down the virtual machine that is associated with the PVC before you can clone it.
- Install the OpenShift CLI (**oc**).

**Procedure**

1. Examine the virtual machine you want to clone to identify the name and namespace of the associated PVC.
2. Create a YAML file for a **VirtualMachine** object. The following virtual machine example clones **my-favorite-vm-disk**, which is located in the **source-namespace** namespace. The **2Gi** data volume called **favorite-clone** is created from **my-favorite-vm-disk**.

For example:

```

apiVersion: kubevirt.io/v1
kind: VirtualMachine
metadata:
  labels:
    kubevirt.io/vm: vm-dv-clone
  name: vm-dv-clone 1
spec:
  running: false
  template:
    metadata:
      labels:
        kubevirt.io/vm: vm-dv-clone
    spec:
      domain:
        devices:
          disks:
            - disk:
                bus: virtio
                name: root-disk
      resources:
        requests:
          memory: 64M
      volumes:
        - dataVolume:
            name: favorite-clone
            name: root-disk
  dataVolumeTemplates:
    - metadata:
        name: favorite-clone
      spec:
        storage:
          accessModes:
            - ReadWriteOnce
        resources:
          requests:
            storage: 2Gi
      source:
        pvc:
          namespace: "source-namespace"
          name: "my-favorite-vm-disk"

```

**1** The virtual machine to create.

3. Create the virtual machine with the PVC-cloned data volume:

```
$ oc create -f <vm-clone-datavolumetemplate>.yaml
```

#### 10.17.3.4. CDI supported operations matrix

This matrix shows the supported CDI operations for content types against endpoints, and which of these operations requires scratch space.

| Content types       | HTTP                      | HTTPS                       | HTTP basic auth           | Registry                 | Upload                     |
|---------------------|---------------------------|-----------------------------|---------------------------|--------------------------|----------------------------|
| KubeVirt<br>(QCOW2) | ✓ QCOW2<br>✓ GZ*<br>✓ XZ* | ✓ QCOW2**<br>✓ GZ*<br>✓ XZ* | ✓ QCOW2<br>✓ GZ*<br>✓ XZ* | ✓ QCOW2*<br>□ GZ<br>□ XZ | ✓ QCOW2*<br>✓ GZ*<br>✓ XZ* |
| KubeVirt<br>(RAW)   | ✓ RAW<br>✓ GZ<br>✓ XZ     | ✓ RAW<br>✓ GZ<br>✓ XZ       | ✓ RAW<br>✓ GZ<br>✓ XZ     | ✓ RAW*<br>□ GZ<br>□ XZ   | ✓ RAW*<br>✓ GZ*<br>✓ XZ*   |

✓ Supported operation

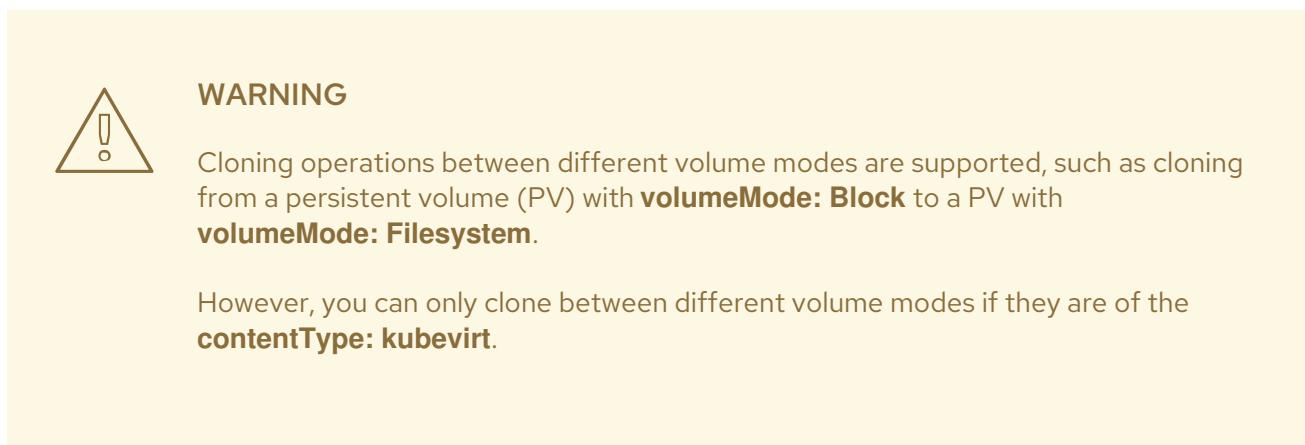
□ Unsupported operation

\* Requires scratch space

\*\* Requires scratch space if a custom certificate authority is required

#### 10.17.4. Cloning a virtual machine disk into a new block storage persistent volume claim

You can clone the persistent volume claim (PVC) of a virtual machine disk into a new block PVC by referencing the source PVC in your clone target data volume configuration file.



#### TIP

When you enable preallocation globally, or for a single data volume, the Containerized Data Importer (CDI) preallocates disk space during cloning. Preallocation enhances write performance. For more information, see [Using preallocation for data volumes](#).

##### 10.17.4.1. Prerequisites

- Users need [additional permissions](#) to clone the PVC of a virtual machine disk into another namespace.

##### 10.17.4.2. About data volumes

**DataVolume** objects are custom resources that are provided by the Containerized Data Importer (CDI)

project. Data volumes orchestrate import, clone, and upload operations that are associated with an underlying persistent volume claim (PVC). You can create a data volume as either a standalone resource or by using the **dataVolumeTemplate** field in the virtual machine (VM) specification.



## NOTE

- VM disk PVCs that are prepared by using standalone data volumes maintain an independent lifecycle from the VM. If you use the **dataVolumeTemplate** field in the VM specification to prepare the PVC, the PVC shares the same lifecycle as the VM.

### 10.17.4.3. About block persistent volumes

A block persistent volume (PV) is a PV that is backed by a raw block device. These volumes do not have a file system and can provide performance benefits for virtual machines by reducing overhead.

Raw block volumes are provisioned by specifying **volumeMode: Block** in the PV and persistent volume claim (PVC) specification.

### 10.17.4.4. Creating a local block persistent volume

If you intend to import a virtual machine image into block storage with a data volume, you must have an available local block persistent volume.

Create a local block persistent volume (PV) on a node by populating a file and mounting it as a loop device. You can then reference this loop device in a PV manifest as a **Block** volume and use it as a block device for a virtual machine image.

#### Procedure

- Log in as **root** to the node on which to create the local PV. This procedure uses **node01** for its examples.

- Create a file and populate it with null characters so that it can be used as a block device. The following example creates a file **loop10** with a size of 2Gb (20 100Mb blocks):

```
$ dd if=/dev/zero of=<loop10> bs=100M count=20
```

- Mount the **loop10** file as a loop device.

```
$ losetup </dev/loop10>d3 <loop10> 1 2
```

**1** File path where the loop device is mounted.

**2** The file created in the previous step to be mounted as the loop device.

- Create a **PersistentVolume** manifest that references the mounted loop device.

```
kind: PersistentVolume
apiVersion: v1
metadata:
  name: <local-block-pv10>
  annotations:
```

```

spec:
  local:
    path: </dev/loop10> ①
  capacity:
    storage: <2Gi>
  volumeMode: Block ②
  storageClassName: local ③
  accessModes:
    - ReadWriteOnce
  persistentVolumeReclaimPolicy: Delete
  nodeAffinity:
    required:
      nodeSelectorTerms:
        - matchExpressions:
          - key: kubernetes.io/hostname
            operator: In
          values:
            - <node01> ④

```

- ① The path of the loop device on the node.
- ② Specifies it is a block PV.
- ③ Optional: Set a storage class for the PV. If you omit it, the cluster default is used.
- ④ The node on which the block device was mounted.

5. Create the block PV.

```
# oc create -f <local-block-pv10.yaml> ①
```

- ① The file name of the persistent volume created in the previous step.

#### 10.17.4.5. Cloning the persistent volume claim of a virtual machine disk into a new data volume

You can clone a persistent volume claim (PVC) of an existing virtual machine disk into a new data volume. The new data volume can then be used for a new virtual machine.



#### NOTE

When a data volume is created independently of a virtual machine, the lifecycle of the data volume is independent of the virtual machine. If the virtual machine is deleted, neither the data volume nor its associated PVC is deleted.

#### Prerequisites

- Determine the PVC of an existing virtual machine disk to use. You must power down the virtual machine that is associated with the PVC before you can clone it.
- Install the OpenShift CLI (**oc**).

- At least one available block persistent volume (PV) that is the same size as or larger than the source PVC.

## Procedure

1. Examine the virtual machine disk you want to clone to identify the name and namespace of the associated PVC.
2. Create a YAML file for a data volume that specifies the name of the new data volume, the name and namespace of the source PVC, **volumeMode: Block** so that an available block PV is used, and the size of the new data volume.

For example:

```
apiVersion: cdi.kubevirt.io/v1beta1
kind: DataVolume
metadata:
  name: <cloner-datavolume> ①
spec:
  source:
    pvc:
      namespace: "<source-namespace>" ②
      name: "<my-favorite-vm-disk>" ③
  pvc:
    accessModes:
      - ReadWriteOnce
    resources:
      requests:
        storage: <2Gi> ④
    volumeMode: Block ⑤
```

- 1 The name of the new data volume.
- 2 The namespace where the source PVC exists.
- 3 The name of the source PVC.
- 4 The size of the new data volume. You must allocate enough space, or the cloning operation fails. The size must be the same as or larger than the source PVC.
- 5 Specifies that the destination is a block PV

3. Start cloning the PVC by creating the data volume:

```
$ oc create -f <cloner-datavolume>.yaml
```



### NOTE

Data volumes prevent a virtual machine from starting before the PVC is prepared, so you can create a virtual machine that references the new data volume while the PVC clones.

## 10.17.4.6. CDI supported operations matrix

This matrix shows the supported CDI operations for content types against endpoints, and which of these operations requires scratch space.

| Content types       | HTTP                      | HTTPS                       | HTTP basic auth           | Registry                 | Upload                     |
|---------------------|---------------------------|-----------------------------|---------------------------|--------------------------|----------------------------|
| KubeVirt<br>(QCOW2) | ✓ QCOW2<br>✓ GZ*<br>✓ XZ* | ✓ QCOW2**<br>✓ GZ*<br>✓ XZ* | ✓ QCOW2<br>✓ GZ*<br>✓ XZ* | ✓ QCOW2*<br>□ GZ<br>□ XZ | ✓ QCOW2*<br>✓ GZ*<br>✓ XZ* |
| KubeVirt<br>(RAW)   | ✓ RAW<br>✓ GZ<br>✓ XZ     | ✓ RAW<br>✓ GZ<br>✓ XZ       | ✓ RAW<br>✓ GZ<br>✓ XZ     | ✓ RAW*<br>□ GZ<br>□ XZ   | ✓ RAW*<br>✓ GZ*<br>✓ XZ*   |

✓ Supported operation

□ Unsupported operation

\* Requires scratch space

\*\* Requires scratch space if a custom certificate authority is required

## 10.18. VIRTUAL MACHINE NETWORKING

### 10.18.1. Configuring the virtual machine for the default pod network

You can connect a virtual machine to the default internal pod network by configuring its network interface to use the **masquerade** binding mode.



#### NOTE

Traffic on the virtual Network Interface Cards (vNICs) that are attached to the default pod network is interrupted during live migration.

#### 10.18.1.1. Configuring masquerade mode from the command line

You can use masquerade mode to hide a virtual machine's outgoing traffic behind the pod IP address. Masquerade mode uses Network Address Translation (NAT) to connect virtual machines to the pod network backend through a Linux bridge.

Enable masquerade mode and allow traffic to enter the virtual machine by editing your virtual machine configuration file.

#### Prerequisites

- The virtual machine must be configured to use DHCP to acquire IPv4 addresses. The examples below are configured to use DHCP.

#### Procedure

- Edit the **interfaces** spec of your virtual machine configuration file:

```

kind: VirtualMachine
spec:
  domain:
    devices:
      interfaces:
        - name: default
          masquerade: {} 1
          ports: 2
            - port: 80
  networks:
    - name: default
      pod: {}

```

**1** Connect using masquerade mode.

**2** Optional: List the ports that you want to expose from the virtual machine, each specified by the **port** field. The **port** value must be a number between 0 and 65536. When the **ports** array is not used, all ports in the valid range are open to incoming traffic. In this example, incoming traffic is allowed on port **80**.



### NOTE

Ports 49152 and 49153 are reserved for use by the libvirt platform and all other incoming traffic to these ports is dropped.

2. Create the virtual machine:

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

#### 10.18.1.2. Configuring masquerade mode with dual-stack (IPv4 and IPv6)

You can configure a new virtual machine (VM) to use both IPv6 and IPv4 on the default pod network by using cloud-init.

The **Network.pod.vmIPv6NetworkCIDR** field in the virtual machine instance configuration determines the static IPv6 address of the VM and the gateway IP address. These are used by the virt-launcher pod to route IPv6 traffic to the virtual machine and are not used externally. The **Network.pod.vmIPv6NetworkCIDR** field specifies an IPv6 address block in Classless Inter-Domain Routing (CIDR) notation. The default value is **fd10:0:2::2/120**. You can edit this value based on your network requirements.

When the virtual machine is running, incoming and outgoing traffic for the virtual machine is routed to both the IPv4 address and the unique IPv6 address of the virt-launcher pod. The virt-launcher pod then routes the IPv4 traffic to the DHCP address of the virtual machine, and the IPv6 traffic to the statically set IPv6 address of the virtual machine.

#### Prerequisites

- The OpenShift Container Platform cluster must use the OVN-Kubernetes Container Network Interface (CNI) network plugin configured for dual-stack.

#### Procedure

- In a new virtual machine configuration, include an interface with **masquerade** and configure the IPv6 address and default gateway by using cloud-init.

```
apiVersion: kubevirt.io/v1
kind: VirtualMachine
metadata:
  name: example-vm-ipv6
# ...
  interfaces:
    - name: default
      masquerade: {} ①
      ports:
        - port: 80 ②
  networks:
    - name: default
      pod: {}
  volumes:
    - cloudInitNoCloud:
      networkData: |
        version: 2
      eternets:
        eth0:
          dhcp4: true
          addresses: [ fd10:0:2::2/120 ] ③
          gateway6: fd10:0:2::1 ④
```

- Connect using masquerade mode.
- Allows incoming traffic on port 80 to the virtual machine.
- The static IPv6 address as determined by the **Network.pod.vmIPv6NetworkCIDR** field in the virtual machine instance configuration. The default value is **fd10:0:2::2/120**.
- The gateway IP address as determined by the **Network.pod.vmIPv6NetworkCIDR** field in the virtual machine instance configuration. The default value is **fd10:0:2::1**.

- Create the virtual machine in the namespace:

```
$ oc create -f example-vm-ipv6.yaml
```

## Verification

- To verify that IPv6 has been configured, start the virtual machine and view the interface status of the virtual machine instance to ensure it has an IPv6 address:

```
$ oc get vmi <vmi-name> -o jsonpath=".status.interfaces[*].ipAddresses"
```

### 10.18.1.3. About jumbo frames support

When using the OVN-Kubernetes CNI plugin, you can send unfragmented jumbo frame packets between two virtual machines (VMs) that are connected on the default pod network. Jumbo frames have a maximum transmission unit (MTU) value greater than 1500 bytes.

The VM automatically gets the MTU value of the cluster network, set by the cluster administrator, in one of the following ways:

- **libvirt**: If the guest OS has the latest version of the VirtIO driver that can interpret incoming data via a Peripheral Component Interconnect (PCI) config register in the emulated device.
- DHCP: If the guest DHCP client can read the MTU value from the DHCP server response.



#### NOTE

For Windows VMs that do not have a VirtIO driver, you must set the MTU manually by using **netsh** or a similar tool. This is because the Windows DHCP client does not read the MTU value.

#### Additional resources

- [Changing the MTU for the cluster network](#)
- [Optimizing the MTU for your network](#)

### 10.18.2. Creating a service to expose a virtual machine

You can expose a virtual machine within the cluster or outside the cluster by using a **Service** object.

#### 10.18.2.1. About services

A Kubernetes service exposes network access for clients to an application running on a set of pods. Services offer abstraction, load balancing, and, in the case of NodePort and LoadBalancer, exposure to the outside world.

Services can be exposed in the **VirtualMachine details → Details** tab of the web console or by specifying a **spec.type** in the **Service** object:

##### ClusterIP

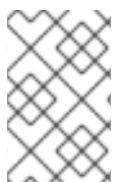
Exposes the service on an internal IP address and as a DNS name to other applications within the cluster. A single service can map to multiple virtual machines. When a client tries to connect to the service, the client's request is load balanced among available backends. **ClusterIP** is the default service **type**.

##### NodePort

Exposes the service on the same port of each selected node in the cluster. **NodePort** makes a service accessible from outside the cluster.

##### LoadBalancer

Creates an external load balancer in the current cloud (if supported) and assigns a fixed, external IP address to the service.



#### NOTE

For on-premise clusters, you can configure a load balancing service by using the MetalLB Operator in layer 2 mode. The BGP mode is not supported. The MetalLB Operator is installed in the **metallb-system** namespace.

#### Additional resources

- [Installing the MetalLB Operator](#)
- [Configuring services to use MetalLB](#)

### 10.18.2.1.1. Dual-stack support

If IPv4 and IPv6 dual-stack networking is enabled for your cluster, you can create a service that uses IPv4, IPv6, or both, by defining the **spec.ipFamilyPolicy** and the **spec.ipFamilies** fields in the **Service** object.

The **spec.ipFamilyPolicy** field can be set to one of the following values:

#### **SingleStack**

The control plane assigns a cluster IP address for the service based on the first configured service cluster IP range.

#### **PreferDualStack**

The control plane assigns both IPv4 and IPv6 cluster IP addresses for the service on clusters that have dual-stack configured.

#### **RequireDualStack**

This option fails for clusters that do not have dual-stack networking enabled. For clusters that have dual-stack configured, the behavior is the same as when the value is set to **PreferDualStack**. The control plane allocates cluster IP addresses from both IPv4 and IPv6 address ranges.

You can define which IP family to use for single-stack or define the order of IP families for dual-stack by setting the **spec.ipFamilies** field to one of the following array values:

- **[IPv4]**
- **[IPv6]**
- **[IPv4, IPv6]**
- **[IPv6, IPv4]**

### 10.18.2.2. Exposing a virtual machine as a service

Create a **ClusterIP**, **NodePort**, or **LoadBalancer** service to connect to a running virtual machine (VM) from within or outside the cluster.

#### Procedure

1. Edit the **VirtualMachine** manifest to add the label for service creation:

```
apiVersion: kubevirt.io/v1
kind: VirtualMachine
metadata:
  name: vm-ephemeral
  namespace: example-namespace
spec:
  running: false
  template:
    metadata:
```

```

  labels:
    special: key ①
# ...

```

- Add the label **special: key** in the **spec.template.metadata.labels** section.



#### NOTE

Labels on a virtual machine are passed through to the pod. The **special: key** label must match the label in the **spec.selector** attribute of the **Service** manifest.

- Save the **VirtualMachine** manifest file to apply your changes.
- Create a **Service** manifest to expose the VM:

```

apiVersion: v1
kind: Service
metadata:
  name: vmservice ①
  namespace: example-namespace ②
spec:
  externalTrafficPolicy: Cluster ③
  ports:
    - nodePort: 30000 ④
      port: 27017
      protocol: TCP
      targetPort: 22 ⑤
  selector:
    special: key ⑥
  type: NodePort ⑦

```

- The name of the **Service** object.
- The namespace where the **Service** object resides. This must match the **metadata.namespace** field of the **VirtualMachine** manifest.
- Optional: Specifies how the nodes distribute service traffic that is received on external IP addresses. This only applies to **NodePort** and **LoadBalancer** service types. The default value is **Cluster** which routes traffic evenly to all cluster endpoints.
- Optional: When set, the **nodePort** value must be unique across all services. If not specified, a value in the range above **30000** is dynamically allocated.
- Optional: The VM port to be exposed by the service. It must reference an open port if a port list is defined in the VM manifest. If **targetPort** is not specified, it takes the same value as **port**.
- The reference to the label that you added in the **spec.template.metadata.labels** stanza of the **VirtualMachine** manifest.
- The type of service. Possible values are **ClusterIP**, **NodePort** and **LoadBalancer**.

4. Save the **Service** manifest file.
5. Create the service by running the following command:

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

6. Start the VM. If the VM is already running, restart it.

### Verification

1. Query the **Service** object to verify that it is available:

```
$ oc get service -n example-namespace
```

#### Example output for ClusterIP service

| NAME      | TYPE      | CLUSTER-IP   | EXTERNAL-IP | PORT(S)   | AGE |
|-----------|-----------|--------------|-------------|-----------|-----|
| vmservice | ClusterIP | 172.30.3.149 | <none>      | 27017/TCP | 2m  |

#### Example output for NodePort service

| NAME      | TYPE     | CLUSTER-IP    | EXTERNAL-IP | PORT(S)         | AGE |
|-----------|----------|---------------|-------------|-----------------|-----|
| vmservice | NodePort | 172.30.232.73 | <none>      | 27017:30000/TCP | 5m  |

#### Example output for LoadBalancer service

| NAME      | TYPE         | CLUSTER-IP  | EXTERNAL-IP                 | PORT(S)         | AGE |
|-----------|--------------|-------------|-----------------------------|-----------------|-----|
| vmservice | LoadBalancer | 172.30.27.5 | 172.29.10.235,172.29.10.235 | 27017:31829/TCP | 5s  |

2. Choose the appropriate method to connect to the virtual machine:

- For a **ClusterIP** service, connect to the VM from within the cluster by using the service IP address and the service port. For example:

```
$ ssh fedora@172.30.3.149 -p 27017
```

- For a **NodePort** service, connect to the VM by specifying the node IP address and the node port outside the cluster network. For example:

```
$ ssh fedora@$NODE_IP -p 30000
```

- For a **LoadBalancer** service, use the **vinagre** client to connect to your virtual machine by using the public IP address and port. External ports are dynamically allocated.

### 10.18.2.3. Additional resources

- Configuring ingress cluster traffic using a NodePort
- Configuring ingress cluster traffic using a load balancer
- Web console overview

### 10.18.3. Connecting a virtual machine to a Linux bridge network

By default, OpenShift Virtualization is installed with a single, internal pod network.

You must create a Linux bridge network attachment definition (NAD) in order to connect to additional networks.

To attach a virtual machine to an additional network:

1. Create a Linux bridge node network configuration policy.
2. Create a Linux bridge network attachment definition.
3. Configure the virtual machine, enabling the virtual machine to recognize the network attachment definition.

For more information about scheduling, interface types, and other node networking activities, see the [node networking](#) section.

#### 10.18.3.1. Connecting to the network through the network attachment definition

##### 10.18.3.1.1. Creating a Linux bridge node network configuration policy

Use a **NodeNetworkConfigurationPolicy** manifest YAML file to create the Linux bridge.

##### Prerequisites

- You have installed the Kubernetes NMState Operator.

##### Procedure

- Create the **NodeNetworkConfigurationPolicy** manifest. This example includes sample values that you must replace with your own information.

```
apiVersion: nmstate.io/v1
kind: NodeNetworkConfigurationPolicy
metadata:
  name: br1-eth1-policy 1
spec:
  desiredState:
    interfaces:
      - name: br1 2
        description: Linux bridge with eth1 as a port 3
        type: linux-bridge 4
        state: up 5
        ipv4:
          enabled: false 6
        bridge:
          options:
            stp:
              enabled: false 7
          port:
            - name: eth1 8
```

- 1** Name of the policy.
- 2** Name of the interface.
- 3** Optional: Human-readable description of the interface.
- 4** The type of interface. This example creates a bridge.
- 5** The requested state for the interface after creation.
- 6** Disables IPv4 in this example.
- 7** Disables STP in this example.
- 8** The node NIC to which the bridge is attached.

#### 10.18.3.2. Creating a Linux bridge network attachment definition



##### WARNING

Configuring IP address management (IPAM) in a network attachment definition for virtual machines is not supported.

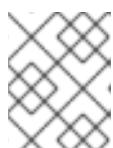
#### 10.18.3.2.1. Creating a Linux bridge network attachment definition in the web console

You can create network attachment definitions to provide layer-2 networking to pods and virtual machines.

A Linux bridge network attachment definition is the most efficient method for connecting a virtual machine to a VLAN.

##### Procedure

1. In the web console, click **Networking** → **NetworkAttachmentDefinitions**.
2. Click **Create Network Attachment Definition**



##### NOTE

The network attachment definition must be in the same namespace as the pod or virtual machine.

3. Enter a unique **Name** and optional **Description**.
4. Select **CNV Linux bridge** from the **Network Type** list.
5. Enter the name of the bridge in the **Bridge Name** field.

6. Optional: If the resource has VLAN IDs configured, enter the ID numbers in the **VLAN Tag Number** field.
7. Optional: Select **MAC Spoof Check** to enable MAC spoof filtering. This feature provides security against a MAC spoofing attack by allowing only a single MAC address to exit the pod.
8. Click **Create**.

#### 10.18.3.2.2. Creating a Linux bridge network attachment definition in the CLI

As a network administrator, you can configure a network attachment definition of type **cnv-bridge** to provide layer-2 networking to pods and virtual machines.

#### Prerequisites

- The node must support nftables and the **nft** binary must be deployed to enable MAC spoof check.

#### Procedure

1. Create a network attachment definition in the same namespace as the virtual machine.
2. Add the virtual machine to the network attachment definition, as in the following example:

```
apiVersion: "k8s.cni.cncf.io/v1"
kind: NetworkAttachmentDefinition
metadata:
  name: <bridge-network> ①
  annotations:
    k8s.v1.cni.cncf.io/resourceName: bridge.network.kubevirt.io/<bridge-interface> ②
spec:
  config: '{
    "cniVersion": "0.3.1",
    "name": "<bridge-network>", ③
    "type": "cnv-bridge", ④
    "bridge": "<bridge-interface>", ⑤
    "macspoofchk": true, ⑥
    "vlan": 100, ⑦
    "preserveDefaultVlan": false ⑧
  }'
```

- ① The name for the **NetworkAttachmentDefinition** object.
- ② Optional: Annotation key-value pair for node selection, where **bridge-interface** must match the name of a bridge configured on some nodes. If you add this annotation to your network attachment definition, your virtual machine instances will only run on the nodes that have the **bridge-interface** bridge connected.
- ③ The name for the configuration. It is recommended to match the configuration name to the **name** value of the network attachment definition.
- ④ The actual name of the Container Network Interface (CNI) plugin that provides the network for this network attachment definition. Do not change this field unless you want to use a different CNI.

- 5 The name of the Linux bridge configured on the node.
- 6 Optional: Flag to enable MAC spoof check. When set to **true**, you cannot change the MAC address of the pod or guest interface. This attribute provides security against a MAC spoofing attack by allowing only a single MAC address to exit the pod.
- 7 Optional: The VLAN tag. No additional VLAN configuration is required on the node network configuration policy.
- 8 Optional: Indicates whether the VM connects to the bridge through the default VLAN. The default value is **true**.



### NOTE

A Linux bridge network attachment definition is the most efficient method for connecting a virtual machine to a VLAN.

3. Create the network attachment definition:

```
$ oc create -f <network-attachment-definition.yaml> ①
```

- 1 Where **<network-attachment-definition.yaml>** is the file name of the network attachment definition manifest.

## Verification

- Verify that the network attachment definition was created by running the following command:

```
$ oc get network-attachment-definition <bridge-network>
```

### 10.18.3.3. Configuring the virtual machine for a Linux bridge network

#### 10.18.3.3.1. Creating a NIC for a virtual machine in the web console

Create and attach additional NICs to a virtual machine from the web console.

#### Prerequisites

- A network attachment definition must be available.

#### Procedure

1. In the correct project in the OpenShift Container Platform console, click **Virtualization** → **VirtualMachines** from the side menu.
2. Select a virtual machine to open the **VirtualMachine details** page.
3. Click **Configuration** → **Network interfaces** to view the NICs already attached to the virtual machine.
4. Click **Add Network Interface** to create a new slot in the list.

5. Select a network attachment definition from the **Network** list for the additional network.
6. Fill in the **Name**, **Model**, **Type**, and **MAC Address** for the new NIC.
7. Click **Save** to save and attach the NIC to the virtual machine.

#### 10.18.3.3.2. Networking fields

| Name        | Description                                                                                                                                                                                                                                                                                |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Name        | Name for the network interface controller.                                                                                                                                                                                                                                                 |
| Model       | Indicates the model of the network interface controller. Supported values are <b>e1000e</b> and <b>virtio</b> .                                                                                                                                                                            |
| Network     | List of available network attachment definitions.                                                                                                                                                                                                                                          |
| Type        | <p>List of available binding methods. Select the binding method suitable for the network interface:</p> <ul style="list-style-type: none"> <li>● Default pod network: <b>masquerade</b></li> <li>● Linux bridge network: <b>bridge</b></li> <li>● SR-IOV network: <b>SR-IOV</b></li> </ul> |
| MAC Address | MAC address for the network interface controller. If a MAC address is not specified, one is assigned automatically.                                                                                                                                                                        |

#### 10.18.3.3.3. Attaching a virtual machine to an additional network in the CLI

Attach a virtual machine to an additional network by adding a bridge interface and specifying a network attachment definition in the virtual machine configuration.

This procedure uses a YAML file to demonstrate editing the configuration and applying the updated file to the cluster. You can alternatively use the **oc edit <object> <name>** command to edit an existing virtual machine.

#### Prerequisites

- Shut down the virtual machine before editing the configuration. If you edit a running virtual machine, you must restart the virtual machine for the changes to take effect.

#### Procedure

1. Create or edit a configuration of a virtual machine that you want to connect to the bridge network.
2. Add the bridge interface to the **spec.template.spec.domain.devices.interfaces** list and the network attachment definition to the **spec.template.spec.networks** list. This example adds a bridge interface called **bridge-net** that connects to the **a-bridge-network** network attachment

definition:

```
apiVersion: kubevirt.io/v1
kind: VirtualMachine
metadata:
  name: <example-vm>
spec:
  template:
    spec:
      domain:
        devices:
          interfaces:
            - masquerade: {}
              name: <default>
            - bridge: {}
              name: <bridge-net> ①
# ...
  networks:
    - name: <default>
      pod: {}
    - name: <bridge-net> ②
      multus:
        networkName: <network-namespace>/<a-bridge-network> ③
# ...
```

- ① The name of the bridge interface.
- ② The name of the network. This value must match the **name** value of the corresponding **spec.template.spec.domain.devices.interfaces** entry.
- ③ The name of the network attachment definition, prefixed by the namespace where it exists. The namespace must be either the **default** namespace or the same namespace where the VM is to be created. In this case, **multus** is used. Multus is a cloud network interface (CNI) plugin that allows multiple CNIs to exist so that a pod or virtual machine can use the interfaces it needs.

3. Apply the configuration:

```
$ oc apply -f <example-vm.yaml>
```

4. Optional: If you edited a running virtual machine, you must restart it for the changes to take effect.

#### 10.18.3.4. Next steps

- [Accessing a virtual machine on a secondary network by using the cluster domain name](#)

#### 10.18.4. Connecting a virtual machine to an SR-IOV network

You can connect a virtual machine (VM) to a Single Root I/O Virtualization (SR-IOV) network by performing the following steps:

1. Configure an SR-IOV network device.

2. Configure an SR-IOV network.
3. Connect the VM to the SR-IOV network.

#### 10.18.4.1. Prerequisites

- You must have [enabled global SR-IOV and VT-d settings in the firmware for the host](#).
- You must have [installed the SR-IOV Network Operator](#).

#### 10.18.4.2. Configuring SR-IOV network devices

The SR-IOV Network Operator adds the **SriovNetworkNodePolicy.sriovnetwork.openshift.io** CustomResourceDefinition to OpenShift Container Platform. You can configure an SR-IOV network device by creating a SriovNetworkNodePolicy custom resource (CR).



#### NOTE

When applying the configuration specified in a **SriovNetworkNodePolicy** object, the SR-IOV Operator might drain the nodes, and in some cases, reboot nodes.

It might take several minutes for a configuration change to apply.

#### Prerequisites

- You installed the OpenShift CLI (**oc**).
- You have access to the cluster as a user with the **cluster-admin** role.
- You have installed the SR-IOV Network Operator.
- You have enough available nodes in your cluster to handle the evicted workload from drained nodes.
- You have not selected any control plane nodes for SR-IOV network device configuration.

#### Procedure

1. Create an **SriovNetworkNodePolicy** object, and then save the YAML in the **<name>-sriov-node-network.yaml** file. Replace **<name>** with the name for this configuration.

```
apiVersion: sriovnetwork.openshift.io/v1
kind: SriovNetworkNodePolicy
metadata:
  name: <name> 1
  namespace: openshift-sriov-network-operator 2
spec:
  resourceName: <sriov_resource_name> 3
  nodeSelector:
    feature.node.kubernetes.io/network-sriov.capable: "true" 4
  priority: <priority> 5
  mtu: <mtu> 6
  numVfs: <num> 7
  nicSelector: 8
```

```

    vendor: "<vendor_code>" ⑨
    deviceID: "<device_id>" ⑩
    pfNames: ["<pf_name>", ...] ⑪
    rootDevices: ["<pci_bus_id>", "..."] ⑫
    deviceType: vfio-pci ⑬
    isRdma: false ⑭
  
```

- ① Specify a name for the CR object.
- ② Specify the namespace where the SR-IOV Operator is installed.
- ③ Specify the resource name of the SR-IOV device plugin. You can create multiple **SriovNetworkNodePolicy** objects for a resource name.
- ④ Specify the node selector to select which nodes are configured. Only SR-IOV network devices on selected nodes are configured. The SR-IOV Container Network Interface (CNI) plugin and device plugin are deployed only on selected nodes.
- ⑤ Optional: Specify an integer value between **0** and **99**. A smaller number gets higher priority, so a priority of **10** is higher than a priority of **99**. The default value is **99**.
- ⑥ Optional: Specify a value for the maximum transmission unit (MTU) of the virtual function. The maximum MTU value can vary for different NIC models.
- ⑦ Specify the number of the virtual functions (VF) to create for the SR-IOV physical network device. For an Intel network interface controller (NIC), the number of VFs cannot be larger than the total VFs supported by the device. For a Mellanox NIC, the number of VFs cannot be larger than **128**.
- ⑧ The **nicSelector** mapping selects the Ethernet device for the Operator to configure. You do not need to specify values for all the parameters. It is recommended to identify the Ethernet adapter with enough precision to minimize the possibility of selecting an Ethernet device unintentionally. If you specify **rootDevices**, you must also specify a value for **vendor**, **deviceID**, or **pfNames**. If you specify both **pfNames** and **rootDevices** at the same time, ensure that they point to an identical device.
- ⑨ Optional: Specify the vendor hex code of the SR-IOV network device. The only allowed values are either **8086** or **15b3**.
- ⑩ Optional: Specify the device hex code of SR-IOV network device. The only allowed values are **158b**, **1015**, **1017**.
- ⑪ Optional: The parameter accepts an array of one or more physical function (PF) names for the Ethernet device.
- ⑫ The parameter accepts an array of one or more PCI bus addresses for the physical function of the Ethernet device. Provide the address in the following format: **0000:02:00.1**.
- ⑬ The **vfio-pci** driver type is required for virtual functions in OpenShift Virtualization.
- ⑭ Optional: Specify whether to enable remote direct memory access (RDMA) mode. For a Mellanox card, set **isRdma** to **false**. The default value is **false**.

**NOTE**

If **isRDMA** flag is set to **true**, you can continue to use the RDMA enabled VF as a normal network device. A device can be used in either mode.

2. Optional: Label the SR-IOV capable cluster nodes with **SriovNetworkNodePolicy.Spec.NodeSelector** if they are not already labeled. For more information about labeling nodes, see "Understanding how to update labels on nodes".
3. Create the **SriovNetworkNodePolicy** object:

```
$ oc create -f <name>-sriov-node-network.yaml
```

where **<name>** specifies the name for this configuration.

After applying the configuration update, all the pods in **sriov-network-operator** namespace transition to the **Running** status.

4. To verify that the SR-IOV network device is configured, enter the following command. Replace **<node\_name>** with the name of a node with the SR-IOV network device that you just configured.

```
$ oc get sriovnetworknodesstates -n openshift-sriov-network-operator <node_name> -o jsonpath='{.status.syncStatus}'
```

#### 10.18.4.3. Configuring SR-IOV additional network

You can configure an additional network that uses SR-IOV hardware by creating an **SriovNetwork** object.

When you create an **SriovNetwork** object, the SR-IOV Network Operator automatically creates a **NetworkAttachmentDefinition** object.

**NOTE**

Do not modify or delete an **SriovNetwork** object if it is attached to pods or virtual machines in a **running** state.

#### Prerequisites

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

#### Procedure

1. Create the following **SriovNetwork** object, and then save the YAML in the **<name>-sriov-network.yaml** file. Replace **<name>** with a name for this additional network.

```
apiVersion: sriovnetwork.openshift.io/v1
kind: SriovNetwork
metadata:
  name: <name> 1
  namespace: openshift-sriov-network-operator 2
```

spec:

```
resourceName: <sriov_resource_name> ③
networkNamespace: <target_namespace> ④
vlan: <vlan> ⑤
spoofChk: "<spoof_check>" ⑥
linkState: <link_state> ⑦
maxTxRate: <max_tx_rate> ⑧
minTxRate: <min_rx_rate> ⑨
vlanQoS: <vlan_qos> ⑩
trust: "<trust_vf>" ⑪
capabilities: <capabilities> ⑫
```

- ① Replace **<name>** with a name for the object. The SR-IOV Network Operator creates a **NetworkAttachmentDefinition** object with same name.
- ② Specify the namespace where the SR-IOV Network Operator is installed.
- ③ Replace **<sriov\_resource\_name>** with the value for the **.spec.resourceName** parameter from the **SriovNetworkNodePolicy** object that defines the SR-IOV hardware for this additional network.
- ④ Replace **<target\_namespace>** with the target namespace for the SriovNetwork. Only pods or virtual machines in the target namespace can attach to the SriovNetwork.
- ⑤ Optional: Replace **<vlan>** with a Virtual LAN (VLAN) ID for the additional network. The integer value must be from **0** to **4095**. The default value is **0**.
- ⑥ Optional: Replace **<spoof\_check>** with the spoof check mode of the VF. The allowed values are the strings **"on"** and **"off"**.



### IMPORTANT

You must enclose the value you specify in quotes or the CR is rejected by the SR-IOV Network Operator.

- ⑦ Optional: Replace **<link\_state>** with the link state of virtual function (VF). Allowed value are **enable**, **disable** and **auto**.
- ⑧ Optional: Replace **<max\_tx\_rate>** with a maximum transmission rate, in Mbps, for the VF.
- ⑨ Optional: Replace **<min\_tx\_rate>** with a minimum transmission rate, in Mbps, for the VF. This value should always be less than or equal to Maximum transmission rate.



### NOTE

Intel NICs do not support the **minTxRate** parameter. For more information, see [BZ#1772847](#).

- ⑩ Optional: Replace **<vlan\_qos>** with an IEEE 802.1p priority level for the VF. The default value is **0**.
- ⑪ Optional: Replace **<trust\_vf>** with the trust mode of the VF. The allowed values are the strings **"on"** and **"off"**.



## IMPORTANT

You must enclose the value you specify in quotes or the CR is rejected by the SR-IOV Network Operator.

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Optional: Replace **<capabilities>** with the capabilities to configure for this network.

2. To create the object, enter the following command. Replace **<name>** with a name for this additional network.

```
$ oc create -f <name>-sriov-network.yaml
```

3. Optional: To confirm that the **NetworkAttachmentDefinition** object associated with the **SriovNetwork** object that you created in the previous step exists, enter the following command. Replace **<namespace>** with the namespace you specified in the **SriovNetwork** object.

```
$ oc get net-attach-def -n <namespace>
```

### 10.18.4.4. Connecting a virtual machine to an SR-IOV network

You can connect the virtual machine (VM) to the SR-IOV network by including the network details in the VM configuration.

#### Procedure

1. Include the SR-IOV network details in the **spec.domain.devices.interfaces** and **spec.networks** of the VM configuration:

```
kind: VirtualMachine
# ...
spec:
  domain:
    devices:
      interfaces:
        - name: <default> ①
          masquerade: {} ②
        - name: <nic1> ③
          sriov: {}
      networks:
        - name: <default> ④
          pod: {}
        - name: <nic1> ⑤
          multus:
            networkName: <sriov-network> ⑥
# ...
```

- ① A unique name for the interface that is connected to the pod network.
- ② The **masquerade** binding to the default pod network.
- ③ A unique name for the SR-IOV interface.
- ④ The name of the pod network interface. This must be the same as the **interfaces.name**

- 5 The name of the SR-IOV interface. This must be the same as the **interfaces.name** that you defined earlier.
- 6 The name of the SR-IOV network attachment definition.

2. Apply the virtual machine configuration:

```
$ oc apply -f <vm-sriov.yaml> 1
```

- 1 The name of the virtual machine YAML file.

#### 10.18.4.5. Configuring a cluster for DPDK workloads

You can use the following procedure to configure an OpenShift Container Platform cluster to run Data Plane Development Kit (DPDK) workloads.



#### IMPORTANT

Configuring a cluster for DPDK workloads 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](#).

#### Prerequisites

- You have access to the cluster as a user with **cluster-admin** permissions.
- You have installed the OpenShift CLI (**oc**).
- You have installed the SR-IOV Network Operator.
- You have installed the Node Tuning Operator.

#### Procedure

1. Map your compute nodes topology to determine which Non-Uniform Memory Access (NUMA) CPUs are isolated for DPDK applications and which ones are reserved for the operating system (OS).
2. Label a subset of the compute nodes with a custom role; for example, **worker-dpdk**:

```
$ oc label node <node_name> node-role.kubernetes.io/worker-dpdk=""
```

3. Create a new **MachineConfigPool** manifest that contains the **worker-dpdk** label in the **spec.machineConfigSelector** object:

#### Example MachineConfigPool manifest



```

apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfigPool
metadata:
  name: worker-dpdk
  labels:
    machineconfiguration.openshift.io/role: worker-dpdk
spec:
  machineConfigSelector:
    matchExpressions:
      - key: machineconfiguration.openshift.io/role
        operator: In
        values:
          - worker
          - worker-dpdk
  nodeSelector:
    matchLabels:
      node-role.kubernetes.io/worker-dpdk: ""

```

4. Create a **PerformanceProfile** manifest that applies to the labeled nodes and the machine config pool that you created in the previous steps. The performance profile specifies the CPUs that are isolated for DPDK applications and the CPUs that are reserved for house keeping.

#### Example PerformanceProfile manifest

```

apiVersion: performance.openshift.io/v2
kind: PerformanceProfile
metadata:
  name: profile-1
spec:
  cpu:
    isolated: 4-39,44-79
    reserved: 0-3,40-43
  hugepages:
    defaultHugepagesSize: 1G
    pages:
      - count: 32
        node: 0
        size: 1G
  net:
    userLevelNetworking: true
  nodeSelector:
    node-role.kubernetes.io/worker-dpdk: ""
  numa:
    topologyPolicy: single-numa-node

```



#### NOTE

The compute nodes automatically restart after you apply the **MachineConfigPool** and **PerformanceProfile** manifests.

5. Retrieve the name of the generated **RuntimeClass** resource from the **status.runtimeClass** field of the **PerformanceProfile** object:

```
$ oc get performanceprofiles.performance.openshift.io profile-1 -o=jsonpath='{.status.runtimeClass}{"\n"}'
```

- Set the previously obtained **RuntimeClass** name as the default container runtime class for the **virt-launcher** pods by adding the following annotation to the **HyperConverged** custom resource (CR):

```
$ oc annotate --overwrite -n openshift-cnv hco kubevirt-hyperconverged \
  kubevirt.kubevirt.io/jsonpatch='[{"op": "add", "path": \
  "/spec/configuration/defaultRuntimeClass", "value": <runtimeclass_name>}]'
```



### NOTE

Adding the annotation to the **HyperConverged** CR changes a global setting that affects all VMs that are created after the annotation is applied. Setting this annotation breaches support of the OpenShift Virtualization instance and must be used only on test clusters. For best performance, apply for a support exception.

- Create an **SriovNetworkNodePolicy** object with the **spec.deviceType** field set to **vfio-pci**:

#### Example SriovNetworkNodePolicy manifest

```
apiVersion: sriovnetwork.openshift.io/v1
kind: SriovNetworkNodePolicy
metadata:
  name: policy-1
  namespace: openshift-sriov-network-operator
spec:
  resourceName: intel_nics_dpdk
  deviceType: vfio-pci
  mtu: 9000
  numVfs: 4
  priority: 99
  nicSelector:
    vendor: "8086"
    devicID: "1572"
    pfNames:
      - eno3
  rootDevices:
    - "0000:19:00.2"
  nodeSelector:
    feature.node.kubernetes.io/network-sriov.capable: "true"
```

#### Additional resources

- [Using CPU Manager and Topology Manager](#)
- [Configuring huge pages](#)
- [Creating a custom machine config pool](#)

#### 10.18.4.6. Configuring a project for DPDK workloads

You can configure the project to run DPDK workloads on SR-IOV hardware.

## Prerequisites

- Your cluster is configured to run DPDK workloads.

## Procedure

1. Create a namespace for your DPDK applications:

```
$ oc create ns dpdk-checkup-ns
```

2. Create an **SriovNetwork** object that references the **SriovNetworkNodePolicy** object. When you create an **SriovNetwork** object, the SR-IOV Network Operator automatically creates a **NetworkAttachmentDefinition** object.

### Example SriovNetwork manifest

```
apiVersion: sriovnetwork.openshift.io/v1
kind: SriovNetwork
metadata:
  name: dpdk-sriovnetwork
  namespace: openshift-sriov-network-operator
spec:
  ipam: |
    {
      "type": "host-local",
      "subnet": "10.56.217.0/24",
      "rangeStart": "10.56.217.171",
      "rangeEnd": "10.56.217.181",
      "routes": [
        {
          "dst": "0.0.0.0/0"
        }],
      "gateway": "10.56.217.1"
    }
  networkNamespace: dpdk-checkup-ns 1
  resourceName: intel_nics_dpdk 2
  spoofChk: "off"
  trust: "on"
  vlan: 1019
```

- 1 The namespace where the **NetworkAttachmentDefinition** object is deployed.
- 2 The value of the **spec.resourceName** attribute of the **SriovNetworkNodePolicy** object that was created when configuring the cluster for DPDK workloads.
3. Optional: Run the virtual machine latency checkup to verify that the network is properly configured.
4. Optional: Run the DPDK checkup to verify that the namespace is ready for DPDK workloads.

## Additional resources

- Working with projects
- Virtual machine latency checkup
- DPDK checkup

#### 10.18.4.7. Configuring a virtual machine for DPDK workloads

You can run Data Packet Development Kit (DPDK) workloads on virtual machines (VMs) to achieve lower latency and higher throughput for faster packet processing in the user space. DPDK uses the SR-IOV network for hardware-based I/O sharing.

##### Prerequisites

- Your cluster is configured to run DPDK workloads.
- You have created and configured the project in which the VM will run.

##### Procedure

1. Edit the **VirtualMachine** manifest to include information about the SR-IOV network interface, CPU topology, CRI-O annotations, and huge pages:

##### Example VirtualMachine manifest

```
apiVersion: kubevirt.io/v1
kind: VirtualMachine
metadata:
  name: rhel-dpdk-vm
spec:
  running: true
  template:
    metadata:
      annotations:
        cpu-load-balancing.crio.io: disable ①
        cpu-quota.crio.io: disable ②
        irq-load-balancing.crio.io: disable ③
    spec:
      nodeSelector:
        node-role.kubernetes.io/worker-dpdk: "" ④
      domain:
        cpu:
          sockets: 1 ⑤
          cores: 5 ⑥
          threads: 2
          dedicatedCpuPlacement: true
          isolateEmulatorThread: true
      interfaces:
        - masquerade: {}
          name: default
        - model: virtio
          name: nic-east
          pciAddress: '0000:07:00.0'
          sriov: {}
```

```

networkInterfaceMultiqueue: true
rng: {}
memory:
hugepages:
  pageSize: 1Gi 7
resources:
requests:
  memory: 8Gi
networks:
- name: default
pod: {}
- multus:
  networkName: dpdk-net 8
  name: nic-east
# ...

```

- 1** This annotation specifies that load balancing is disabled for CPUs that are used by the container.
- 2** This annotation specifies that the CPU quota is disabled for CPUs that are used by the container.
- 3** This annotation specifies that Interrupt Request (IRQ) load balancing is disabled for CPUs that are used by the container.
- 4** The label that is used in the **MachineConfigPool** and **PerformanceProfile** manifests that were created when configuring the cluster for DPDK workloads.
- 5** The number of sockets inside the VM. This field must be set to **1** for the CPUs to be scheduled from the same Non-Uniform Memory Access (NUMA) node.
- 6** The number of cores inside the VM. This must be a value greater than or equal to **1**. In this example, the VM is scheduled with 5 hyper-threads or 10 CPUs.
- 7** The size of the huge pages. The possible values for x86-64 architecture are 1Gi and 2Mi. In this example, the request is for 8 huge pages of size 1Gi.
- 8** The name of the SR-IOV **NetworkAttachmentDefinition** object.

2. Save and exit the editor.

3. Apply the **VirtualMachine** manifest:

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

4. Configure the guest operating system. The following example shows the configuration steps for RHEL 8 OS:

- a. Configure isolated VM CPUs and specify huge pages by using the GRUB bootloader command-line interface. In the following example, 8 1G huge pages are specified. The first two CPUs (0 and 1) are set aside for house keeping tasks and the rest are isolated for the DPDK application.

```
$ grubby --update-kernel=ALL --args="default_hugepagesz=1GB hugepagesz=1G
hugepages=8 isolcpus=2-9"
```

- b. To achieve low-latency tuning by using the **cpu-partitioning** profile in the TuneD application, run the following commands:

```
$ dnf install -y tuned-profiles-cpu-partitioning
$ echo isolated_cores=2-9 > /etc/tuned/cpu-partitioning-variables.conf
$ tuned-adm profile cpu-partitioning
```

- c. Override the SR-IOV NIC driver by using the **driverctl** device driver control utility:

```
$ dnf install -y driverctl
$ driverctl set-override 0000:07:00.0 vfio-pci
```

5. Restart the VM to apply the changes.

#### 10.18.4.8. Next steps

- [Accessing a virtual machine on a secondary network by using the cluster domain name](#)

### 10.18.5. Connecting a virtual machine to a service mesh

OpenShift Virtualization is now integrated with OpenShift Service Mesh. You can monitor, visualize, and control traffic between pods that run virtual machine workloads on the default pod network with IPv4.

#### 10.18.5.1. Prerequisites

- You must have [installed the Service Mesh Operator](#) and [deployed the service mesh control plane](#).
- You must have added the namespace where the virtual machine is created to the [service mesh member roll](#).
- You must use the **masquerade** binding method for the default pod network.

#### 10.18.5.2. Configuring a virtual machine for the service mesh

To add a virtual machine (VM) workload to a service mesh, enable automatic sidecar injection in the VM configuration file by setting the **sidecar.istio.io/inject** annotation to **true**. Then expose your VM as a service to view your application in the mesh.

#### Prerequisites

- To avoid port conflicts, do not use ports used by the Istio sidecar proxy. These include ports 15000, 15001, 15006, 15008, 15020, 15021, and 15090.

#### Procedure

1. Edit the VM configuration file to add the **sidecar.istio.io/inject: "true"** annotation.

#### Example configuration file

```

apiVersion: kubevirt.io/v1
kind: VirtualMachine
metadata:
  labels:
    kubevirt.io/vm: vm-istio
  name: vm-istio
spec:
  runStrategy: Always
  template:
    metadata:
      labels:
        kubevirt.io/vm: vm-istio
        app: vm-istio 1
      annotations:
        sidecar.istio.io/inject: "true" 2
    spec:
      domain:
        devices:
          interfaces:
            - name: default
              masquerade: {} 3
        disks:
          - disk:
              bus: virtio
              name: containerdisk
          - disk:
              bus: virtio
              name: cloudinitdisk
      resources:
        requests:
          memory: 1024M
      networks:
        - name: default
          pod: {}
      terminationGracePeriodSeconds: 180
      volumes:
        - containerDisk:
            image: registry:5000/kubevirt/fedora-cloud-container-disk-demo:devel
            name: containerdisk

```

- 1** The key/value pair (label) that must be matched to the service selector attribute.
- 2** The annotation to enable automatic sidecar injection.
- 3** The binding method (masquerade mode) for use with the default pod network.

2. Apply the VM configuration:

```
$ oc apply -f <vm_name>.yaml 1
```

- 1** The name of the virtual machine YAML file.

3. Create a **Service** object to expose your VM to the service mesh.

```

apiVersion: v1
kind: Service
metadata:
  name: vm-istio
spec:
  selector:
    app: vm-istio 1
  ports:
    - port: 8080
      name: http
      protocol: TCP

```

- 1** The service selector that determines the set of pods targeted by a service. This attribute corresponds to the **spec.metadata.labels** field in the VM configuration file. In the above example, the **Service** object named **vm-istio** targets TCP port 8080 on any pod with the label **app=vm-istio**.

#### 4. Create the service:

```
$ oc create -f <service_name>.yaml 1
```

- 1** The name of the service YAML file.

### 10.18.6. Configuring IP addresses for virtual machines

You can configure static and dynamic IP addresses for virtual machines.

#### 10.18.6.1. Configuring an IP address for a new virtual machine using cloud-init

You can use cloud-init to configure the IP address of a secondary NIC when you create a virtual machine (VM). The IP address can be dynamically or statically provisioned.



#### NOTE

If the VM is connected to the pod network, the pod network interface is the default route unless you update it.

#### Prerequisites

- The virtual machine is connected to a secondary network.
- You have a DHCP server available on the secondary network to configure a dynamic IP for the virtual machine.

#### Procedure

- Edit the **spec.template.spec.volumes.cloudInitNoCloud.networkData** stanza of the virtual machine configuration:
  - To configure a dynamic IP address, specify the interface name and enable DHCP:

```
kind: VirtualMachine
```

```

spec:
# ...
template:
# ...
spec:
volumes:
- cloudInitNoCloud:
  networkData: |
    version: 2
  eternets:
    eth1: ①
  dhcp4: true

```

- ① Specify the interface name.

- To configure a static IP, specify the interface name and the IP address:

```

kind: VirtualMachine
spec:
# ...
template:
# ...
spec:
volumes:
- cloudInitNoCloud:
  networkData: |
    version: 2
  eternets:
    eth1: ①
    addresses:
      - 10.10.10.14/24 ②

```

- ① Specify the interface name.

- ② Specify the static IP address.

## 10.18.7. Viewing the IP address of NICs on a virtual machine

You can view the IP address for a network interface controller (NIC) by using the web console or the **oc** client. The [QEMU guest agent](#) displays additional information about the virtual machine's secondary networks.

### 10.18.7.1. Prerequisites

- Install the QEMU guest agent on the virtual machine.

### 10.18.7.2. Viewing the IP address of a virtual machine interface in the CLI

The network interface configuration is included in the **oc describe vmi <vmi\_name>** command.

You can also view the IP address information by running **ip addr** on the virtual machine, or by running **oc get vmi <vmi\_name> -o yaml**.

## Procedure

- Use the **oc describe** command to display the virtual machine interface configuration:

```
$ oc describe vmi <vmi_name>
```

## Example output

```
# ...
Interfaces:
  Interface Name: eth0
  Ip Address: 10.244.0.37/24
  Ip Addresses:
    10.244.0.37/24
    fe80::858:aff:fef4:25/64
  Mac: 0a:58:0a:f4:00:25
  Name: default
  Interface Name: v2
  Ip Address: 1.1.1.7/24
  Ip Addresses:
    1.1.1.7/24
    fe80::f4d9:70ff:fe13:9089/64
  Mac: f6:d9:70:13:90:89
  Interface Name: v1
  Ip Address: 1.1.1.1/24
  Ip Addresses:
    1.1.1.1/24
    1.1.1.2/24
    1.1.1.4/24
    2001:de7:0:f101::1/64
    2001:db8:0:f101::1/64
    fe80::1420:84ff:fe10:17aa/64
  Mac: 16:20:84:10:17:aa
```

### 10.18.7.3. Viewing the IP address of a virtual machine interface in the web console

The IP information is displayed on the **VirtualMachine details** page for the virtual machine.

## Procedure

1. In the OpenShift Container Platform console, click **Virtualization** → **VirtualMachines** from the side menu.
2. Select a virtual machine name to open the **VirtualMachine details** page.

The information for each attached NIC is displayed under **IP Address** on the **Details** tab.

### 10.18.8. Accessing a virtual machine on a secondary network by using the cluster domain name

You can access a virtual machine (VM) that is attached to a secondary network interface from outside the cluster by using the fully qualified domain name (FQDN) of the cluster.



## IMPORTANT

Accessing VMs by using the cluster FQDN 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](#).

### 10.18.8.1. Configuring DNS server for secondary networks

The Cluster Network Addons Operator (CNAO) deploys the Domain Name Server (DNS) server and monitoring components when you enable the **KubeSecondaryDNS** feature gate in the **HyperConverged** custom resource (CR).

#### Prerequisites

- You installed the OpenShift CLI (**oc**).
- You have access to an OpenShift Container Platform cluster with **cluster-admin** permissions.

#### Procedure

1. Create a **LoadBalancer** service using MetallLB or any other load balancer to expose the DNS server outside the cluster. The service listens on port 53 and targets port 5353. For example:

```
$ oc expose -n openshift-cnv deployment/secondary-dns --name=dns-lb --type=LoadBalancer --port=53 --target-port=5353 --protocol='UDP'
```

2. Retrieve the public IP address of the service by querying the **Service** object:

```
$ oc get service -n openshift-cnv
```

#### Example output

| NAME   | TYPE         | CLUSTER-IP  | EXTERNAL-IP | PORT(S)      | AGE |
|--------|--------------|-------------|-------------|--------------|-----|
| dns-lb | LoadBalancer | 172.30.27.5 | 10.46.41.94 | 53:31829/TCP | 5s  |

3. Deploy the DNS server and monitoring components by editing the **HyperConverged** CR:

```
apiVersion: hco.kubevirt.io/v1beta1
kind: HyperConverged
metadata:
  name: kubevirt-hyperconverged
  namespace: openshift-cnv
spec:
  featureGates:
    deployKubeSecondaryDNS: true 1
    kubeSecondaryDNSNameServerIP: "10.46.41.94" 2
# ...
```

- 1** Set the **KubeSecondaryDNS** feature gate to **true**.
  - 2** Set the IP address of the service to the value retrieved in step 2.
4. Retrieve the FQDN of the OpenShift Container Platform cluster by using the following command:

```
$ oc get dnses.config.openshift.io cluster -o json | jq .spec.baseDomain
```

#### Example output

```
openshift.example.com
```

5. Point to the DNS server by using one of the following methods:

- Add the **kubeSecondaryDNSNameServerIP** value to the **resolv.conf** file on your local machine.



#### NOTE

Editing the **resolv.conf** file overwrites any existing DNS settings.

- Add the **kubeSecondaryDNSNameServerIP** value and the cluster FQDN to the enterprise DNS server records. For example:

```
vm.<FQDN>. IN NS ns.vm.<FQDN>.
```

```
ns.vm.<FQDN>. IN A 10.46.41.94
```

### 10.18.8.2. Connecting to a virtual machine on a secondary network by using the cluster FQDN

You can access a virtual machine (VM) that is attached to a secondary network interface from outside the cluster by using the fully qualified domain name (FQDN) of the cluster.

#### Prerequisites

- The QEMU guest agent must be running on the virtual machine.
- The IP address of the VM that you want to connect to, by using a DNS client, must be public.
- You have configured the DNS server for secondary networks.
- You have retrieved the fully qualified domain name (FQDN) of the cluster.

#### Procedure

1. Retrieve the VM configuration by using the following command:

```
$ oc get vm -n <namespace> <vm_name> -o yaml
```

#### Example output

```

apiVersion: kubevirt.io/v1
kind: VirtualMachine
metadata:
  labels:
    kubevirt.io/vm: example-vm
  name: example-vm
  namespace: example-namespace
spec:
  running: true
  template:
    metadata:
      labels:
        kubevirt.io/vm: example-vm
    spec:
      domain:
        devices:
# ...
      interfaces:
        - bridge: {}
          name: example-nic
# ...
      networks:
        - multus:
          networkName: bridge-conf
          name: example-nic ①
# ...

```

① Specify the name of the secondary network interface.

2. Connect to the VM by using the **ssh** command:

```
$ ssh <user_name>@<interface_name>.<vm_name>.<namespace>.vm.<FQDN> ①
```

① Specify the user name, interface name, VM name, VM namespace, and FQDN.

## Example

```
$ ssh you@example-nic.example-vm.example-namespace.vm.openshift.example.com
```

### 10.18.8.3. Additional resources

- Configuring ingress cluster traffic using a load balancer
- Load balancing with MetalLB
- Configuring IP addresses for virtual machines

### 10.18.9. Using a MAC address pool for virtual machines

The *KubeMacPool* component provides a MAC address pool service for virtual machine NICs in a namespace.

### 10.18.9.1. About KubeMacPool

KubeMacPool provides a MAC address pool per namespace and allocates MAC addresses for virtual machine NICs from the pool. This ensures that the NIC is assigned a unique MAC address that does not conflict with the MAC address of another virtual machine.

Virtual machine instances created from that virtual machine retain the assigned MAC address across reboots.



#### NOTE

KubeMacPool does not handle virtual machine instances created independently from a virtual machine.

KubeMacPool is enabled by default when you install OpenShift Virtualization. You can disable a MAC address pool for a namespace by adding the **mutatevirtualmachines.kubemacpool.io=ignore** label to the namespace. Re-enable KubeMacPool for the namespace by removing the label.

### 10.18.9.2. Disabling a MAC address pool for a namespace in the CLI

Disable a MAC address pool for virtual machines in a namespace by adding the **mutatevirtualmachines.kubemacpool.io=ignore** label to the namespace.

#### Procedure

- Add the **mutatevirtualmachines.kubemacpool.io=ignore** label to the namespace. The following example disables KubeMacPool for two namespaces, <namespace1> and <namespace2>:

```
$ oc label namespace <namespace1> <namespace2>
mutatevirtualmachines.kubemacpool.io=ignore
```

### 10.18.9.3. Re-enabling a MAC address pool for a namespace in the CLI

If you disabled KubeMacPool for a namespace and want to re-enable it, remove the **mutatevirtualmachines.kubemacpool.io=ignore** label from the namespace.



#### NOTE

Earlier versions of OpenShift Virtualization used the label **mutatevirtualmachines.kubemacpool.io=allocate** to enable KubeMacPool for a namespace. This is still supported but redundant as KubeMacPool is now enabled by default.

#### Procedure

- Remove the KubeMacPool label from the namespace. The following example re-enables KubeMacPool for two namespaces, <namespace1> and <namespace2>:

```
$ oc label namespace <namespace1> <namespace2>
mutatevirtualmachines.kubemacpool.io-
```

## 10.19. VIRTUAL MACHINE DISKS

### 10.19.1. Configuring local storage for virtual machines

You can configure local storage for virtual machines by using the hostpath provisioner (HPP).

When you install the OpenShift Virtualization Operator, the Hostpath Provisioner (HPP) Operator is automatically installed. The HPP is a local storage provisioner designed for OpenShift Virtualization that is created by the Hostpath Provisioner Operator. To use the HPP, you must create an HPP custom resource (CR).

#### 10.19.1.1. Creating a hostpath provisioner with a basic storage pool

You configure a hostpath provisioner (HPP) with a basic storage pool by creating an HPP custom resource (CR) with a **storagePools** stanza. The storage pool specifies the name and path used by the CSI driver.

#### Prerequisites

- The directories specified in **spec.storagePools.path** must have read/write access.
- The storage pools must not be in the same partition as the operating system. Otherwise, the operating system partition might become filled to capacity, which will impact performance or cause the node to become unstable or unusable.

#### Procedure

1. Create an **hpp\_cr.yaml** file with a **storagePools** stanza as in the following example:

```
apiVersion: hostpathprovisioner.kubevirt.io/v1beta1
kind: HostPathProvisioner
metadata:
  name: hostpath-provisioner
spec:
  imagePullPolicy: IfNotPresent
  storagePools: ①
    - name: any_name
      path: "/var/myvolumes" ②
  workload:
    nodeSelector:
      kubernetes.io/os: linux
```

- 1 The **storagePools** stanza is an array to which you can add multiple entries.
- 2 Specify the storage pool directories under this node path.

- 2 Save the file and exit.
- 3 Create the HPP by running the following command:

```
$ oc create -f_hpp_cr.yaml
```

#### 10.19.1.1.1. About creating storage classes

When you create a storage class, you set parameters that affect the dynamic provisioning of persistent volumes (PVs) that belong to that storage class. You cannot update a **StorageClass** object's parameters after you create it.

In order to use the hostpath provisioner (HPP) you must create an associated storage class for the CSI driver with the **storagePools** stanza.



## NOTE

Virtual machines use data volumes that are based on local PVs. Local PVs are bound to specific nodes. While the disk image is prepared for consumption by the virtual machine, it is possible that the virtual machine cannot be scheduled to the node where the local storage PV was previously pinned.

To solve this problem, use the Kubernetes pod scheduler to bind the persistent volume claim (PVC) to a PV on the correct node. By using the **StorageClass** value with **volumeBindingMode** parameter set to **WaitForFirstConsumer**, the binding and provisioning of the PV is delayed until a pod is created using the PVC.

### 10.19.1.1.2. Creating a storage class for the CSI driver with the **storagePools** stanza

You create a storage class custom resource (CR) for the hostpath provisioner (HPP) CSI driver.

#### Procedure

- 1 Create a **storageclass\_csi.yaml** file to define the storage class:

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: hostpath-csi
provisioner: kubevirt.io/hostpath-provisioner
reclaimPolicy: Delete ①
volumeBindingMode: WaitForFirstConsumer ②
parameters:
  storagePool: my-storage-pool ③
```

- 1 The two possible **reclaimPolicy** values are **Delete** and **Retain**. If you do not specify a value, the default value is **Delete**.
- 2 The **volumeBindingMode** parameter determines when dynamic provisioning and volume binding occur. Specify **WaitForFirstConsumer** to delay the binding and provisioning of a persistent volume (PV) until after a pod that uses the persistent volume claim (PVC) is created. This ensures that the PV meets the pod's scheduling requirements.
- 3 Specify the name of the storage pool defined in the HPP CR.

- 1 Save the file and exit.
- 2 Create the **StorageClass** object by running the following command:

```
$ oc create -f storageclass_csi.yaml
```

### 10.19.1.2. About storage pools created with PVC templates

If you have a single, large persistent volume (PV), you can create a storage pool by defining a PVC template in the hostpath provisioner (HPP) custom resource (CR).

A storage pool created with a PVC template can contain multiple HPP volumes. Splitting a PV into smaller volumes provides greater flexibility for data allocation.

The PVC template is based on the **spec** stanza of the **PersistentVolumeClaim** object:

#### Example PersistentVolumeClaim object

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: iso-pvc
spec:
  volumeMode: Block 1
  storageClassName: my-storage-class
  accessModes:
  - ReadWriteOnce
  resources:
    requests:
      storage: 5Gi
```

**1** This value is only required for block volume mode PVs.

You define a storage pool using a **pvcTemplate** specification in the HPP CR. The Operator creates a PVC from the **pvcTemplate** specification for each node containing the HPP CSI driver. The PVC created from the PVC template consumes the single large PV, allowing the HPP to create smaller dynamic volumes.

You can combine basic storage pools with storage pools created from PVC templates.

### 10.19.1.2.1. Creating a storage pool with a PVC template

You can create a storage pool for multiple hostpath provisioner (HPP) volumes by specifying a PVC template in the HPP custom resource (CR).

#### Prerequisites

- The directories specified in **spec.storagePools.path** must have read/write access.
- The storage pools must not be in the same partition as the operating system. Otherwise, the operating system partition might become filled to capacity, which will impact performance or cause the node to become unstable or unusable.

#### Procedure

1. Create an **hpp\_pvc\_template\_pool.yaml** file for the HPP CR that specifies a persistent volume (PVC) template in the **storagePools** stanza according to the following example:

```
apiVersion: hostpathprovisioner.kubevirt.io/v1beta1
kind: HostPathProvisioner
```

```

metadata:
  name: hostpath-provisioner
spec:
  imagePullPolicy: IfNotPresent
  storagePools: ①
    - name: my-storage-pool
      path: "/var/myvolumes" ②
  pvcTemplate:
    volumeMode: Block ③
    storageClassName: my-storage-class ④
    accessModes:
      - ReadWriteOnce
    resources:
      requests:
        storage: 5Gi ⑤
  workload:
    nodeSelector:
      kubernetes.io/os: linux

```

- ① The **storagePools** stanza is an array that can contain both basic and PVC template storage pools.
- ② Specify the storage pool directories under this node path.
- ③ Optional: The **volumeMode** parameter can be either **Block** or **Filesystem** as long as it matches the provisioned volume format. If no value is specified, the default is **Filesystem**. If the **volumeMode** is **Block**, the mounting pod creates an XFS file system on the block volume before mounting it.
- ④ If the **storageClassName** parameter is omitted, the default storage class is used to create PVCs. If you omit **storageClassName**, ensure that the HPP storage class is not the default storage class.
- ⑤ You can specify statically or dynamically provisioned storage. In either case, ensure the requested storage size is appropriate for the volume you want to virtually divide or the PVC cannot be bound to the large PV. If the storage class you are using uses dynamically provisioned storage, pick an allocation size that matches the size of a typical request.

2. Save the file and exit.

3. Create the HPP with a storage pool by running the following command:

```
$ oc create -f_hpp_pvc_template_pool.yaml
```

#### Additional resources

- [Customizing the storage profile](#)

#### 10.19.2. Creating data volumes

You can create a data volume by using either the PVC or storage API.



## IMPORTANT

When using OpenShift Virtualization with OpenShift Container Platform Container Storage, specify RBD block mode persistent volume claims (PVCs) when creating virtual machine disks. With virtual machine disks, RBD block mode volumes are more efficient and provide better performance than Ceph FS or RBD filesystem-mode PVCs.

To specify RBD block mode PVCs, use the 'ocs-storagecluster-ceph-rbd' storage class and **VolumeMode: Block**.

## TIP

Whenever possible, use the storage API to optimize space allocation and maximize performance.

A *storage profile* is a custom resource that the CDI manages. It provides recommended storage settings based on the associated storage class. A storage profile is allocated for each storage class.

Storage profiles enable you to create data volumes quickly while reducing coding and minimizing potential errors.

For recognized storage types, the CDI provides values that optimize the creation of PVCs. However, you can configure automatic settings for a storage class if you customize the storage profile.

### 10.19.2.1. About data volumes

**DataVolume** objects are custom resources that are provided by the Containerized Data Importer (CDI) project. Data volumes orchestrate import, clone, and upload operations that are associated with an underlying persistent volume claim (PVC). You can create a data volume as either a standalone resource or by using the **dataVolumeTemplate** field in the virtual machine (VM) specification.



## NOTE

- VM disk PVCs that are prepared by using standalone data volumes maintain an independent lifecycle from the VM. If you use the **dataVolumeTemplate** field in the VM specification to prepare the PVC, the PVC shares the same lifecycle as the VM.

### 10.19.2.2. Creating data volumes using the storage API

When you create a data volume using the storage API, the Containerized Data Interface (CDI) optimizes your persistent volume claim (PVC) allocation based on the type of storage supported by your selected storage class. You only have to specify the data volume name, namespace, and the amount of storage that you want to allocate.

For example:

- When using Ceph RBD, **accessModes** is automatically set to **ReadWriteMany**, which enables live migration. **volumeMode** is set to **Block** to maximize performance.
- When you are using **volumeMode: Filesystem**, more space will automatically be requested by the CDI, if required to accommodate file system overhead.

In the following YAML, using the storage API requests a data volume with two gigabytes of usable space. The user does not need to know the **volumeMode** in order to correctly estimate the required persistent volume claim (PVC) size. The CDI chooses the optimal combination of **accessModes** and **volumeMode**.

attributes automatically. These optimal values are based on the type of storage or the defaults that you define in your storage profile. If you want to provide custom values, they override the system-calculated values.

### Example DataVolume definition

```
apiVersion: cdi.kubevirt.io/v1beta1
kind: DataVolume
metadata:
  name: <datavolume> ①
spec:
  source:
    pvc: ②
      namespace: "<source_namespace>" ③
      name: "<my_vm_disk>" ④
  storage: ⑤
    resources:
      requests:
        storage: 2Gi ⑥
  storageClassName: <storage_class> ⑦
```

- ① The name of the new data volume.
- ② Indicate that the source of the import is an existing persistent volume claim (PVC).
- ③ The namespace where the source PVC exists.
- ④ The name of the source PVC.
- ⑤ Indicates allocation using the storage API.
- ⑥ Specifies the amount of available space that you request for the PVC.
- ⑦ Optional: The name of the storage class. If the storage class is not specified, the system default storage class is used.

#### 10.19.2.3. Creating data volumes using the PVC API

When you create a data volume using the PVC API, the Containerized Data Interface (CDI) creates the data volume based on what you specify for the following fields:

- **accessModes** (**ReadWriteOnce**, **ReadWriteMany**, or **ReadOnlyMany**)
- **volumeMode** (**Filesystem** or **Block**)
- **capacity** of **storage** (**5Gi**, for example)

In the following YAML, using the PVC API allocates a data volume with a storage capacity of two gigabytes. You specify an access mode of **ReadWriteMany** to enable live migration. Because you know the values your system can support, you specify **Block** storage instead of the default, **Filesystem**.

### Example DataVolume definition

```
apiVersion: cdi.kubevirt.io/v1beta1
```

```

kind: DataVolume
metadata:
  name: <datavolume> ①
spec:
  source:
    pvc: ②
      namespace: "<source_namespace>" ③
      name: "<my_vm_disk>" ④
  pvc: ⑤
    accessModes: ⑥
      - ReadWriteMany
  resources:
    requests:
      storage: 2Gi ⑦
  volumeMode: Block ⑧
  storageClassName: <storage_class> ⑨

```

- ① The name of the new data volume.
- ② In the **source** section, **pvc** indicates that the source of the import is an existing persistent volume claim (PVC).
- ③ The namespace where the source PVC exists.
- ④ The name of the source PVC.
- ⑤ Indicates allocation using the PVC API.
- ⑥ **accessModes** is required when using the PVC API.
- ⑦ Specifies the amount of space you are requesting for your data volume.
- ⑧ Specifies that the destination is a block PVC.
- ⑨ Optionally, specify the storage class. If the storage class is not specified, the system default storage class is used.



## IMPORTANT

When you explicitly allocate a data volume by using the PVC API and you are not using **volumeMode: Block**, consider file system overhead.

File system overhead is the amount of space required by the file system to maintain its metadata. The amount of space required for file system metadata is file system dependent. Failing to account for file system overhead in your storage capacity request can result in an underlying persistent volume claim (PVC) that is not large enough to accommodate your virtual machine disk.

If you use the storage API, the CDI will factor in file system overhead and request a larger persistent volume claim (PVC) to ensure that your allocation request is successful.

### 10.19.2.4. Customizing the storage profile

You can specify default parameters by editing the **StorageProfile** object for the provisioner's storage class. These default parameters only apply to the persistent volume claim (PVC) if they are not configured in the **DataVolume** object.

An empty **status** section in a storage profile indicates that a storage provisioner is not recognized by the Containerized Data Interface (CDI). Customizing a storage profile is necessary if you have a storage provisioner that is not recognized by the CDI. In this case, the administrator sets appropriate values in the storage profile to ensure successful allocations.



### WARNING

If you create a data volume and omit YAML attributes and these attributes are not defined in the storage profile, then the requested storage will not be allocated and the underlying persistent volume claim (PVC) will not be created.

## Prerequisites

- Ensure that your planned configuration is supported by the storage class and its provider. Specifying an incompatible configuration in a storage profile causes volume provisioning to fail.

## Procedure

1. Edit the storage profile. In this example, the provisioner is not recognized by CDI:

```
$ oc edit -n openshift-cnv storageprofile <storage_class>
```

### Example storage profile

```
apiVersion: cdi.kubevirt.io/v1beta1
kind: StorageProfile
metadata:
  name: <unknown_provisioner_class>
# ...
spec: {}
status:
  provisioner: <unknown_provisioner>
  storageClass: <unknown_provisioner_class>
```

2. Provide the needed attribute values in the storage profile:

### Example storage profile

```
apiVersion: cdi.kubevirt.io/v1beta1
kind: StorageProfile
metadata:
  name: <unknown_provisioner_class>
# ...
spec:
  claimPropertySets:
  - accessModes:
```

```

- ReadWriteOnce ①
volumeMode:
  Filesystem ②
status:
  provisioner: <unknown_provisioner>
  storageClass: <unknown_provisioner_class>

```

- ① The **accessModes** that you select.
- ② The **volumeMode** that you select.

After you save your changes, the selected values appear in the storage profile **status** element.

#### 10.19.2.4.1. Setting a default cloning strategy using a storage profile

You can use storage profiles to set a default cloning method for a storage class, creating a *cloning strategy*. Setting cloning strategies can be helpful, for example, if your storage vendor only supports certain cloning methods. It also allows you to select a method that limits resource usage or maximizes performance.

Cloning strategies can be specified by setting the **cloneStrategy** attribute in a storage profile to one of these values:

- **snapshot** is used by default when snapshots are configured. This cloning strategy uses a temporary volume snapshot to clone the volume. The storage provisioner must support Container Storage Interface (CSI) snapshots.
- **copy** uses a source pod and a target pod to copy data from the source volume to the target volume. Host-assisted cloning is the least efficient method of cloning.
- **csi-clone** uses the CSI clone API to efficiently clone an existing volume without using an interim volume snapshot. Unlike **snapshot** or **copy**, which are used by default if no storage profile is defined, CSI volume cloning is only used when you specify it in the **StorageProfile** object for the provisioner's storage class.



#### NOTE

You can also set clone strategies using the CLI without modifying the default **claimPropertySets** in your YAML **spec** section.

#### Example storage profile

```

apiVersion: cdi.kubevirt.io/v1beta1
kind: StorageProfile
metadata:
  name: <provisioner_class>
# ...
spec:
  claimPropertySets:
    - accessModes:
        - ReadWriteOnce ①
      volumeMode:
        Filesystem ②
  cloneStrategy: csi-clone ③

```

```
status:
provisioner: <provisioner>
storageClass: <provisioner_class>
```

- 1 Specify the access mode.
- 2 Specify the volume mode.
- 3 Specify the default cloning strategy.

#### 10.19.2.5. Additional resources

- [About creating storage classes](#)
- [Overriding the default file system overhead value](#)
- [Cloning a data volume using smart cloning](#)

#### 10.19.3. Reserving PVC space for file system overhead

By default, the OpenShift Virtualization reserves space for file system overhead data in persistent volume claims (PVCs) that use the **Filesystem** volume mode. You can set the percentage to reserve space for this purpose globally and for specific storage classes.

##### 10.19.3.1. How file system overhead affects space for virtual machine disks

When you add a virtual machine disk to a persistent volume claim (PVC) that uses the **Filesystem** volume mode, you must ensure that there is enough space on the PVC for:

- The virtual machine disk.
- The space reserved for file system overhead, such as metadata

By default, OpenShift Virtualization reserves 5.5% of the PVC space for overhead, reducing the space available for virtual machine disks by that amount.

You can configure a different overhead value by editing the **HCO** object. You can change the value globally and you can specify values for specific storage classes.

##### 10.19.3.2. Overriding the default file system overhead value

Change the amount of persistent volume claim (PVC) space that the OpenShift Virtualization reserves for file system overhead by editing the **spec.filesystemOverhead** attribute of the **HCO** object.

#### Prerequisites

- Install the OpenShift CLI (**oc**).

#### Procedure

1. Open the **HCO** object for editing by running the following command:

```
$ oc edit hco -n openshift-cnv kubevirt-hyperconverged
```

2. Edit the **spec.filesystemOverhead** fields, populating them with your chosen values:

```
# ...
spec:
  filesystemOverhead:
    global: "<new_global_value>" ①
    storageClass:
      <storage_class_name>: "<new_value_for_this_storage_class>" ②
```

- ① The default file system overhead percentage used for any storage classes that do not already have a set value. For example, **global: "0.07"** reserves 7% of the PVC for file system overhead.
- ② The file system overhead percentage for the specified storage class. For example, **mystorageclass: "0.04"** changes the default overhead value for PVCs in the **mystorageclass** storage class to 4%.

3. Save and exit the editor to update the **HCO** object.

## Verification

- View the **CDIConfig** status and verify your changes by running one of the following commands:  
To generally verify changes to **CDIConfig**:

```
$ oc get cdiconfig -o yaml
```

To view your specific changes to **CDIConfig**:

```
$ oc get cdiconfig -o jsonpath='{.items..status.filesystemOverhead}'
```

## 10.19.4. Configuring CDI to work with namespaces that have a compute resource quota

You can use the Containerized Data Importer (CDI) to import, upload, and clone virtual machine disks into namespaces that are subject to CPU and memory resource restrictions.

### 10.19.4.1. About CPU and memory quotas in a namespace

A *resource quota*, defined by the **ResourceQuota** object, imposes restrictions on a namespace that limit the total amount of compute resources that can be consumed by resources within that namespace.

The **HyperConverged** custom resource (CR) defines the user configuration for the Containerized Data Importer (CDI). The CPU and memory request and limit values are set to a default value of **0**. This ensures that pods created by CDI that do not specify compute resource requirements are given the default values and are allowed to run in a namespace that is restricted with a quota.

### 10.19.4.2. Overriding CPU and memory defaults

Modify the default settings for CPU and memory requests and limits for your use case by adding the **spec.resourceRequirements.storageWorkloads** stanza to the **HyperConverged** custom resource (CR).

## Prerequisites

- Install the OpenShift CLI (**oc**).

## Procedure

1. Edit the **HyperConverged** CR by running the following command:

```
$ oc edit hco -n openshift-cnv kubevirt-hyperconverged
```

2. Add the **spec.resourceRequirements.storageWorkloads** stanza to the CR, setting the values based on your use case. For example:

```
apiVersion: hco.kubevirt.io/v1beta1
kind: HyperConverged
metadata:
  name: kubevirt-hyperconverged
spec:
  resourceRequirements:
    storageWorkloads:
      limits:
        cpu: "500m"
        memory: "2Gi"
      requests:
        cpu: "250m"
        memory: "1Gi"
```

3. Save and exit the editor to update the **HyperConverged** CR.

### 10.19.4.3. Additional resources

- [Resource quotas per project](#)

### 10.19.5. Managing data volume annotations

Data volume (DV) annotations allow you to manage pod behavior. You can add one or more annotations to a data volume, which then propagates to the created importer pods.

#### 10.19.5.1. Example: Data volume annotations

This example shows how you can configure data volume (DV) annotations to control which network the importer pod uses. The **v1.multus-cni.io/default-network: bridge-network** annotation causes the pod to use the multus network named **bridge-network** as its default network. If you want the importer pod to use both the default network from the cluster and the secondary multus network, use the **k8s.v1.cni.cncf.io/networks: <network\_name>** annotation.

#### Multus network annotation example

```
apiVersion: cdi.kubevirt.io/v1beta1
kind: DataVolume
metadata:
  name: dv-ann
  annotations:
    v1.multus-cni.io/default-network: bridge-network ①
```

```

spec:
source:
  http:
    url: "example.exampleurl.com"
pvc:
  accessModes:
    - ReadWriteOnce
  resources:
    requests:
      storage: 1Gi

```

- 1 Multus network annotation

## 10.19.6. Using preallocation for data volumes

The Containerized Data Importer can preallocate disk space to improve write performance when creating data volumes.

You can enable preallocation for specific data volumes.

### 10.19.6.1. About preallocation

The Containerized Data Importer (CDI) can use the QEMU preallocate mode for data volumes to improve write performance. You can use preallocation mode for importing and uploading operations and when creating blank data volumes.

If preallocation is enabled, CDI uses the better preallocation method depending on the underlying file system and device type:

#### **fallocate**

If the file system supports it, CDI uses the operating system's **fallocate** call to preallocate space by using the **posix\_fallocate** function, which allocates blocks and marks them as uninitialized.

#### **full**

If **fallocate** mode cannot be used, **full** mode allocates space for the image by writing data to the underlying storage. Depending on the storage location, all the empty allocated space might be zeroed.

## 10.19.6.2. Enabling preallocation for a data volume

You can enable preallocation for specific data volumes by including the **spec.preallocation** field in the data volume manifest. You can enable preallocation mode in either the web console or by using the OpenShift CLI (**oc**).

Preallocation mode is supported for all CDI source types.

### Procedure

- Specify the **spec.preallocation** field in the data volume manifest:

```

apiVersion: cdi.kubevirt.io/v1beta1
kind: DataVolume
metadata:
  name: preallocated-datavolume

```

```

spec:
source: ①
...
pvc:
...
preallocation: true ②

```

- ① All CDI source types support preallocation, however preallocation is ignored for cloning operations.
- ② The **preallocation** field is a boolean that defaults to false.

## 10.19.7. Uploading local disk images by using the web console

You can upload a locally stored disk image file by using the web console.

### 10.19.7.1. Prerequisites

- You must have a virtual machine image file in IMG, ISO, or QCOW2 format.
- If you require scratch space according to the [CDI supported operations matrix](#), you must first [define a storage class or prepare CDI scratch space](#) for this operation to complete successfully.

### 10.19.7.2. CDI supported operations matrix

This matrix shows the supported CDI operations for content types against endpoints, and which of these operations requires scratch space.

| Content types       | HTTP                      | HTTPS                       | HTTP basic auth           | Registry                 | Upload                     |
|---------------------|---------------------------|-----------------------------|---------------------------|--------------------------|----------------------------|
| KubeVirt<br>(QCOW2) | ✓ QCOW2<br>✓ GZ*<br>✓ XZ* | ✓ QCOW2**<br>✓ GZ*<br>✓ XZ* | ✓ QCOW2<br>✓ GZ*<br>✓ XZ* | ✓ QCOW2*<br>□ GZ<br>□ XZ | ✓ QCOW2*<br>✓ GZ*<br>✓ XZ* |
| KubeVirt<br>(RAW)   | ✓ RAW<br>✓ GZ<br>✓ XZ     | ✓ RAW<br>✓ GZ<br>✓ XZ       | ✓ RAW<br>✓ GZ<br>✓ XZ     | ✓ RAW*<br>□ GZ<br>□ XZ   | ✓ RAW*<br>✓ GZ*<br>✓ XZ*   |

✓ Supported operation

□ Unsupported operation

\* Requires scratch space

\*\* Requires scratch space if a custom certificate authority is required

### 10.19.7.3. Uploading an image file using the web console

Use the web console to upload an image file to a new persistent volume claim (PVC). You can later use this PVC to attach the image to new virtual machines.

## Prerequisites

- You must have one of the following:
  - A raw virtual machine image file in either ISO or IMG format.
  - A virtual machine image file in QCOW2 format.
- For best results, compress your image file according to the following guidelines before you upload it:
  - Compress a raw image file by using **xz** or **gzip**.



### NOTE

Using a compressed raw image file results in the most efficient upload.

- Compress a QCOW2 image file by using the method that is recommended for your client:
  - If you use a Linux client, *sparsify* the QCOW2 file by using the [virt-sparsify](#) tool.
  - If you use a Windows client, compress the QCOW2 file by using **xz** or **gzip**.

## Procedure

1. From the side menu of the web console, click **Storage** → **Persistent Volume Claims**
2. Click the **Create Persistent Volume Claim** drop-down list to expand it.
3. Click **With Data Upload Form** to open the **Upload Data to Persistent Volume Claim** page.
4. Click **Browse** to open the file manager and select the image that you want to upload, or drag the file into the **Drag a file here or browse to upload** field.
5. Optional: Set this image as the default image for a specific operating system.
  - a. Select the **Attach this data to a virtual machine operating system** check box.
  - b. Select an operating system from the list.
6. The **Persistent Volume Claim Name** field is automatically filled with a unique name and cannot be edited. Take note of the name assigned to the PVC so that you can identify it later, if necessary.
7. Select a storage class from the **Storage Class** list.
8. In the **Size** field, enter the size value for the PVC. Select the corresponding unit of measurement from the drop-down list.



### WARNING

The PVC size must be larger than the size of the uncompressed virtual disk.

9. Select an **Access Mode** that matches the storage class that you selected.
10. Click **Upload**.

#### 10.19.7.4. Additional resources

- [Configure preallocation mode](#) to improve write performance for data volume operations.

### 10.19.8. Uploading local disk images by using the `virtctl` tool

You can upload a locally stored disk image to a new or existing persistent volume claim (PVC) by using the **virtctl** command-line utility.

#### 10.19.8.1. Prerequisites

- [Install virtctl](#).
- You might need to [define a storage class or prepare CDI scratch space](#) for this operation to complete successfully.

#### 10.19.8.2. About data volumes

**DataVolume** objects are custom resources that are provided by the Containerized Data Importer (CDI) project. Data volumes orchestrate import, clone, and upload operations that are associated with an underlying persistent volume claim (PVC). You can create a data volume as either a standalone resource or by using the **dataVolumeTemplate** field in the virtual machine (VM) specification.



#### NOTE

- VM disk PVCs that are prepared by using standalone data volumes maintain an independent lifecycle from the VM. If you use the **dataVolumeTemplate** field in the VM specification to prepare the PVC, the PVC shares the same lifecycle as the VM.

#### 10.19.8.3. Creating an upload data volume

You can manually create a data volume with an **upload** data source to use for uploading local disk images.

#### Procedure

1. Create a data volume configuration that specifies **spec: source: upload{}**:

```
apiVersion: cdi.kubevirt.io/v1beta1
kind: DataVolume
metadata:
  name: <upload-datavolume> ①
spec:
  source:
    upload: {}
  pvc:
    accessModes:
      - ReadWriteOnce
```

```
resources:
  requests:
    storage: <2Gi> 2
```

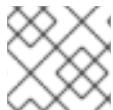
- 1** The name of the data volume.
- 2** The size of the data volume. Ensure that this value is greater than or equal to the size of the disk that you upload.

2. Create the data volume by running the following command:

```
$ oc create -f <upload-datavolume>.yaml
```

#### 10.19.8.4. Uploading a local disk image to a data volume

You can use the **virtctl** CLI utility to upload a local disk image from a client machine to a data volume (DV) in your cluster. You can use a DV that already exists in your cluster or create a new DV during this procedure.



#### NOTE

After you upload a local disk image, you can add it to a virtual machine.

#### Prerequisites

- You must have one of the following:
  - A raw virtual machine image file in either ISO or IMG format.
  - A virtual machine image file in QCOW2 format.
- For best results, compress your image file according to the following guidelines before you upload it:
  - Compress a raw image file by using **xz** or **gzip**.



#### NOTE

Using a compressed raw image file results in the most efficient upload.

- Compress a QCOW2 image file by using the method that is recommended for your client:
  - If you use a Linux client, *sparsify* the QCOW2 file by using the **virt-sparsify** tool.
  - If you use a Windows client, compress the QCOW2 file by using **xz** or **gzip**.
- The **kubevirt-virtctl** package must be installed on the client machine.
- The client machine must be configured to trust the OpenShift Container Platform router's certificate.

#### Procedure

1. Identify the following items:

- The name of the upload data volume that you want to use. If this data volume does not exist, it is created automatically.
  - The size of the data volume, if you want it to be created during the upload procedure. The size must be greater than or equal to the size of the disk image.
  - The file location of the virtual machine disk image that you want to upload.
2. Upload the disk image by running the **virtctl image-upload** command. Specify the parameters that you identified in the previous step. For example:

```
$ virtctl image-upload dv <datavolume_name> \ ①
--size=<datavolume_size> \ ②
--image-path=</path/to/image> \ ③
```

- ① The name of the data volume.
- ② The size of the data volume. For example: **--size=500Mi**, **--size=1G**
- ③ The file path of the virtual machine disk image.



#### NOTE

- If you do not want to create a new data volume, omit the **--size** parameter and include the **--no-create** flag.
- When uploading a disk image to a PVC, the PVC size must be larger than the size of the uncompressed virtual disk.
- To allow insecure server connections when using HTTPS, use the **--insecure** parameter. Be aware that when you use the **--insecure** flag, the authenticity of the upload endpoint is **not** verified.

3. Optional. To verify that a data volume was created, view all data volumes by running the following command:

```
$ oc get dvs
```

#### 10.19.8.5. CDI supported operations matrix

This matrix shows the supported CDI operations for content types against endpoints, and which of these operations requires scratch space.

| Content types       | HTTP                      | HTTPS                       | HTTP basic auth           | Registry                 | Upload                     |
|---------------------|---------------------------|-----------------------------|---------------------------|--------------------------|----------------------------|
| KubeVirt<br>(QCOW2) | ✓ QCOW2<br>✓ GZ*<br>✓ XZ* | ✓ QCOW2**<br>✓ GZ*<br>✓ XZ* | ✓ QCOW2<br>✓ GZ*<br>✓ XZ* | ✓ QCOW2*<br>□ GZ<br>□ XZ | ✓ QCOW2*<br>✓ GZ*<br>✓ XZ* |

| Content types     | HTTP                                                                                                                        | HTTPS                                                                                                                       | HTTP basic auth                                                                                                             | Registry                                                                                               | Upload                                                                                                                         |
|-------------------|-----------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|
| KubeVirt<br>(RAW) | <input checked="" type="checkbox"/> RAW<br><input checked="" type="checkbox"/> GZ<br><input checked="" type="checkbox"/> XZ | <input checked="" type="checkbox"/> RAW<br><input checked="" type="checkbox"/> GZ<br><input checked="" type="checkbox"/> XZ | <input checked="" type="checkbox"/> RAW<br><input checked="" type="checkbox"/> GZ<br><input checked="" type="checkbox"/> XZ | <input checked="" type="checkbox"/> RAW*<br><input type="checkbox"/> GZ<br><input type="checkbox"/> XZ | <input checked="" type="checkbox"/> RAW*<br><input checked="" type="checkbox"/> GZ*<br><input checked="" type="checkbox"/> XZ* |

✓ Supported operation

□ Unsupported operation

\* Requires scratch space

\*\* Requires scratch space if a custom certificate authority is required

#### 10.19.8.6. Additional resources

- Configure preallocation mode to improve write performance for data volume operations.

#### 10.19.9. Uploading a local disk image to a block storage persistent volume claim

You can upload a local disk image into a block persistent volume claim (PVC) by using the **virtctl** command-line utility.

In this workflow, you create a local block device to use as a persistent volume, associate this block volume with an **upload** data volume, and use **virtctl** to upload the local disk image into the PVC.

##### 10.19.9.1. Prerequisites

- Install **virtctl**.
- You might need to define a storage class or prepare CDI scratch space for this operation to complete successfully.

##### 10.19.9.2. About data volumes

**DataVolume** objects are custom resources that are provided by the Containerized Data Importer (CDI) project. Data volumes orchestrate import, clone, and upload operations that are associated with an underlying persistent volume claim (PVC). You can create a data volume as either a standalone resource or by using the **dataVolumeTemplate** field in the virtual machine (VM) specification.



##### NOTE

- VM disk PVCs that are prepared by using standalone data volumes maintain an independent lifecycle from the VM. If you use the **dataVolumeTemplate** field in the VM specification to prepare the PVC, the PVC shares the same lifecycle as the VM.

##### 10.19.9.3. About block persistent volumes

A block persistent volume (PV) is a PV that is backed by a raw block device. These volumes do not have a file system and can provide performance benefits for virtual machines by reducing overhead.

Raw block volumes are provisioned by specifying **volumeMode: Block** in the PV and persistent volume claim (PVC) specification.

#### 10.19.9.4. Creating a local block persistent volume

If you intend to import a virtual machine image into block storage with a data volume, you must have an available local block persistent volume.

Create a local block persistent volume (PV) on a node by populating a file and mounting it as a loop device. You can then reference this loop device in a PV manifest as a **Block** volume and use it as a block device for a virtual machine image.

#### Procedure

1. Log in as **root** to the node on which to create the local PV. This procedure uses **node01** for its examples.
2. Create a file and populate it with null characters so that it can be used as a block device. The following example creates a file **loop10** with a size of 2Gb (20 100Mb blocks):

```
$ dd if=/dev/zero of=<loop10> bs=100M count=20
```

3. Mount the **loop10** file as a loop device.

```
$ losetup </dev/loop10>d3 <loop10> ① ②
```

- ① File path where the loop device is mounted.
- ② The file created in the previous step to be mounted as the loop device.

4. Create a **PersistentVolume** manifest that references the mounted loop device.

```
kind: PersistentVolume
apiVersion: v1
metadata:
  name: <local-block-pv10>
  annotations:
spec:
  local:
    path: </dev/loop10> ①
  capacity:
    storage: <2Gi>
  volumeMode: Block ②
  storageClassName: local ③
  accessModes:
    - ReadWriteOnce
  persistentVolumeReclaimPolicy: Delete
  nodeAffinity:
    required:
      nodeSelectorTerms:
        - matchExpressions:
          - key: kubernetes.io/hostname
```

```
operator: In
values:
- <node01> ④
```

- 1 The path of the loop device on the node.
- 2 Specifies it is a block PV.
- 3 Optional: Set a storage class for the PV. If you omit it, the cluster default is used.
- 4 The node on which the block device was mounted.

5. Create the block PV.

```
# oc create -f <local-block-pv10.yaml> ①
```

- 1 The file name of the persistent volume created in the previous step.

#### 10.19.9.5. Creating an upload data volume

You can manually create a data volume with an **upload** data source to use for uploading local disk images.

##### Procedure

1. Create a data volume configuration that specifies **spec: source: upload{}**:

```
apiVersion: cdi.kubevirt.io/v1beta1
kind: DataVolume
metadata:
  name: <upload-datavolume> ①
spec:
  source:
    upload: {}
  pvc:
    accessModes:
      - ReadWriteOnce
    resources:
      requests:
        storage: <2Gi> ②
```

- 1 The name of the data volume.
- 2 The size of the data volume. Ensure that this value is greater than or equal to the size of the disk that you upload.

2. Create the data volume by running the following command:

```
$ oc create -f <upload-datavolume>.yaml
```

#### 10.19.9.6. Uploading a local disk image to a data volume

You can use the **virtctl** CLI utility to upload a local disk image from a client machine to a data volume (DV) in your cluster. You can use a DV that already exists in your cluster or create a new DV during this procedure.



### NOTE

After you upload a local disk image, you can add it to a virtual machine.

## Prerequisites

- You must have one of the following:
  - A raw virtual machine image file in either ISO or IMG format.
  - A virtual machine image file in QCOW2 format.
- For best results, compress your image file according to the following guidelines before you upload it:
  - Compress a raw image file by using **xz** or **gzip**.



### NOTE

Using a compressed raw image file results in the most efficient upload.

- Compress a QCOW2 image file by using the method that is recommended for your client:
  - If you use a Linux client, *sparsify* the QCOW2 file by using the [virt-sparsify](#) tool.
  - If you use a Windows client, compress the QCOW2 file by using **xz** or **gzip**.
- The **kubevirt-virtctl** package must be installed on the client machine.
- The client machine must be configured to trust the OpenShift Container Platform router's certificate.

## Procedure

1. Identify the following items:
  - The name of the upload data volume that you want to use. If this data volume does not exist, it is created automatically.
  - The size of the data volume, if you want it to be created during the upload procedure. The size must be greater than or equal to the size of the disk image.
  - The file location of the virtual machine disk image that you want to upload.
2. Upload the disk image by running the **virtctl image-upload** command. Specify the parameters that you identified in the previous step. For example:

```
$ virtctl image-upload dv <datavolume_name> \ ①
--size=<datavolume_size> \ ②
--image-path=</path/to/image> \ ③
```

- 1 The name of the data volume.
- 2 The size of the data volume. For example: **--size=500Mi**, **--size=1G**
- 3 The file path of the virtual machine disk image.



### NOTE

- If you do not want to create a new data volume, omit the **--size** parameter and include the **--no-create** flag.
- When uploading a disk image to a PVC, the PVC size must be larger than the size of the uncompressed virtual disk.
- To allow insecure server connections when using HTTPS, use the **--insecure** parameter. Be aware that when you use the **--insecure** flag, the authenticity of the upload endpoint is **not** verified.

3. Optional. To verify that a data volume was created, view all data volumes by running the following command:

```
$ oc get dvs
```

#### 10.19.9.7. CDI supported operations matrix

This matrix shows the supported CDI operations for content types against endpoints, and which of these operations requires scratch space.

| Content types       | HTTP                                                                                                                            | HTTPS                                                                                                                             | HTTP basic auth                                                                                                                 | Registry                                                                                                 | Upload                                                                                                                           |
|---------------------|---------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|
| KubeVirt<br>(QCOW2) | <input checked="" type="checkbox"/> QCOW2<br><input checked="" type="checkbox"/> GZ*<br><input checked="" type="checkbox"/> XZ* | <input checked="" type="checkbox"/> QCOW2**<br><input checked="" type="checkbox"/> GZ*<br><input checked="" type="checkbox"/> XZ* | <input checked="" type="checkbox"/> QCOW2<br><input checked="" type="checkbox"/> GZ*<br><input checked="" type="checkbox"/> XZ* | <input checked="" type="checkbox"/> QCOW2*<br><input type="checkbox"/> GZ<br><input type="checkbox"/> XZ | <input checked="" type="checkbox"/> QCOW2*<br><input checked="" type="checkbox"/> GZ*<br><input checked="" type="checkbox"/> XZ* |
| KubeVirt<br>(RAW)   | <input checked="" type="checkbox"/> RAW<br><input checked="" type="checkbox"/> GZ<br><input checked="" type="checkbox"/> XZ     | <input checked="" type="checkbox"/> RAW<br><input checked="" type="checkbox"/> GZ<br><input checked="" type="checkbox"/> XZ       | <input checked="" type="checkbox"/> RAW<br><input checked="" type="checkbox"/> GZ<br><input checked="" type="checkbox"/> XZ     | <input checked="" type="checkbox"/> RAW*<br><input type="checkbox"/> GZ<br><input type="checkbox"/> XZ   | <input checked="" type="checkbox"/> RAW*<br><input checked="" type="checkbox"/> GZ*<br><input checked="" type="checkbox"/> XZ*   |

✓ Supported operation

□ Unsupported operation

\* Requires scratch space

\*\* Requires scratch space if a custom certificate authority is required

#### 10.19.9.8. Additional resources

- [Configure preallocation mode](#) to improve write performance for data volume operations.

## 10.19.10. Managing virtual machine snapshots

You can create and delete virtual machine (VM) snapshots for VMs, whether the VMs are powered off (offline) or on (online). You can only restore to a powered off (offline) VM. OpenShift Virtualization supports VM snapshots on the following:

- Red Hat OpenShift Data Foundation
- Any other cloud storage provider with the Container Storage Interface (CSI) driver that supports the Kubernetes Volume Snapshot API

Online snapshots have a default time deadline of five minutes (**5m**) that can be changed, if needed.



### IMPORTANT

Online snapshots are supported for virtual machines that have hot-plugged virtual disks. However, hot-plugged disks that are not in the virtual machine specification are not included in the snapshot.



### NOTE

To create snapshots of an online (Running state) VM with the highest integrity, install the QEMU guest agent.

The QEMU guest agent takes a consistent snapshot by attempting to quiesce the VM file system as much as possible, depending on the system workload. This ensures that in-flight I/O is written to the disk before the snapshot is taken. If the guest agent is not present, quiescing is not possible and a best-effort snapshot is taken. The conditions under which the snapshot was taken are reflected in the snapshot indications that are displayed in the web console or CLI.

## 10.19.10.1. About virtual machine snapshots

A *snapshot* represents the state and data of a virtual machine (VM) at a specific point in time. You can use a snapshot to restore an existing VM to a previous state (represented by the snapshot) for backup and disaster recovery or to rapidly roll back to a previous development version.

A VM snapshot is created from a VM that is powered off (Stopped state) or powered on (Running state).

When taking a snapshot of a running VM, the controller checks that the QEMU guest agent is installed and running. If so, it freezes the VM file system before taking the snapshot, and thaws the file system after the snapshot is taken.

The snapshot stores a copy of each Container Storage Interface (CSI) volume attached to the VM and a copy of the VM specification and metadata. Snapshots cannot be changed after creation.

With the VM snapshots feature, cluster administrators and application developers can:

- Create a new snapshot
- List all snapshots attached to a specific VM
- Restore a VM from a snapshot
- Delete an existing VM snapshot

### 10.19.10.1.1. Virtual machine snapshot controller and custom resource definitions (CRDs)

The VM snapshot feature introduces three new API objects defined as CRDs for managing snapshots:

- **VirtualMachineSnapshot**: Represents a user request to create a snapshot. It contains information about the current state of the VM.
- **VirtualMachineSnapshotContent**: Represents a provisioned resource on the cluster (a snapshot). It is created by the VM snapshot controller and contains references to all resources required to restore the VM.
- **VirtualMachineRestore**: Represents a user request to restore a VM from a snapshot.

The VM snapshot controller binds a **VirtualMachineSnapshotContent** object with the **VirtualMachineSnapshot** object for which it was created, with a one-to-one mapping.

### 10.19.10.2. Installing QEMU guest agent on a Linux virtual machine

The **qemu-guest-agent** is widely available and available by default in Red Hat Enterprise Linux (RHEL) virtual machines (VMs). Install the agent and start the service.



#### NOTE

To create snapshots of an online (Running state) VM with the highest integrity, install the QEMU guest agent.

The QEMU guest agent takes a consistent snapshot by attempting to quiesce the VM's file system as much as possible, depending on the system workload. This ensures that in-flight I/O is written to the disk before the snapshot is taken. If the guest agent is not present, quiescing is not possible and a best-effort snapshot is taken. The conditions under which the snapshot was taken are reflected in the snapshot indications that are displayed in the web console or CLI.

#### Procedure

1. Access the virtual machine command line through one of the consoles or by SSH.
2. Install the QEMU guest agent on the virtual machine:

```
$ yum install -y qemu-guest-agent
```

3. Ensure the service is persistent and start it:

```
$ systemctl enable --now qemu-guest-agent
```

#### Verification

1. Run the following command to verify that **AgentConnected** is listed in the VM spec:

```
$ oc get vm <vm_name>
```

### 10.19.10.3. Installing QEMU guest agent on a Windows virtual machine

For Windows virtual machines, the QEMU guest agent is included in the VirtIO drivers. Install the drivers on an existing or a new Windows installation.



### NOTE

To create snapshots of an online (Running state) VM with the highest integrity, install the QEMU guest agent.

The QEMU guest agent takes a consistent snapshot by attempting to quiesce the VM's file system as much as possible, depending on the system workload. This ensures that in-flight I/O is written to the disk before the snapshot is taken. If the guest agent is not present, quiescing is not possible and a best-effort snapshot is taken. The conditions under which the snapshot was taken are reflected in the snapshot indications that are displayed in the web console or CLI.

### Procedure

1. In the Windows Guest Operating System (OS), use the **File Explorer** to navigate to the **guest-agent** directory in the **virtio-win** CD drive.
2. Run the **qemu-ga-x86\_64.msi** installer.

### Verification

1. Run the following command to verify that the output contains the **QEMU Guest Agent**:

```
$ net start
```

#### 10.19.10.3.1. Installing VirtIO drivers on an existing Windows virtual machine

Install the VirtIO drivers from the attached SATA CD drive to an existing Windows virtual machine.



### NOTE

This procedure uses a generic approach to adding drivers to Windows. The process might differ slightly between versions of Windows. See the installation documentation for your version of Windows for specific installation steps.

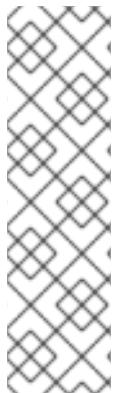
### Procedure

1. Start the virtual machine and connect to a graphical console.
2. Log in to a Windows user session.
3. Open **Device Manager** and expand **Other devices** to list any **Unknown device**.
  - a. Open the **Device Properties** to identify the unknown device. Right-click the device and select **Properties**.
  - b. Click the **Details** tab and select **Hardware Ids** in the **Property** list.
  - c. Compare the **Value** for the **Hardware Ids** with the supported VirtIO drivers.
4. Right-click the device and select **Update Driver Software**.

5. Click **Browse my computer for driver software** and browse to the attached SATA CD drive, where the VirtIO drivers are located. The drivers are arranged hierarchically according to their driver type, operating system, and CPU architecture.
6. Click **Next** to install the driver.
7. Repeat this process for all the necessary VirtIO drivers.
8. After the driver installs, click **Close** to close the window.
9. Reboot the virtual machine to complete the driver installation.

#### 10.19.10.4. Creating a virtual machine snapshot in the web console

You can create a virtual machine (VM) snapshot by using the web console.



##### NOTE

To create snapshots of an online (Running state) VM with the highest integrity, install the QEMU guest agent.

The QEMU guest agent takes a consistent snapshot by attempting to quiesce the VM's file system as much as possible, depending on the system workload. This ensures that in-flight I/O is written to the disk before the snapshot is taken. If the guest agent is not present, quiescing is not possible and a best-effort snapshot is taken. The conditions under which the snapshot was taken are reflected in the snapshot indications that are displayed in the web console or CLI.

The VM snapshot only includes disks that meet the following requirements:

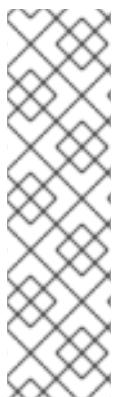
- Must be either a data volume or persistent volume claim
- Belong to a storage class that supports Container Storage Interface (CSI) volume snapshots

##### Procedure

1. Click **Virtualization** → **VirtualMachines** from the side menu.
2. Select a virtual machine to open the **VirtualMachine details** page.
3. If the virtual machine is running, click **Actions** → **Stop** to power it down.
4. Click the **Snapshots** tab and then click **Take Snapshot**.
5. Fill in the **Snapshot Name** and optional **Description** fields.
6. Expand **Disks included in this Snapshot** to see the storage volumes to be included in the snapshot.
7. If your VM has disks that cannot be included in the snapshot and you still wish to proceed, select the **I am aware of this warning and wish to proceed** checkbox.
8. Click **Save**.

#### 10.19.10.5. Creating a virtual machine snapshot in the CLI

You can create a virtual machine (VM) snapshot for an offline or online VM by creating a **VirtualMachineSnapshot** object. Kubevirt will coordinate with the QEMU guest agent to create a snapshot of the online VM.



## NOTE

To create snapshots of an online (Running state) VM with the highest integrity, install the QEMU guest agent.

The QEMU guest agent takes a consistent snapshot by attempting to quiesce the VM's file system as much as possible, depending on the system workload. This ensures that in-flight I/O is written to the disk before the snapshot is taken. If the guest agent is not present, quiescing is not possible and a best-effort snapshot is taken. The conditions under which the snapshot was taken are reflected in the snapshot indications that are displayed in the web console or CLI.

## Prerequisites

- Ensure that the persistent volume claims (PVCs) are in a storage class that supports Container Storage Interface (CSI) volume snapshots.
- Install the OpenShift CLI (**oc**).
- Optional: Power down the VM for which you want to create a snapshot.

## Procedure

1. Create a YAML file to define a **VirtualMachineSnapshot** object that specifies the name of the new **VirtualMachineSnapshot** and the name of the source VM.  
For example:

```
apiVersion: snapshot.kubevirt.io/v1beta1
kind: VirtualMachineSnapshot
metadata:
  name: my-vmsnapshot 1
spec:
  source:
    apiGroup: kubevirt.io
    kind: VirtualMachine
    name: my-vm 2
```

- 1 The name of the new **VirtualMachineSnapshot** object.
- 2 The name of the source VM.

2. Create the **VirtualMachineSnapshot** resource. The snapshot controller creates a **VirtualMachineSnapshotContent** object, binds it to the **VirtualMachineSnapshot** and updates the **status** and **readyToUse** fields of the **VirtualMachineSnapshot** object.

```
$ oc create -f <my-vmsnapshot>.yaml
```

3. Optional: If you are taking an online snapshot, you can use the **wait** command and monitor the status of the snapshot:

```
--> oc get vmsnapshots --export --wait=readyToUse
```

- Enter the following command:

```
$ oc wait my-vm my-vmsnapshot --for condition=Ready
```

- Verify the status of the snapshot:

- InProgress** - The online snapshot operation is still in progress.
- Succeeded** - The online snapshot operation completed successfully.
- Failed** - The online snapshot operation failed.



### NOTE

Online snapshots have a default time deadline of five minutes (**5m**). If the snapshot does not complete successfully in five minutes, the status is set to **failed**. Afterwards, the file system will be thawed and the VM unfrozen but the status remains **failed** until you delete the failed snapshot image.

To change the default time deadline, add the **FailureDeadline** attribute to the VM snapshot spec with the time designated in minutes (**m**) or in seconds (**s**) that you want to specify before the snapshot operation times out.

To set no deadline, you can specify **0**, though this is generally not recommended, as it can result in an unresponsive VM.

If you do not specify a unit of time such as **m** or **s**, the default is seconds (**s**).

## Verification

- Verify that the **VirtualMachineSnapshot** object is created and bound with **VirtualMachineSnapshotContent**. The **readyToUse** flag must be set to **true**.

```
$ oc describe vmsnapshot <my-vmsnapshot>
```

### Example output

```
apiVersion: snapshot.kubevirt.io/v1beta1
kind: VirtualMachineSnapshot
metadata:
  creationTimestamp: "2020-09-30T14:41:51Z"
  finalizers:
  - snapshot.kubevirt.io/vmsnapshot-protection
  generation: 5
  name: mysnap
  namespace: default
  resourceVersion: "3897"
  selfLink:
    /apis/snapshot.kubevirt.io/v1beta1/namespaces/default/virtualmachinesnapshots/my-vmsnapshot
  uid: 28eedf08-5d6a-42c1-969c-2eda58e2a78d
spec:
```

```

source:
  apiGroup: kubevirt.io
  kind: VirtualMachine
  name: my-vm
status:
  conditions:
    - lastProbeTime: null
      lastTransitionTime: "2020-09-30T14:42:03Z"
      reason: Operation complete
      status: "False" ①
      type: Progressing
    - lastProbeTime: null
      lastTransitionTime: "2020-09-30T14:42:03Z"
      reason: Operation complete
      status: "True" ②
      type: Ready
  creationTime: "2020-09-30T14:42:03Z"
  readyToUse: true ③
  sourceUID: 355897f3-73a0-4ec4-83d3-3c2df9486f4f
  virtualMachineSnapshotContentName: vmsnapshot-content-28eedf08-5d6a-42c1-969c-2eda58e2a78d ④

```

- ① The **status** field of the **Progressing** condition specifies if the snapshot is still being created.
- ② The **status** field of the **Ready** condition specifies if the snapshot creation process is complete.
- ③ Specifies if the snapshot is ready to be used.
- ④ Specifies that the snapshot is bound to a **VirtualMachineSnapshotContent** object created by the snapshot controller.

2. Check the **spec:volumeBackups** property of the **VirtualMachineSnapshotContent** resource to verify that the expected PVCs are included in the snapshot.

#### 10.19.10.6. Verifying online snapshot creation with snapshot indications

Snapshot indications are contextual information about online virtual machine (VM) snapshot operations. Indications are not available for offline virtual machine (VM) snapshot operations. Indications are helpful in describing details about the online snapshot creation.

##### Prerequisites

- To view indications, you must have attempted to create an online VM snapshot using the CLI or the web console.

##### Procedure

1. Display the output from the snapshot indications by doing one of the following:
  - For snapshots created with the CLI, view indicator output in the **VirtualMachineSnapshot** object YAML, in the **status** field.

- For snapshots created using the web console, click **VirtualMachineSnapshot > Status** in the **Snapshot details** screen.
2. Verify the status of your online VM snapshot:

- **Online** indicates that the VM was running during online snapshot creation.
- **NoGuestAgent** indicates that the QEMU guest agent was not running during online snapshot creation. The QEMU guest agent could not be used to freeze and thaw the file system, either because the QEMU guest agent was not installed or running or due to another error.

#### 10.19.10.7. Restoring a virtual machine from a snapshot in the web console

You can restore a virtual machine (VM) to a previous configuration represented by a snapshot in the web console.

##### Procedure

1. Click **Virtualization → VirtualMachines** from the side menu.
2. Select a virtual machine to open the **VirtualMachine details** page.
3. If the virtual machine is running, click **Actions → Stop** to power it down.
4. Click the **Snapshots** tab. The page displays a list of snapshots associated with the virtual machine.
5. Choose one of the following methods to restore a VM snapshot:
  - a. For the snapshot that you want to use as the source to restore the VM, click **Restore**.
  - b. Select a snapshot to open the **Snapshot Details** screen and click **Actions → Restore VirtualMachineSnapshot**.
6. In the confirmation pop-up window, click **Restore** to restore the VM to its previous configuration represented by the snapshot.

#### 10.19.10.8. Restoring a virtual machine from a snapshot in the CLI

You can restore an existing virtual machine (VM) to a previous configuration by using a VM snapshot. You can only restore from an offline VM snapshot.

##### Prerequisites

- Install the OpenShift CLI (**oc**).
- Power down the VM you want to restore to a previous state.

##### Procedure

1. Create a YAML file to define a **VirtualMachineRestore** object that specifies the name of the VM you want to restore and the name of the snapshot to be used as the source.  
For example:

```
apiVersion: snapshot.kubevirt.io/v1beta1
```

```

kind: VirtualMachineRestore
metadata:
  name: my-vmrestore 1
spec:
  target:
    apiGroup: kubevirt.io
    kind: VirtualMachine
    name: my-vm 2
  virtualMachineSnapshotName: my-vmsnapshot 3

```

- 1** The name of the new **VirtualMachineRestore** object.
- 2** The name of the target VM you want to restore.
- 3** The name of the **VirtualMachineSnapshot** object to be used as the source.

2. Create the **VirtualMachineRestore** resource. The snapshot controller updates the status fields of the **VirtualMachineRestore** object and replaces the existing VM configuration with the snapshot content.

```
$ oc create -f <my-vmrestore>.yaml
```

## Verification

- Verify that the VM is restored to the previous state represented by the snapshot. The **complete** flag must be set to **true**.

```
$ oc get vmrestore <my-vmrestore>
```

## Example output

```

apiVersion: snapshot.kubevirt.io/v1beta1
kind: VirtualMachineRestore
metadata:
  creationTimestamp: "2020-09-30T14:46:27Z"
  generation: 5
  name: my-vmrestore
  namespace: default
  ownerReferences:
  - apiVersion: kubevirt.io/v1
    blockOwnerDeletion: true
    controller: true
    kind: VirtualMachine
    name: my-vm
    uid: 355897f3-73a0-4ec4-83d3-3c2df9486f4f
  resourceVersion: "5512"
  selfLink: /apis/snapshot.kubevirt.io/v1beta1/namespaces/default/virtualmachinerestores/my-vmrestore
  uid: 71c679a8-136e-46b0-b9b5-f57175a6a041
spec:
  target:
    apiGroup: kubevirt.io
    kind: VirtualMachine

```

```

name: my-vm
virtualMachineSnapshotName: my-vmsnapshot
status:
  complete: true ①
  conditions:
    - lastProbeTime: null
      lastTransitionTime: "2020-09-30T14:46:28Z"
      reason: Operation complete
      status: "False" ②
    type: Progressing
    - lastProbeTime: null
      lastTransitionTime: "2020-09-30T14:46:28Z"
      reason: Operation complete
      status: "True" ③
    type: Ready
  deletedDataVolumes:
    - test-dv1
  restoreTime: "2020-09-30T14:46:28Z"
  restores:
    - dataVolumeName: restore-71c679a8-136e-46b0-b9b5-f57175a6a041-datavolumedisk1
      persistentVolumeClaim: restore-71c679a8-136e-46b0-b9b5-f57175a6a041-
        datavolumedisk1
      volumeName: datavolumedisk1
      volumeSnapshotName: vmsnapshot-28eedf08-5d6a-42c1-969c-2eda58e2a78d-volume-
        datavolumedisk1

```

- ① Specifies if the process of restoring the VM to the state represented by the snapshot is complete.
- ② The **status** field of the **Progressing** condition specifies if the VM is still being restored.
- ③ The **status** field of the **Ready** condition specifies if the VM restoration process is complete.

#### 10.19.10.9. Deleting a virtual machine snapshot in the web console

You can delete an existing virtual machine snapshot by using the web console.

##### Procedure

1. Click **Virtualization** → **VirtualMachines** from the side menu.
2. Select a virtual machine to open the **VirtualMachine details** page.
3. Click the **Snapshots** tab. The page displays a list of snapshots associated with the virtual machine.
4. Click the Options menu  of the virtual machine snapshot that you want to delete and select **Delete VirtualMachineSnapshot**.
5. In the confirmation pop-up window, click **Delete** to delete the snapshot.

### 10.19.10.10. Deleting a virtual machine snapshot in the CLI

You can delete an existing virtual machine (VM) snapshot by deleting the appropriate **VirtualMachineSnapshot** object.

#### Prerequisites

- Install the OpenShift CLI (**oc**).

#### Procedure

- Delete the **VirtualMachineSnapshot** object. The snapshot controller deletes the **VirtualMachineSnapshot** along with the associated **VirtualMachineSnapshotContent** object.

```
$ oc delete vmsnapshot <my-vmsnapshot>
```

#### Verification

- Verify that the snapshot is deleted and no longer attached to this VM:

```
$ oc get vmsnapshot
```

### 10.19.10.11. Additional resources

- [CSI Volume Snapshots](#)

### 10.19.11. Moving a local virtual machine disk to a different node

Virtual machines that use local volume storage can be moved so that they run on a specific node.

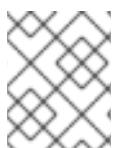
You might want to move the virtual machine to a specific node for the following reasons:

- The current node has limitations to the local storage configuration.
- The new node is better optimized for the workload of that virtual machine.

To move a virtual machine that uses local storage, you must clone the underlying volume by using a data volume. After the cloning operation is complete, you can [edit the virtual machine configuration](#) so that it uses the new data volume, or [add the new data volume to another virtual machine](#).

#### TIP

When you enable preallocation globally, or for a single data volume, the Containerized Data Importer (CDI) preallocates disk space during cloning. Preallocation enhances write performance. For more information, see [Using preallocation for data volumes](#).



#### NOTE

Users without the **cluster-admin** role require [additional user permissions](#) to clone volumes across namespaces.

### 10.19.11.1. Cloning a local volume to another node

You can move a virtual machine disk so that it runs on a specific node by cloning the underlying persistent volume claim (PVC).

To ensure the virtual machine disk is cloned to the correct node, you must either create a new persistent volume (PV) or identify one on the correct node. Apply a unique label to the PV so that it can be referenced by the data volume.



## NOTE

The destination PV must be the same size or larger than the source PVC. If the destination PV is smaller than the source PVC, the cloning operation fails.

## Prerequisites

- The virtual machine must not be running. Power down the virtual machine before cloning the virtual machine disk.

## Procedure

1. Either create a new local PV on the node, or identify a local PV already on the node:
  - Create a local PV that includes the **nodeAffinity.nodeSelectorTerms** parameters. The following manifest creates a **10Gi** local PV on **node01**.

```
kind: PersistentVolume
apiVersion: v1
metadata:
  name: <destination-pv> ①
  annotations:
  spec:
    accessModes:
      - ReadWriteOnce
    capacity:
      storage: 10Gi ②
    local:
      path: /mnt/local-storage/local/disk1 ③
    nodeAffinity:
      required:
        nodeSelectorTerms:
          - matchExpressions:
              - key: kubernetes.io/hostname
                operator: In
                values:
                  - node01 ④
    persistentVolumeReclaimPolicy: Delete
    storageClassName: local
    volumeMode: Filesystem
```

- 1 The name of the PV.
- 2 The size of the PV. You must allocate enough space, or the cloning operation fails. The size must be the same as or larger than the source PVC.
- 3 The mount path on the node.

- ④ The name of the node where you want to create the PV.
- Identify a PV that already exists on the target node. You can identify the node where a PV is provisioned by viewing the **nodeAffinity** field in its configuration:

```
$ oc get pv <destination-pv> -o yaml
```

The following snippet shows that the PV is on **node01**:

### Example output

```
# ...
spec:
  nodeAffinity:
    required:
      nodeSelectorTerms:
        - matchExpressions:
            - key: kubernetes.io/hostname ①
              operator: In
              values:
                - node01 ②
# ...
```

- ① The **kubernetes.io/hostname** key uses the node hostname to select a node.  
 ② The hostname of the node.

- Add a unique label to the PV:

```
$ oc label pv <destination-pv> node=node01
```

- Create a data volume manifest that references the following:

- The PVC name and namespace of the virtual machine.
- The label you applied to the PV in the previous step.
- The size of the destination PV.

```
apiVersion: cdi.kubevirt.io/v1beta1
kind: DataVolume
metadata:
  name: <clone-datavolume> ①
spec:
  source:
    pvc:
      name: "<source-vm-disk>" ②
      namespace: "<source-namespace>" ③
  pvc:
    accessModes:
      - ReadWriteOnce
    selector:
      matchLabels:
```

```

    node: node01 4
resources:
requests:
storage: <10Gi> 5

```

- 1** The name of the new data volume.
- 2** The name of the source PVC. If you do not know the PVC name, you can find it in the virtual machine configuration: **spec.volumes.persistentVolumeClaim.claimName**.
- 3** The namespace where the source PVC exists.
- 4** The label that you applied to the PV in the previous step.
- 5** The size of the destination PV.

4. Start the cloning operation by applying the data volume manifest to your cluster:

```
$ oc apply -f <clone-datavolume.yaml>
```

The data volume clones the PVC of the virtual machine into the PV on the specific node.

### 10.19.12. Expanding virtual storage by adding blank disk images

You can increase your storage capacity or create new data partitions by adding blank disk images to OpenShift Virtualization.

#### 10.19.12.1. About data volumes

**DataVolume** objects are custom resources that are provided by the Containerized Data Importer (CDI) project. Data volumes orchestrate import, clone, and upload operations that are associated with an underlying persistent volume claim (PVC). You can create a data volume as either a standalone resource or by using the **dataVolumeTemplate** field in the virtual machine (VM) specification.



#### NOTE

- VM disk PVCs that are prepared by using standalone data volumes maintain an independent lifecycle from the VM. If you use the **dataVolumeTemplate** field in the VM specification to prepare the PVC, the PVC shares the same lifecycle as the VM.

#### 10.19.12.2. Creating a blank disk image with data volumes

You can create a new blank disk image in a persistent volume claim by customizing and deploying a data volume configuration file.

#### Prerequisites

- At least one available persistent volume.
- Install the OpenShift CLI (**oc**).

#### Procedure

1. Edit the **DataVolume** manifest:

```
apiVersion: cdi.kubevirt.io/v1beta1
kind: DataVolume
metadata:
  name: blank-image-datavolume
spec:
  source:
    blank: {}
  pvc:
    storageClassName: "hostpath" ①
    accessModes:
      - ReadWriteOnce
  resources:
    requests:
      storage: 500Mi
```

- ① Optional: If you do not specify a storage class, the default storage class is applied.

2. Create the blank disk image by running the following command:

```
$ oc create -f <blank-image-datavolume>.yaml
```

#### 10.19.12.3. Additional resources

- [Configure preallocation mode](#) to improve write performance for data volume operations.

#### 10.19.13. Cloning a data volume using smart-cloning

Smart-cloning is a built-in feature of Red Hat OpenShift Data Foundation. Smart-cloning is faster and more efficient than host-assisted cloning.

You do not need to perform any action to enable smart-cloning, but you need to ensure your storage environment is compatible with smart-cloning to use this feature.

When you create a data volume with a persistent volume claim (PVC) source, you automatically initiate the cloning process. You always receive a clone of the data volume if your environment supports smart-cloning or not. However, you will only receive the performance benefits of smart cloning if your storage provider supports smart-cloning.

##### 10.19.13.1. About data volumes

**DataVolume** objects are custom resources that are provided by the Containerized Data Importer (CDI) project. Data volumes orchestrate import, clone, and upload operations that are associated with an underlying persistent volume claim (PVC). You can create a data volume as either a standalone resource or by using the **dataVolumeTemplate** field in the virtual machine (VM) specification.



##### NOTE

- VM disk PVCs that are prepared by using standalone data volumes maintain an independent lifecycle from the VM. If you use the **dataVolumeTemplate** field in the VM specification to prepare the PVC, the PVC shares the same lifecycle as the VM.

### 10.19.13.2. About smart-cloning

When a data volume is smart-cloned, the following occurs:

1. A snapshot of the source persistent volume claim (PVC) is created.
2. A PVC is created from the snapshot.
3. The snapshot is deleted.

### 10.19.13.3. Cloning a data volume

#### Prerequisites

For smart-cloning to occur, the following conditions are required:

- Your storage provider must support snapshots.
- The source and target PVCs must be defined to the same storage class.
- The source and target PVCs share the same **volumeMode**.
- The **VolumeSnapshotClass** object must reference the storage class defined to both the source and target PVCs.

#### Procedure

To initiate cloning of a data volume:

1. Create a YAML file for a **DataVolume** object that specifies the name of the new data volume and the name and namespace of the source PVC. In this example, because you specify the **storage** API, there is no need to specify **accessModes** or **volumeMode**. The optimal values will be calculated for you automatically.

```
apiVersion: cdi.kubevirt.io/v1beta1
kind: DataVolume
metadata:
  name: <cloner-datavolume> ①
spec:
  source:
    pvc:
      namespace: "<source-namespace>" ②
      name: "<my-favorite-vm-disk>" ③
  storage: ④
  resources:
    requests:
      storage: <2Gi> ⑤
```

- ① The name of the new data volume.
- ② The namespace where the source PVC exists.
- ③ The name of the source PVC.
- ④ Specifies allocation with the **storage** API

- 5** The size of the new data volume.

2. Start cloning the PVC by creating the data volume:

```
$ oc create -f <cloner-datavolume>.yaml
```



#### NOTE

Data volumes prevent a virtual machine from starting before the PVC is prepared, so you can create a virtual machine that references the new data volume while the PVC clones.

#### 10.19.13.4. Additional resources

- [Cloning the persistent volume claim of a virtual machine disk into a new data volume](#)
- [Configure preallocation mode](#) to improve write performance for data volume operations.
- [Customizing the storage profile](#)

#### 10.19.14. Hot plugging virtual disks

You can add or remove virtual disks without stopping your virtual machine (VM) or virtual machine instance (VMI).

##### 10.19.14.1. About hot plugging virtual disks

When you *hot plug* a virtual disk, you attach a virtual disk to a virtual machine instance while the virtual machine is running.

When you *hot unplug* a virtual disk, you detach a virtual disk from a virtual machine instance while the virtual machine is running.

Only data volumes and persistent volume claims (PVCs) can be hot plugged and hot unplugged. You cannot hot plug or hot unplug container disks.

After you hot plug a virtual disk, it remains attached until you detach it, even if you restart the virtual machine.

In the web console, hot-plugged volumes are marked by a "persistent hotplug" label on the disk in the disk list (**VirtualMachine Details** → **Configuration** → **Disks** tab). To change a hot-plug volume to a



persistent volume, click the **Options** menu and select **Make persistent**. The "persistent hotplug" label is removed and the change is applied after the next reboot.

##### 10.19.14.2. About virtio-scsi

In OpenShift Virtualization, each virtual machine (VM) has a **virtio-scsi** controller so that hot plugged disks can use a **scsi** bus. The **virtio-scsi** controller overcomes the limitations of **virtio** while retaining its performance advantages. It is highly scalable and supports hot plugging over 4 million disks.

Regular **virtio** is not available for hot plugged disks because it is not scalable: each **virtio** disk uses one of the limited PCI Express (PCIe) slots in the VM. PCIe slots are also used by other devices and must be reserved in advance, therefore slots might not be available on demand.

#### 10.19.14.3. Hot plugging a virtual disk using the CLI

Hot plug virtual disks that you want to attach to a virtual machine instance (VMI) while a virtual machine is running.

##### Prerequisites

- You must have a running virtual machine to hot plug a virtual disk.
- You must have at least one data volume or persistent volume claim (PVC) available for hot plugging.

##### Procedure

- Hot plug a virtual disk by running the following command:

```
$ virtctl addvolume <virtual-machine|virtual-machine-instance> --volume-name=<datavolume|PVC> \  
[--persist] [--serial=<label-name>]
```

- Use the optional **--persist** flag to add the hot plugged disk to the virtual machine specification as a permanently mounted virtual disk. Stop, restart, or reboot the virtual machine to permanently mount the virtual disk. After specifying the **--persist** flag, you can no longer hot plug or hot unplug the virtual disk. The **--persist** flag applies to virtual machines, not virtual machine instances.
- The optional **--serial** flag allows you to add an alphanumeric string label of your choice. This helps you to identify the hot plugged disk in a guest virtual machine. If you do not specify this option, the label defaults to the name of the hot plugged data volume or PVC.

#### 10.19.14.4. Hot unplugging a virtual disk using the CLI

Hot unplug virtual disks that you want to detach from a virtual machine instance (VMI) while a virtual machine is running.

##### Prerequisites

- Your virtual machine must be running.
- You must have at least one data volume or persistent volume claim (PVC) available and hot plugged.

##### Procedure

- Hot unplug a virtual disk by running the following command:

```
$ virtctl removevolume <virtual-machine|virtual-machine-instance> --volume-name=<datavolume|PVC>
```

#### 10.19.14.5. Hot plugging a virtual disk using the web console

Hot plug virtual disks that you want to attach to a virtual machine instance (VMI) while a virtual machine is running. When you hot plug a virtual disk, it remains attached to the VMI until you unplug it.

## Prerequisites

- You must have a running virtual machine to hot plug a virtual disk.

## Procedure

1. Click **Virtualization** → **VirtualMachines** from the side menu.
2. Select the running virtual machine to which you want to hot plug a virtual disk.
3. On the **VirtualMachine details** page, click **Configuration** → **Disks**.
4. Click **Add disk**.
5. In the **Add disk (hot plugged)** window, fill in the information for the virtual disk that you want to hot plug.
6. Click **Save**.

### 10.19.14.6. Hot unplugging a virtual disk using the web console

Hot unplug virtual disks that you want to detach from a virtual machine instance (VMI) while a virtual machine is running.

## Prerequisites

- Your virtual machine must be running with a hot plugged disk attached.

## Procedure

1. Click **Virtualization** → **VirtualMachines** from the side menu.
2. Select the running virtual machine with the disk you want to hot unplug to open the **VirtualMachine details** page.
3. Click **Configuration** → **Disks**.
4. Click the Options menu  beside the virtual disk that you want to hot unplug and select **Detach**.
5. Click **Detach**.

### 10.19.15. Using container disks with virtual machines

You can build a virtual machine image into a container disk and store it in your container registry. You can then import the container disk into persistent storage for a virtual machine or attach it directly to the virtual machine for ephemeral storage.



## IMPORTANT

If you use large container disks, I/O traffic might increase, impacting worker nodes. This can lead to unavailable nodes. You can resolve this by:

- [Pruning DeploymentConfig objects](#)
- [Configuring garbage collection](#)

### 10.19.15.1. About container disks

A container disk is a virtual machine image that is stored as a container image in a container image registry. You can use container disks to deliver the same disk images to multiple virtual machines and to create large numbers of virtual machine clones.

A container disk can either be imported into a persistent volume claim (PVC) by using a data volume that is attached to a virtual machine, or attached directly to a virtual machine as an ephemeral **containerDisk** volume.

#### 10.19.15.1.1. Importing a container disk into a PVC by using a data volume

Use the Containerized Data Importer (CDI) to import the container disk into a PVC by using a data volume. You can then attach the data volume to a virtual machine for persistent storage.

#### 10.19.15.1.2. Attaching a container disk to a virtual machine as a **containerDisk** volume

A **containerDisk** volume is ephemeral. It is discarded when the virtual machine is stopped, restarted, or deleted. When a virtual machine with a **containerDisk** volume starts, the container image is pulled from the registry and hosted on the node that is hosting the virtual machine.

Use **containerDisk** volumes for read-only file systems such as CD-ROMs or for disposable virtual machines.



## IMPORTANT

Using **containerDisk** volumes for read-write file systems is not recommended because the data is temporarily written to local storage on the hosting node. This slows live migration of the virtual machine, such as in the case of node maintenance, because the data must be migrated to the destination node. Additionally, all data is lost if the node loses power or otherwise shuts down unexpectedly.

### 10.19.15.2. Preparing a container disk for virtual machines

You must build a container disk with a virtual machine image and push it to a container registry before it can be used with a virtual machine. You can then either import the container disk into a PVC using a data volume and attach it to a virtual machine, or you can attach the container disk directly to a virtual machine as an ephemeral **containerDisk** volume.

The size of a disk image inside a container disk is limited by the maximum layer size of the registry where the container disk is hosted.



## NOTE

For [Red Hat Quay](#), you can change the maximum layer size by editing the YAML configuration file that is created when Red Hat Quay is first deployed.

## Prerequisites

- Install **podman** if it is not already installed.
- The virtual machine image must be either QCOW2 or RAW format.

## Procedure

1. Create a Dockerfile to build the virtual machine image into a container image. The virtual machine image must be owned by QEMU, which has a UID of **107**, and placed in the **/disk/** directory inside the container. Permissions for the **/disk/** directory must then be set to **0440**. The following example uses the Red Hat Universal Base Image (UBI) to handle these configuration changes in the first stage, and uses the minimal **scratch** image in the second stage to store the result:

```
$ cat > Dockerfile << EOF
FROM registry.access.redhat.com/ubi8/ubi:latest AS builder
ADD --chown=107:107 <vm_image>.qcow2 /disk/ 1
RUN chmod 0440 /disk/*

FROM scratch
COPY --from=builder /disk/* /disk/
EOF
```

- 1 Where **<vm\_image>** is the virtual machine image in either QCOW2 or RAW format. To use a remote virtual machine image, replace **<vm\_image>.qcow2** with the complete url for the remote image.

- 2 Build and tag the container:

```
$ podman build -t <registry>/<container_disk_name>:latest .
```

- 3 Push the container image to the registry:

```
$ podman push <registry>/<container_disk_name>:latest
```

If your container registry does not have TLS you must add it as an insecure registry before you can import container disks into persistent storage.

### 10.19.15.3. Disabling TLS for a container registry to use as insecure registry

You can disable TLS (transport layer security) for one or more container registries by editing the **insecureRegistries** field of the **HyperConverged** custom resource.

## Prerequisites

- Log in to the cluster as a user with the **cluster-admin** role.

## Procedure

- Edit the **HyperConverged** custom resource and add a list of insecure registries to the **spec.storageImport.insecureRegistries** field.

```

apiVersion: hco.kubevirt.io/v1beta1
kind: HyperConverged
metadata:
  name: kubevirt-hyperconverged
  namespace: openshift-cnv
spec:
  storageImport:
    insecureRegistries: 1
      - "private-registry-example-1:5000"
      - "private-registry-example-2:5000"

```

- 1** Replace the examples in this list with valid registry hostnames.

#### 10.19.15.4. Next steps

- Import the container disk into persistent storage for a virtual machine .
- Create a virtual machine that uses a **containerDisk** volume for ephemeral storage.

#### 10.19.16. Preparing CDI scratch space

##### 10.19.16.1. About data volumes

**DataVolume** objects are custom resources that are provided by the Containerized Data Importer (CDI) project. Data volumes orchestrate import, clone, and upload operations that are associated with an underlying persistent volume claim (PVC). You can create a data volume as either a standalone resource or by using the **dataVolumeTemplate** field in the virtual machine (VM) specification.



##### NOTE

- VM disk PVCs that are prepared by using standalone data volumes maintain an independent lifecycle from the VM. If you use the **dataVolumeTemplate** field in the VM specification to prepare the PVC, the PVC shares the same lifecycle as the VM.

##### 10.19.16.2. About scratch space

The Containerized Data Importer (CDI) requires scratch space (temporary storage) to complete some operations, such as importing and uploading virtual machine images. During this process, CDI provisions a scratch space PVC equal to the size of the PVC backing the destination data volume (DV). The scratch space PVC is deleted after the operation completes or aborts.

You can define the storage class that is used to bind the scratch space PVC in the **spec.scratchSpaceStorageClass** field of the **HyperConverged** custom resource.

If the defined storage class does not match a storage class in the cluster, then the default storage class defined for the cluster is used. If there is no default storage class defined in the cluster, the storage class used to provision the original DV or PVC is used.

**NOTE**

CDI requires requesting scratch space with a **file** volume mode, regardless of the PVC backing the origin data volume. If the origin PVC is backed by **block** volume mode, you must define a storage class capable of provisioning **file** volume mode PVCs.

**Manual provisioning**

If there are no storage classes, CDI uses any PVCs in the project that match the size requirements for the image. If there are no PVCs that match these requirements, the CDI import pod remains in a **Pending** state until an appropriate PVC is made available or until a timeout function kills the pod.

**10.19.16.3. CDI operations that require scratch space**

| Type                                 | Reason                                                                                                                                                                |
|--------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Registry imports                     | CDI must download the image to a scratch space and extract the layers to find the image file. The image file is then passed to QEMU-IMG for conversion to a raw disk. |
| Upload image                         | QEMU-IMG does not accept input from STDIN. Instead, the image to upload is saved in scratch space before it can be passed to QEMU-IMG for conversion.                 |
| HTTP imports of archived images      | QEMU-IMG does not know how to handle the archive formats CDI supports. Instead, the image is unarchived and saved into scratch space before it is passed to QEMU-IMG. |
| HTTP imports of authenticated images | QEMU-IMG inadequately handles authentication. Instead, the image is saved to scratch space and authenticated before it is passed to QEMU-IMG.                         |
| HTTP imports of custom certificates  | QEMU-IMG inadequately handles custom certificates of HTTPS endpoints. Instead, CDI downloads the image to scratch space before passing the file to QEMU-IMG.          |

**10.19.16.4. Defining a storage class**

You can define the storage class that the Containerized Data Importer (CDI) uses when allocating scratch space by adding the **spec.scratchSpaceStorageClass** field to the **HyperConverged** custom resource (CR).

**Prerequisites**

- Install the OpenShift CLI (**oc**).

**Procedure**

1. Edit the **HyperConverged** CR by running the following command:

```
$ oc edit hco -n openshift-cnv kubevirt-hyperconverged
```

- Add the **spec.scratchSpaceStorageClass** field to the CR, setting the value to the name of a storage class that exists in the cluster:

```
apiVersion: hco.kubevirt.io/v1beta1
kind: HyperConverged
metadata:
  name: kubevirt-hyperconverged
spec:
  scratchSpaceStorageClass: "<storage_class>" ①
```

- If you do not specify a storage class, CDI uses the storage class of the persistent volume claim that is being populated.

- Save and exit your default editor to update the **HyperConverged** CR.

#### 10.19.16.5. CDI supported operations matrix

This matrix shows the supported CDI operations for content types against endpoints, and which of these operations requires scratch space.

| Content types       | HTTP                                                                                                                            | HTTPS                                                                                                                             | HTTP basic auth                                                                                                                 | Registry                                                                                                 | Upload                                                                                                                           |
|---------------------|---------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|
| KubeVirt<br>(QCOW2) | <input checked="" type="checkbox"/> QCOW2<br><input checked="" type="checkbox"/> GZ*<br><input checked="" type="checkbox"/> XZ* | <input checked="" type="checkbox"/> QCOW2**<br><input checked="" type="checkbox"/> GZ*<br><input checked="" type="checkbox"/> XZ* | <input checked="" type="checkbox"/> QCOW2<br><input checked="" type="checkbox"/> GZ*<br><input checked="" type="checkbox"/> XZ* | <input checked="" type="checkbox"/> QCOW2*<br><input type="checkbox"/> GZ<br><input type="checkbox"/> XZ | <input checked="" type="checkbox"/> QCOW2*<br><input checked="" type="checkbox"/> GZ*<br><input checked="" type="checkbox"/> XZ* |
| KubeVirt<br>(RAW)   | <input checked="" type="checkbox"/> RAW<br><input checked="" type="checkbox"/> GZ<br><input checked="" type="checkbox"/> XZ     | <input checked="" type="checkbox"/> RAW<br><input checked="" type="checkbox"/> GZ<br><input checked="" type="checkbox"/> XZ       | <input checked="" type="checkbox"/> RAW<br><input checked="" type="checkbox"/> GZ<br><input checked="" type="checkbox"/> XZ     | <input checked="" type="checkbox"/> RAW*<br><input type="checkbox"/> GZ<br><input type="checkbox"/> XZ   | <input checked="" type="checkbox"/> RAW*<br><input checked="" type="checkbox"/> GZ*<br><input checked="" type="checkbox"/> XZ*   |

✓ Supported operation

□ Unsupported operation

\* Requires scratch space

\*\* Requires scratch space if a custom certificate authority is required

#### 10.19.16.6. Additional resources

- [Dynamic provisioning](#)

#### 10.19.17. Re-using persistent volumes

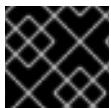
To re-use a statically provisioned persistent volume (PV), you must first reclaim the volume. This involves deleting the PV so that the storage configuration can be re-used.

##### 10.19.17.1. About reclaiming statically provisioned persistent volumes

When you reclaim a persistent volume (PV), you unbind the PV from a persistent volume claim (PVC) and delete the PV. Depending on the underlying storage, you might need to manually delete the shared storage.

You can then re-use the PV configuration to create a PV with a different name.

Statically provisioned PVs must have a reclaim policy of **Retain** to be reclaimed. If they do not, the PV enters a failed state when the PVC is unbound from the PV.



### IMPORTANT

The **Recycle** reclaim policy is deprecated in OpenShift Container Platform 4.

#### 10.19.17.2. Reclaiming statically provisioned persistent volumes

Reclaim a statically provisioned persistent volume (PV) by unbinding the persistent volume claim (PVC) and deleting the PV. You might also need to manually delete the shared storage.

Reclaiming a statically provisioned PV is dependent on the underlying storage. This procedure provides a general approach that might need to be customized depending on your storage.

#### Procedure

1. Ensure that the reclaim policy of the PV is set to **Retain**:

- a. Check the reclaim policy of the PV:

```
$ oc get pv <pv_name> -o yaml | grep 'persistentVolumeReclaimPolicy'
```

- b. If the **persistentVolumeReclaimPolicy** is not set to **Retain**, edit the reclaim policy with the following command:

```
$ oc patch pv <pv_name> -p '{"spec":{"persistentVolumeReclaimPolicy":"Retain"}}'
```

2. Ensure that no resources are using the PV:

```
$ oc describe pvc <pvc_name> | grep 'Mounted By:'
```

Remove any resources that use the PVC before continuing.

3. Delete the PVC to release the PV:

```
$ oc delete pvc <pvc_name>
```

4. Optional: Export the PV configuration to a YAML file. If you manually remove the shared storage later in this procedure, you can refer to this configuration. You can also use **spec** parameters in this file as the basis to create a new PV with the same storage configuration after you reclaim the PV:

```
$ oc get pv <pv_name> -o yaml > <file_name>.yaml
```

5. Delete the PV:

```
$ oc delete pv <pv_name>
```

6. Optional: Depending on the storage type, you might need to remove the contents of the shared storage folder:

```
$ rm -rf <path_to_share_storage>
```

7. Optional: Create a PV that uses the same storage configuration as the deleted PV. If you exported the reclaimed PV configuration earlier, you can use the **spec** parameters of that file as the basis for a new PV manifest:



#### NOTE

To avoid possible conflict, it is good practice to give the new PV object a different name than the one that you deleted.

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

### Additional resources

- [Configuring local storage for virtual machines](#)
- The OpenShift Container Platform Storage documentation has more information on [Persistent Storage](#).

## 10.19.18. Expanding a virtual machine disk

You can enlarge the size of a virtual machine's (VM) disk to provide a greater storage capacity by resizing the disk's persistent volume claim (PVC).

However, you cannot reduce the size of a VM disk.

### 10.19.18.1. Enlarging a virtual machine disk

Virtual machine (VM) disk enlargement makes extra space available to the virtual machine. However, it is the responsibility of the VM owner to decide how to consume the storage.

If the disk is a **Filesystem** PVC, the matching file expands to the remaining size while reserving some space for file system overhead.

#### Procedure

1. Edit the **PersistentVolumeClaim** manifest of the VM disk that you want to expand:

```
$ oc edit pvc <pvc_name>
```

2. Update the disk size:

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: vm-disk-expand
spec:
  accessModes:
```

```
- ReadWriteMany  
resources:  
requests:  
storage: 3Gi ①  
# ...
```

- ① Specify the new disk size.

#### 10.19.18.2. Additional resources

- [Extending a basic volume in Windows](#) .
- [Extending an existing file system partition without destroying data in Red Hat Enterprise Linux](#) .
- [Extending a logical volume and its file system online in Red Hat Enterprise Linux](#) .

# CHAPTER 11. VIRTUAL MACHINE TEMPLATES

## 11.1. CREATING VIRTUAL MACHINE TEMPLATES

### 11.1.1. About virtual machine templates

Preconfigured Red Hat virtual machine templates are listed in the [Virtualization → Templates](#) page. These templates are available for different versions of Red Hat Enterprise Linux, Fedora, Microsoft Windows 10, and Microsoft Windows Servers. Each Red Hat virtual machine template is preconfigured with the operating system image, default settings for the operating system, flavor (CPU and memory), and workload type (server).

The [Templates](#) page displays four types of virtual machine templates:

- **Red Hat Supported** templates are fully supported by Red Hat.
- **User Supported** templates are **Red Hat Supported** templates that were cloned and created by users.
- **Red Hat Provided** templates have limited support from Red Hat.
- **User Provided** templates are **Red Hat Provided** templates that were cloned and created by users.

You can use the filters in the template [Catalog](#) to sort the templates by attributes such as boot source availability, operating system, and workload.

You cannot edit or delete a **Red Hat Supported** or **Red Hat Provided** template. You can clone the template, save it as a custom virtual machine template, and then edit it.

You can also create a custom virtual machine template by editing a YAML file example.

### 11.1.2. About virtual machines and boot sources

Virtual machines consist of a virtual machine definition and one or more disks that are backed by data volumes. Virtual machine templates enable you to create virtual machines using predefined virtual machine specifications.

Every virtual machine template requires a boot source, which is a fully configured virtual machine disk image including configured drivers. Each virtual machine template contains a virtual machine definition with a pointer to the boot source. Each boot source has a predefined name and namespace. For some operating systems, a boot source is automatically provided. If it is not provided, then an administrator must prepare a custom boot source.

Provided boot sources are updated automatically to the latest version of the operating system. For auto-updated boot sources, persistent volume claims (PVCs) are created with the cluster's default storage class. If you select a different default storage class after configuration, you must delete the existing data volumes in the cluster namespace that are configured with the previous default storage class.

To use the boot sources feature, install the latest release of OpenShift Virtualization. The namespace **openshift-virtualization-os-images** enables the feature and is installed with the OpenShift Virtualization Operator. Once the boot source feature is installed, you can create boot sources, attach them to templates, and create virtual machines from the templates.

Define a boot source by using a persistent volume claim (PVC) that is populated by uploading a local file, cloning an existing PVC, importing from a registry, or by URL. Attach a boot source to a virtual machine template by using the web console. After the boot source is attached to a virtual machine template, you create any number of fully configured ready-to-use virtual machines from the template.

### 11.1.3. Creating a virtual machine template in the web console

You create a virtual machine template by editing a YAML file example in the OpenShift Container Platform web console.

#### Procedure

1. In the web console, click **Virtualization** → **Templates** in the side menu.
2. Optional: Use the **Project** drop-down menu to change the project associated with the new template. All templates are saved to the **openshift** project by default.
3. Click **Create Template**.
4. Specify the template parameters by editing the YAML file.
5. Click **Create**.  
The template is displayed on the **Templates** page.
6. Optional: Click **Download** to download and save the YAML file.

### 11.1.4. Adding a boot source for a virtual machine template

A boot source can be configured for any virtual machine template that you want to use for creating virtual machines or custom templates. When virtual machine templates are configured with a boot source, they are labeled **Source available** on the **Templates** page. After you add a boot source to a template, you can create a new virtual machine from the template.

There are four methods for selecting and adding a boot source in the web console:

- **Upload local file (creates PVC)**
- **URL (creates PVC)**
- **Clone (creates PVC)**
- **Registry (creates PVC)**

#### Prerequisites

- To add a boot source, you must be logged in as a user with the **os-images.kubevirt.io:edit** RBAC role or as an administrator. You do not need special privileges to create a virtual machine from a template with a boot source added.
- To upload a local file, the operating system image file must exist on your local machine.
- To import via URL, access to the web server with the operating system image is required. For example: the Red Hat Enterprise Linux web page with images.
- To clone an existing PVC, access to the project with a PVC is required.

- To import via registry, access to the container registry is required.

## Procedure

1. In the OpenShift Container Platform console, click **Virtualization** → **Templates** from the side menu.
2. Click the options menu beside a template and select **Edit boot source**.
3. Click **Add disk**.
4. In the **Add disk** window, select **Use this disk as a boot source**
5. Enter the disk name and select a **Source**, for example, **Blank (creates PVC)**.
6. Enter a value for **Persistent Volume Claim size** to specify the PVC size that is adequate for the uncompressed image and any additional space that is required.
7. Select a **Type**, for example, **Disk**.
8. Optional: Click **Storage class** and select the storage class that is used to create the disk. Typically, this storage class is the default storage class that is created for use by all PVCs.



### NOTE

Provided boot sources are updated automatically to the latest version of the operating system. For auto-updated boot sources, persistent volume claims (PVCs) are created with the cluster's default storage class. If you select a different default storage class after configuration, you must delete the existing data volumes in the cluster namespace that are configured with the previous default storage class.

9. Optional: Clear **Apply optimized StorageProfile settings** to edit the access mode or volume mode.
10. Select the appropriate method to save your boot source:
  - a. Click **Save and upload** if you uploaded a local file.
  - b. Click **Save and import** if you imported content from a URL or the registry.
  - c. Click **Save and clone** if you cloned an existing PVC.

Your custom virtual machine template with a boot source is listed on the **Catalog** page. You can use this template to create a virtual machine.

### 11.1.4.1. Virtual machine template fields for adding a boot source

The following table describes the fields for **Add boot source to template** window. This window displays when you click **Add source** for a virtual machine template on the **Virtualization** → **Templates** page.

| Name | Parameter | Description |
|------|-----------|-------------|
|      |           |             |

| Name                      | Parameter                       | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|---------------------------|---------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Boot source type          | Upload local file (creates PVC) | Upload a file from your local device. Supported file types include gz, xz, tar, and qcow2.                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|                           | URL (creates PVC)               | Import content from an image available from an HTTP or HTTPS endpoint. Obtain the download link URL from the web page where the image download is available and enter that URL link in the <b>Import URL</b> field. Example: For a Red Hat Enterprise Linux image, log on to the Red Hat Customer Portal, access the image download page, and copy the download link URL for the KVM guest image.                                                                                                                                                     |
|                           | PVC (creates PVC)               | Use a PVC that is already available in the cluster and clone it.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|                           | Registry (creates PVC)          | Specify the bootable operating system container that is located in a registry and accessible from the cluster. Example: kubevirt/cirros-registry-dis-demo.                                                                                                                                                                                                                                                                                                                                                                                            |
| Source provider           |                                 | Optional field. Add descriptive text about the source for the template or the name of the user who created the template. Example: Red Hat.                                                                                                                                                                                                                                                                                                                                                                                                            |
| Advanced Storage settings | StorageClass                    | The storage class that is used to create the disk.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|                           | Access mode                     | Access mode of the persistent volume. Supported access modes are <b>Single User (RWO)</b> , <b>Shared Access (RWX)</b> , <b>Read Only (ROX)</b> . If <b>Single User (RWO)</b> is selected, the disk can be mounted as read/write by a single node. If <b>Shared Access (RWX)</b> is selected, the disk can be mounted as read-write by many nodes. The <b>kubevirt-storage-class-defaults</b> config map provides access mode defaults for data volumes. The default value is set according to the best option for each storage class in the cluster. |
|                           |                                 |  <b>NOTE</b><br>Shared Access (RWX) is required for some features, such as live migration of virtual machines between nodes.                                                                                                                                                                                                                                                                                                                                       |

| Name | Parameter   | Description                                                                                                                                                                                                                                                                                                                                        |
|------|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|      | Volume mode | Defines whether the persistent volume uses a formatted file system or raw block state. Supported modes are <b>Block</b> and <b>Filesystem</b> . The <b>kubevirt-storage-class-defaults</b> config map provides volume mode defaults for data volumes. The default value is set according to the best option for each storage class in the cluster. |

### 11.1.5. Additional resources

- [Creating and using boot sources](#)
- [Customizing the storage profile](#)

## 11.2. EDITING VIRTUAL MACHINE TEMPLATES

You can edit a virtual machine template in the web console.



#### NOTE

You cannot edit a template provided by the Red Hat Virtualization Operator. If you clone the template, you can edit it.

### 11.2.1. Editing a virtual machine template in the web console

You can edit a virtual machine template by using the OpenShift Container Platform web console or the command line interface.

Editing a virtual machine template does not affect virtual machines already created from that template.

#### Procedure

1. Navigate to **Virtualization → Templates** in the web console.
2. Click the Options menu beside a virtual machine template and select the object to edit.
3. To edit a Red Hat template, click the Options menu, select **Clone** to create a custom template, and then edit the custom template.



#### NOTE

**Edit boot source reference** is disabled if the template's data source is managed by the **DataImportCron** custom resource or if the template does not have a data volume reference.

4. Click **Save**.

### 11.2.1.1. Adding a network interface to a virtual machine template

Use this procedure to add a network interface to a virtual machine template.

#### Procedure

1. Click **Virtualization → Templates** from the side menu.
2. Select a virtual machine template to open the **Template details** page.
3. On the **Network interfaces** tab, click **Add Network Interface**.
4. In the **Add Network Interface** window, specify the **Name**, **Model**, **Network**, **Type**, and **MAC Address** of the network interface.
5. Click **Add**.

### 11.2.1.2. Adding a virtual disk to a virtual machine template

Use this procedure to add a virtual disk to a virtual machine template.

#### Procedure

1. Click **Virtualization → Templates** from the side menu.
2. Select a virtual machine template to open the **Template details** page.
3. On the **Disk** tab, click **Add disk**.
4. Specify the **Source**, **Name**, **Size**, **Type**, **Interface**, and **Storage Class**.
  - a. Optional: You can enable preallocation if you use a blank disk source and require maximum write performance when creating data volumes. To do so, select the **Enable preallocation** checkbox.
  - b. Optional: You can clear **Apply optimized StorageProfile settings** to change the **Volume Mode** and **Access Mode** for the virtual disk. If you do not specify these parameters, the system uses the default values from the **kubevirt-storage-class-defaults** config map.
5. Click **Add**.

## 11.3. ENABLING DEDICATED RESOURCES FOR VIRTUAL MACHINE TEMPLATES

Virtual machines can have resources of a node, such as CPU, dedicated to them to improve performance.

### 11.3.1. About dedicated resources

When you enable dedicated resources for your virtual machine, your virtual machine's workload is scheduled on CPUs that will not be used by other processes. By using dedicated resources, you can improve the performance of the virtual machine and the accuracy of latency predictions.

### 11.3.2. Prerequisites

- The [CPU Manager](#) must be configured on the node. Verify that the node has the `cpumanager = true` label before scheduling virtual machine workloads.

### 11.3.3. Enabling dedicated resources for a virtual machine template

You enable dedicated resources for a virtual machine template in the **Details** tab. Virtual machines that were created from a Red Hat template can be configured with dedicated resources.

#### Procedure

1. In the OpenShift Container Platform console, click **Virtualization** → **Templates** from the side menu.
2. Select a virtual machine template to open the **Template details** page.
3. On the **Scheduling** tab, click the edit icon beside **Dedicated Resources**.
4. Select **Schedule this workload with dedicated resources (guaranteed policy)**
5. Click **Save**.

## 11.4. DEPLOYING A VIRTUAL MACHINE TEMPLATE TO A CUSTOM NAMESPACE

Red Hat provides preconfigured virtual machine templates that are installed in the `openshift` namespace. The **ssp-operator** deploys virtual machine templates to the `openshift` namespace by default. Templates in the `openshift` namespace are publicly available to all users. These templates are listed on the **Virtualization** → **Templates** page for different operating systems.

### 11.4.1. Creating a custom namespace for templates

You can create a custom namespace that is used to deploy virtual machine templates for use by anyone who has permissions to access those templates. To add templates to a custom namespace, edit the **HyperConverged** custom resource (CR), add **commonTemplatesNamespace** to the spec, and specify the custom namespace for the virtual machine templates. After the **HyperConverged** CR is modified, the **ssp-operator** populates the templates in the custom namespace.

#### Prerequisites

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

#### Procedure

- Use the following command to create your custom namespace:

```
$ oc create namespace <mycustomnamespace>
```

### 11.4.2. Adding templates to a custom namespace

The **ssp-operator** deploys virtual machine templates to the `openshift` namespace by default. Templates in the `openshift` namespace are publicly available to all users. When a custom namespace is

created and templates are added to that namespace, you can modify or delete virtual machine templates in the **openshift** namespace. To add templates to a custom namespace, edit the **HyperConverged** custom resource (CR) which contains the **ssp-operator**.

### Procedure

- View the list of virtual machine templates that are available in the **openshift** namespace.

```
$ oc get templates -n openshift
```

- Edit the **HyperConverged** CR in your default editor by running the following command:

```
$ oc edit hco -n openshift-cnv kubevirt-hyperconverged
```

- View the list of virtual machine templates that are available in the custom namespace.

```
$ oc get templates -n customnamespace
```

- Add the **commonTemplatesNamespace** attribute and specify the custom namespace.  
Example:

```
apiVersion: hco.kubevirt.io/v1beta1
kind: HyperConverged
metadata:
  name: kubevirt-hyperconverged
spec:
  commonTemplatesNamespace: customnamespace ①
```

① The custom namespace for deploying templates.

- Save your changes and exit the editor. The **ssp-operator** adds virtual machine templates that exist in the default **openshift** namespace to the custom namespace.

#### 11.4.2.1. Deleting templates from a custom namespace

To delete virtual machine templates from a custom namespace, remove the **commonTemplateNamespace** attribute from the **HyperConverged** custom resource (CR) and delete each template from that custom namespace.

### Procedure

- Edit the **HyperConverged** CR in your default editor by running the following command:

```
$ oc edit hco -n openshift-cnv kubevirt-hyperconverged
```

- Remove the **commonTemplateNamespace** attribute.

```
apiVersion: hco.kubevirt.io/v1beta1
kind: HyperConverged
metadata:
```

```

name: kubevirt-hyperconverged
spec:
  commonTemplatesNamespace: customnamespace ①

```

- ① The **commonTemplatesNamespace** attribute to be deleted.

3. Delete a specific template from the custom namespace that was removed.

```
$ oc delete templates -n customnamespace <template_name>
```

## Verification

- Verify that the template was deleted from the custom namespace.

```
$ oc get templates -n customnamespace
```

### 11.4.2.2. Additional resources

- [Creating virtual machine templates](#)

## 11.5. DELETING VIRTUAL MACHINE TEMPLATES

You can delete customized virtual machine templates based on Red Hat templates by using the web console.

You cannot delete Red Hat templates.

### 11.5.1. Deleting a virtual machine template in the web console

Deleting a virtual machine template permanently removes it from the cluster.



#### NOTE

You can delete customized virtual machine templates. You cannot delete Red Hat-supplied templates.

#### Procedure

1. In the OpenShift Container Platform console, click **Virtualization** → **Templates** from the side menu.
2. Click the Options menu of a template and select **Delete template**.
3. Click **Delete**.

## 11.6. CREATING AND USING BOOT SOURCES

A boot source contains a bootable operating system (OS) and all of the configuration settings for the OS, such as drivers.

You use a boot source to create virtual machine templates with specific configurations. These templates can be used to create any number of available virtual machines.

Quick Start tours are available in the OpenShift Container Platform web console to assist you in creating a custom boot source, uploading a boot source, and other tasks. Select **Quick Starts** from the **Help** menu to view the Quick Start tours.

### 11.6.1. About virtual machines and boot sources

Virtual machines consist of a virtual machine definition and one or more disks that are backed by data volumes. Virtual machine templates enable you to create virtual machines using predefined virtual machine specifications.

Every virtual machine template requires a boot source, which is a fully configured virtual machine disk image including configured drivers. Each virtual machine template contains a virtual machine definition with a pointer to the boot source. Each boot source has a predefined name and namespace. For some operating systems, a boot source is automatically provided. If it is not provided, then an administrator must prepare a custom boot source.

Provided boot sources are updated automatically to the latest version of the operating system. For auto-updated boot sources, persistent volume claims (PVCs) are created with the cluster’s default storage class. If you select a different default storage class after configuration, you must delete the existing data volumes in the cluster namespace that are configured with the previous default storage class.

To use the boot sources feature, install the latest release of OpenShift Virtualization. The namespace **openshift-virtualization-os-images** enables the feature and is installed with the OpenShift Virtualization Operator. Once the boot source feature is installed, you can create boot sources, attach them to templates, and create virtual machines from the templates.

Define a boot source by using a persistent volume claim (PVC) that is populated by uploading a local file, cloning an existing PVC, importing from a registry, or by URL. Attach a boot source to a virtual machine template by using the web console. After the boot source is attached to a virtual machine template, you create any number of fully configured ready-to-use virtual machines from the template.

### 11.6.2. Importing a RHEL image as a boot source

You can import a Red Hat Enterprise Linux (RHEL) image as a boot source by specifying a URL for the image.

#### Prerequisites

- You must have access to a web page with the operating system image. For example: Download Red Hat Enterprise Linux web page with images.

#### Procedure

1. In the OpenShift Container Platform console, click **Virtualization** → **Templates** from the side menu.
2. Identify the RHEL template for which you want to configure a boot source and click **Add source**.
3. In the **Add boot source to template** window, select **URL (creates PVC)** from the **Boot source type** list.

4. Click **RHEL download page** to access the Red Hat Customer Portal. A list of available installers and images is displayed on the Download Red Hat Enterprise Linux page.
5. Identify the Red Hat Enterprise Linux KVM guest image that you want to download. Right-click **Download Now**, and copy the URL for the image.
6. In the **Add boot source to template** window, paste the URL into the **Import URL** field, and click **Save and import**.

## Verification

1. Verify that the template displays a green checkmark in the **Boot source** column on the **Templates** page.

You can now use this template to create RHEL virtual machines.

### 11.6.3. Adding a boot source for a virtual machine template

A boot source can be configured for any virtual machine template that you want to use for creating virtual machines or custom templates. When virtual machine templates are configured with a boot source, they are labeled **Source available** on the **Templates** page. After you add a boot source to a template, you can create a new virtual machine from the template.

There are four methods for selecting and adding a boot source in the web console:

- **Upload local file (creates PVC)**
- **URL (creates PVC)**
- **Clone (creates PVC)**
- **Registry (creates PVC)**

## Prerequisites

- To add a boot source, you must be logged in as a user with the **os-images.kubevirt.io:edit** RBAC role or as an administrator. You do not need special privileges to create a virtual machine from a template with a boot source added.
- To upload a local file, the operating system image file must exist on your local machine.
- To import via URL, access to the web server with the operating system image is required. For example: the Red Hat Enterprise Linux web page with images.
- To clone an existing PVC, access to the project with a PVC is required.
- To import via registry, access to the container registry is required.

## Procedure

1. In the OpenShift Container Platform console, click **Virtualization** → **Templates** from the side menu.
2. Click the options menu beside a template and select **Edit boot source**.
3. Click **Add disk**.

4. In the **Add disk** window, select **Use this disk as a boot source**
5. Enter the disk name and select a **Source**, for example, **Blank (creates PVC)**.
6. Enter a value for **Persistent Volume Claim size** to specify the PVC size that is adequate for the uncompressed image and any additional space that is required.
7. Select a **Type**, for example, **Disk**.
8. Optional: Click **Storage class** and select the storage class that is used to create the disk. Typically, this storage class is the default storage class that is created for use by all PVCs.



#### NOTE

Provided boot sources are updated automatically to the latest version of the operating system. For auto-updated boot sources, persistent volume claims (PVCs) are created with the cluster's default storage class. If you select a different default storage class after configuration, you must delete the existing data volumes in the cluster namespace that are configured with the previous default storage class.

9. Optional: Clear **Apply optimized StorageProfile settings** to edit the access mode or volume mode.
10. Select the appropriate method to save your boot source:
  - a. Click **Save and upload** if you uploaded a local file.
  - b. Click **Save and import** if you imported content from a URL or the registry.
  - c. Click **Save and clone** if you cloned an existing PVC.

Your custom virtual machine template with a boot source is listed on the **Catalog** page. You can use this template to create a virtual machine.

#### 11.6.4. Creating a virtual machine from a template with an attached boot source

After you add a boot source to a template, you can create a virtual machine from the template.

##### Procedure

1. In the OpenShift Container Platform web console, click **Virtualization** → **Catalog** in the side menu.
2. Select the updated template and click **Quick create VirtualMachine**.

The **VirtualMachine details** is displayed with the status **Starting**.

#### 11.6.5. Additional resources

- [Creating virtual machine templates](#)
- [Managing automatic boot source updates](#)

### 11.7. MANAGING AUTOMATIC BOOT SOURCE UPDATES

Manage automatic boot source updates.

### 11.7.1. About automatic boot source updates

Boot sources can make virtual machine (VM) creation more accessible and efficient for users. If automatic boot source updates are enabled, the Containerized Data Importer (CDI) imports, polls, and updates the images so that they are ready to be cloned for new VMs. By default, CDI automatically updates the system-defined boot sources that OpenShift Virtualization provides.

You can opt out of automatic updates for all system-defined boot sources by disabling the **enableCommonBootImageImport** feature gate. If you disable this feature gate, all **DataImportCron** objects are deleted. This does not remove previously imported **PersistentVolumeClaim** (PVC) objects that store operating system images, though administrators can delete them manually.

When the **enableCommonBootImageImport** feature gate is disabled, **DataSource** objects are reset so that they no longer point to the original PVCs. An administrator can manually provide a boot source by creating a new PVC for the **DataSource** object and populating the PVC with an operating system image.

*Custom* boot sources that are not provided by OpenShift Virtualization are not controlled by the feature gate. You must manage them individually by editing the **HyperConverged** custom resource (CR). You can also use this method to manage individual system-defined boot sources.

### 11.7.2. Enable or disable automatic updates for all system boot sources

Control automatic updates for all system-defined boot sources by using the feature gate.

#### 11.7.2.1. Managing automatic updates for all system-defined boot sources

Disabling automatic boot source imports and updates can lower resource usage. In disconnected environments, disabling automatic boot source updates prevents **CDIDataImportCronOutdated** alerts from filling up logs.

To disable automatic updates for all system-defined boot sources, turn off the **enableCommonBootImageImport** feature gate by setting the value to **false**. Setting this value to **true** re-enables the feature gate and turns automatic updates back on.



#### NOTE

Custom boot sources are not affected by this setting.

#### Procedure

- Toggle the feature gate for automatic boot source updates by editing the **HyperConverged** custom resource (CR).
  - To disable automatic boot source updates, set the **spec.featureGates.enableCommonBootImageImport** field in the **HyperConverged** CR to **false**. For example:

```
$ oc patch hco kubevirt-hyperconverged -n openshift-cnv \
--type json -p '[{"op": "replace", "path": \
"/spec/featureGates/enableCommonBootImageImport", \
"value": false}]'
```

- To re-enable automatic boot source updates, set the **spec.featureGates.enableCommonBootImageImport** field in the **HyperConverged** CR to **true**. For example:

```
$ oc patch hco kubevirt-hyperconverged -n openshift-cnv \
--type json -p '[{"op": "replace", "path": \
"/spec/featureGates/enableCommonBootImageImport", \
"value": true}]'
```

## 11.7.3. Enable automatic updates for custom boot sources

Ensure that your cluster has a default storage class. Then, enable automatic updates for custom boot sources.

### 11.7.3.1. Configuring a storage class for custom boot source updates

Specify a new default storage class in the **HyperConverged** custom resource (CR).



#### IMPORTANT

Boot sources are created from storage using the default storage class. If your cluster does not have a default storage class, you must define one before configuring automatic updates for custom boot sources.

#### Procedure

1. Open the **HyperConverged** CR in your default editor by running the following command:

```
$ oc edit hco -n openshift-cnv kubevirt-hyperconverged
```

2. Define a new storage class by entering a value in the **storageClassName** field:

```
apiVersion: hco.kubevirt.io/v1beta1
kind: HyperConverged
metadata:
  name: kubevirt-hyperconverged
spec:
  dataImportCronTemplates:
  - metadata:
      name: rhel8-image-cron
    spec:
      template:
        spec:
          storageClassName: <new_storage_class> ①
#...
```

- 1 Define the storage class.

3. Remove the **storageclass.kubernetes.io/is-default-class** annotation from the current default storage class.
  - a. Retrieve the name of the current default storage class by running the following command:

```
$ oc get sc
```

### Example output

```
NAME PROVISIONER RECLAIMPOLICY VOLUMEBINDINGMODE
ALLOWVOLUMEEXPANSION AGE
csi-manila-ceph manila.csi.openstack.org Delete Immediate false 11d
hostpath-csi-basic (default) kubevirt.io.hostpath-provisioner Delete
WaitForFirstConsumer false 11d ①
...

```

- 1 In this example, the current default storage class is named **hostpath-csi-basic**.
- b. Remove the annotation from the current default storage class by running the following command:
 

```
$ oc patch storageclass <current_default_storage_class> -p '{"metadata": {"annotations": {"storageclass.kubernetes.io/is-default-class":"false"}}}' ①
```
- 1 Replace **<current\_default\_storage\_class>** with the **storageClassName** value of the default storage class.
- 4 Set the new storage class as the default by running the following command:
 

```
$ oc patch storageclass <new_storage_class> -p '{"metadata": {"annotations": {"storageclass.kubernetes.io/is-default-class":"true"}}}' ①
```
- 1 Replace **<new\_storage\_class>** with the **storageClassName** value that you added to the **HyperConverged** CR.

#### 11.7.3.2. Enabling automatic updates for custom boot sources

OpenShift Virtualization automatically updates system-defined boot sources by default, but does not automatically update custom boot sources. You must manually enable automatic updates by editing the **HyperConverged** custom resource (CR).

##### Prerequisites

- The cluster has a default storage class.

##### Procedure

- 1 Open the **HyperConverged** CR in your default editor by running the following command:
 

```
$ oc edit hyperconverged kubevirt-hyperconverged -n openshift-cnv
```
- 2 Edit the **HyperConverged** CR, adding the appropriate template and boot source in the **dataImportCronTemplates** section. For example:

##### Example custom resource

```

apiVersion: hco.kubevirt.io/v1beta1
kind: HyperConverged
metadata:
  name: kubevirt-hyperconverged
spec:
  dataImportCronTemplates:
    - metadata:
        name: centos7-image-cron
        annotations:
          cdi.kubevirt.io/storage.bind.immediate.requested: "true" 1
    spec:
      schedule: "0 */12 * * *" 2
      template:
        spec:
          source:
            registry: 3
            url: docker://quay.io/containerdisks/centos:7-2009
          storage:
            resources:
              requests:
                storage: 10Gi
            managedDataSource: centos7 4
            retentionPolicy: "None" 5

```

- 1** This annotation is required for storage classes with **volumeBindingMode** set to **WaitForFirstConsumer**.
- 2** Schedule for the job specified in cron format.
- 3** Use to create a data volume from a registry source. Use the default **pod pullMethod** and not **node pullMethod**, which is based on the **node** docker cache. The **node** docker cache is useful when a registry image is available via **Container.Image**, but the CDI importer is not authorized to access it.
- 4** For the custom image to be detected as an available boot source, the name of the image's **managedDataSource** must match the name of the template's **DataSource**, which is found under **spec.dataVolumeTemplates.spec.sourceRef.name** in the VM template YAML file.
- 5** Use **All** to retain data volumes and data sources when the cron job is deleted. Use **None** to delete data volumes and data sources when the cron job is deleted.

3. Save the file.

#### 11.7.4. Disable automatic updates for a specific boot source

Disable automatic updates for individual boot sources.

##### 11.7.4.1. Disabling automatic updates for a single boot source

You can disable automatic updates for an individual boot source, whether it is custom or system-defined, by editing the **HyperConverged** custom resource (CR).

#### Procedure

1. Open the **HyperConverged** CR in your default editor by running the following command:

```
$ oc edit hyperconverged kubevirt-hyperconverged -n openshift-cnv
```

2. Disable automatic updates for an individual boot source by editing the **spec.dataImportCronTemplates** field.

#### Custom boot source

- Remove the boot source from the **spec.dataImportCronTemplates** field. Automatic updates are disabled for custom boot sources by default.

#### System-defined boot source

- a. Add the boot source to **spec.dataImportCronTemplates**.



#### NOTE

Automatic updates are enabled by default for system-defined boot sources, but these boot sources are not listed in the CR unless you add them.

- b. Set the value of the **dataimportcrontemplate.kubevirt.io/enable** annotation to **false**. For example:

```
apiVersion: hco.kubevirt.io/v1beta1
kind: HyperConverged
metadata:
  name: kubevirt-hyperconverged
spec:
  dataImportCronTemplates:
    - metadata:
        annotations:
          dataimportcrontemplate.kubevirt.io/enable: false
        name: rhel8-image-cron
    # ...
```

3. Save the file.

### 11.7.5. Verifying the status of a boot source

You can determine if a boot source is system-defined or custom by viewing the **HyperConverged** custom resource (CR).

#### Procedure

1. View the contents of the **HyperConverged** CR by running the following command:

```
$ oc get hco -n openshift-cnv kubevirt-hyperconverged -o yaml
```

#### Example output

```

apiVersion: hco.kubevirt.io/v1beta1
kind: HyperConverged
metadata:
  name: kubevirt-hyperconverged
spec:
# ...
status:
# ...
  dataImportCronTemplates:
    - metadata:
        annotations:
          cdi.kubevirt.io/storage.bind.immediate.requested: "true"
        name: centos-7-image-cron
      spec:
        garbageCollect: Outdated
        managedDataSource: centos7
        schedule: 55 8/12 * * *
        template:
          metadata: {}
          spec:
            source:
              registry:
                url: docker://quay.io/containerdisks/centos:7-2009
            storage:
              resources:
                requests:
                  storage: 30Gi
            status: {}
          status:
            commonTemplate: true ①
# ...
    - metadata:
        annotations:
          cdi.kubevirt.io/storage.bind.immediate.requested: "true"
        name: user-defined-dic
      spec:
        garbageCollect: Outdated
        managedDataSource: user-defined-centos-stream8
        schedule: 55 8/12 * * *
        template:
          metadata: {}
          spec:
            source:
              registry:
                pullMethod: node
                url: docker://quay.io/containerdisks/centos-stream:8
            storage:
              resources:
                requests:
                  storage: 30Gi
            status: {}
          status: {} ②
# ...

```

① Indicates a system-defined boot source.

2 Indicates a custom boot source.

2. Verify the status of the boot source by reviewing the **status.dataImportCronTemplates.status** field.

- If the field contains **commonTemplate: true**, it is a system-defined boot source.
- If the **status.dataImportCronTemplates.status** field has the value **{}**, it is a custom boot source.

# CHAPTER 12. LIVE MIGRATION

## 12.1. VIRTUAL MACHINE LIVE MIGRATION

### 12.1.1. About live migration

Live migration is the process of moving a running virtual machine instance (VMI) to another node in the cluster without interrupting the virtual workload or access. If a VMI uses the **LiveMigrate** eviction strategy, it automatically migrates when the node that the VMI runs on is placed into maintenance mode. You can also manually start live migration by selecting a VMI to migrate.

You can use live migration if the following conditions are met:

- Shared storage with **ReadWriteMany** (RWX) access mode.
- Sufficient RAM and network bandwidth.
- If the virtual machine uses a host model CPU, the nodes must support the virtual machine's host model CPU.

By default, live migration traffic is encrypted using Transport Layer Security (TLS).

### 12.1.2. Additional resources

- [Migrating a virtual machine instance to another node](#)
- [Live migration metrics](#)
- [Live migration limiting](#)
- [Customizing the storage profile](#)
- [VM migration tuning](#)

## 12.2. LIVE MIGRATION LIMITS AND TIMEOUTS

Apply live migration limits and timeouts so that migration processes do not overwhelm the cluster. Configure these settings by editing the **HyperConverged** custom resource (CR).

### 12.2.1. Configuring live migration limits and timeouts

Configure live migration limits and timeouts for the cluster by updating the **HyperConverged** custom resource (CR), which is located in the **openshift-cnv** namespace.

#### Procedure

- Edit the **HyperConverged** CR and add the necessary live migration parameters.

```
$ oc edit hco -n openshift-cnv kubevirt-hyperconverged
```

#### Example configuration file

```
apiVersion: hco.kubevirt.io/v1beta1
```

```

kind: HyperConverged
metadata:
  name: kubevirt-hyperconverged
  namespace: openshift-cnv
spec:
  liveMigrationConfig: ①
    bandwidthPerMigration: 64Mi
    completionTimeoutPerGiB: 800
    parallelMigrationsPerCluster: 5
    parallelOutboundMigrationsPerNode: 2
    progressTimeout: 150

```

- ① In this example, the `spec.liveMigrationConfig` array contains the default values for each field.



#### NOTE

You can restore the default value for any `spec.liveMigrationConfig` field by deleting that key/value pair and saving the file. For example, delete `progressTimeout: <value>` to restore the default `progressTimeout: 150`.

### 12.2.2. Cluster-wide live migration limits and timeouts

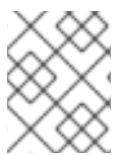
Table 12.1. Migration parameters

| Parameter                                      | Description                                                                                                                                                                                                                                                                                                                                   | Default |
|------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| <code>parallelMigrationsPerCluster</code>      | Number of migrations running in parallel in the cluster.                                                                                                                                                                                                                                                                                      | 5       |
| <code>parallelOutboundMigrationsPerNode</code> | Maximum number of outbound migrations per node.                                                                                                                                                                                                                                                                                               | 2       |
| <code>bandwidthPerMigration</code>             | Bandwidth limit of each migration, in MiB/s.                                                                                                                                                                                                                                                                                                  | 0 [1]   |
| <code>completionTimeoutPerGiB</code>           | The migration is canceled if it has not completed in this time, in seconds per GiB of memory. For example, a virtual machine instance with 6GiB memory times out if it has not completed migration in 4800 seconds. If the <b>Migration Method</b> is <b>BlockMigration</b> , the size of the migrating disks is included in the calculation. | 800     |
| <code>progressTimeout</code>                   | The migration is canceled if memory copy fails to make progress in this time, in seconds.                                                                                                                                                                                                                                                     | 150     |

1. The default value of **0** is unlimited.

### 12.3. MIGRATING A VIRTUAL MACHINE INSTANCE TO ANOTHER NODE

Manually initiate a live migration of a virtual machine instance to another node using either the web console or the CLI.



#### NOTE

If a virtual machine uses a host model CPU, you can perform live migration of that virtual machine only between nodes that support its host CPU model.

### 12.3.1. Initiating live migration of a virtual machine instance in the web console

Migrate a running virtual machine instance to a different node in the cluster.



#### NOTE

The **Migrate** action is visible to all users but only admin users can initiate a virtual machine migration.

#### Procedure

1. In the OpenShift Container Platform console, click **Virtualization** → **VirtualMachines** from the side menu.
2. You can initiate the migration from this page, which makes it easier to perform actions on multiple virtual machines on the same page, or from the **VirtualMachine details** page where you can view comprehensive details of the selected virtual machine:
  - Click the Options menu  next to the virtual machine and select **Migrate**.
  - Click the virtual machine name to open the **VirtualMachine details** page and click **Actions** → **Migrate**.
3. Click **Migrate** to migrate the virtual machine to another node.

#### 12.3.1.1. Monitoring live migration by using the web console

You can monitor the progress of all live migrations on the [Overview](#) → **Migrations** tab in the web console.

You can view the migration metrics of a virtual machine on the [VirtualMachine details](#) → **Metrics** tab in the web console.

### 12.3.2. Initiating live migration of a virtual machine instance in the CLI

Initiate a live migration of a running virtual machine instance by creating a **VirtualMachineInstanceMigration** object in the cluster and referencing the name of the virtual machine instance.

#### Procedure

1. Create a **VirtualMachineInstanceMigration** configuration file for the virtual machine instance to migrate. For example, **vmi-migrate.yaml**:
 

```
apiVersion: kubevirt.io/v1
```

```

kind: VirtualMachineInstanceMigration
metadata:
  name: migration-job
spec:
  vmiName: vmi-fedora

```

2. Create the object in the cluster by running the following command:

```
$ oc create -f vmi-migrate.yaml
```

The **VirtualMachineInstanceMigration** object triggers a live migration of the virtual machine instance. This object exists in the cluster for as long as the virtual machine instance is running, unless manually deleted.

### 12.3.2.1. Monitoring live migration of a virtual machine instance in the CLI

The status of the virtual machine migration is stored in the **Status** component of the **VirtualMachineInstance** configuration.

#### Procedure

- Use the **oc describe** command on the migrating virtual machine instance:

```
$ oc describe vmi vmi-fedora
```

#### Example output

```

# ...
Status:
Conditions:
  Last Probe Time:      <nil>
  Last Transition Time: <nil>
  Status:              True
  Type:                LiveMigratable
Migration Method:  LiveMigration
Migration State:
  Completed:           true
  End Timestamp:       2018-12-24T06:19:42Z
  Migration UID:       d78c8962-0743-11e9-a540-fa163e0c69f1
  Source Node:          node2.example.com
  Start Timestamp:      2018-12-24T06:19:35Z
  Target Node:          node1.example.com
  Target Node Address:  10.9.0.18:43891
  Target Node Domain Detected: true

```

### 12.3.3. Additional resources

- [Cancelling the live migration of a virtual machine instance](#)

## 12.4. MIGRATING A VIRTUAL MACHINE OVER A DEDICATED ADDITIONAL NETWORK

You can configure a dedicated [Multus network](#) for live migration. A dedicated network minimizes the effects of network saturation on tenant workloads during live migration.

### 12.4.1. Configuring a dedicated secondary network for virtual machine live migration

To configure a dedicated secondary network for live migration, you must first create a bridge network attachment definition for the `openshift-cnv` namespace by using the CLI. Then, add the name of the `NetworkAttachmentDefinition` object to the `HyperConverged` custom resource (CR).

#### Prerequisites

- You installed the OpenShift CLI (`oc`).
- You logged in to the cluster as a user with the `cluster-admin` role.
- The Multus Container Network Interface (CNI) plugin is installed on the cluster.
- Every node on the cluster has at least two Network Interface Cards (NICs), and the NICs to be used for live migration are connected to the same VLAN.
- The virtual machine (VM) is running with the `LiveMigrate` eviction strategy.

#### Procedure

1. Create a `NetworkAttachmentDefinition` manifest.

#### Example configuration file

```
apiVersion: "k8s.cni.cncf.io/v1"
kind: NetworkAttachmentDefinition
metadata:
  name: my-secondary-network 1
  namespace: openshift-cnv 2
spec:
  config: {
    "cniVersion": "0.3.1",
    "name": "migration-bridge",
    "type": "macvlan",
    "master": "eth1", 3
    "mode": "bridge",
    "ipam": {
      "type": "whereabouts", 4
      "range": "10.200.5.0/24" 5
    }
  }
```

- 1** The name of the `NetworkAttachmentDefinition` object.
- 2** The namespace where the `NetworkAttachmentDefinition` object resides. This must be `openshift-cnv`.
- 3** The name of the NIC to be used for live migration.
- 4** The name of the CNI plugin that provides the network for this network attachment definition.

- 5** The IP address range for the secondary network. This range must not have any overlap with the IP addresses of the main network.

2. Open the **HyperConverged** CR in your default editor by running the following command:

```
oc edit hyperconverged kubevirt-hyperconverged -n openshift-cnv
```

3. Add the name of the **NetworkAttachmentDefinition** object to the **spec.liveMigrationConfig** stanza of the **HyperConverged** CR. For example:

#### Example configuration file

```
apiVersion: hco.kubevirt.io/v1beta1
kind: HyperConverged
metadata:
  name: kubevirt-hyperconverged
spec:
  liveMigrationConfig:
    completionTimeoutPerGiB: 800
    network: my-secondary-network 1
    parallelMigrationsPerCluster: 5
    parallelOutboundMigrationsPerNode: 2
    progressTimeout: 150
# ...
```

- 1** The name of the Multus **NetworkAttachmentDefinition** object to be used for live migrations.

4. Save your changes and exit the editor. The **virt-handler** pods restart and connect to the secondary network.

#### Verification

- When the node that the virtual machine runs on is placed into maintenance mode, the VM automatically migrates to another node in the cluster. You can verify that the migration occurred over the secondary network and not the default pod network by checking the target IP address in the virtual machine instance (VMI) metadata.

```
oc get vmi <vmi_name> -o jsonpath='{.status.migrationState.targetNodeAddress}'
```

#### 12.4.2. Selecting a dedicated network by using the web console

You can select a dedicated network for live migration by using the OpenShift Container Platform web console.

##### Prerequisites

- You configured a Multus network for live migration.

##### Procedure

- Navigate to **Virtualization > Overview** in the OpenShift Container Platform web console.

2. Click the **Settings** tab and then click **Live migration**.
3. Select the network from the **Live migration network** list.

### 12.4.3. Additional resources

- [Live migration limits and timeouts](#)

## 12.5. CANCELLING THE LIVE MIGRATION OF A VIRTUAL MACHINE INSTANCE

Cancel the live migration so that the virtual machine instance remains on the original node.

You can cancel a live migration from either the web console or the CLI.

### 12.5.1. Cancelling live migration of a virtual machine instance in the web console

You can cancel the live migration of a virtual machine instance in the web console.

#### Procedure

1. In the OpenShift Container Platform console, click **Virtualization** → **VirtualMachines** from the side menu.
2. Click the Options menu  beside a virtual machine and select **Cancel Migration**.

### 12.5.2. Cancelling live migration of a virtual machine instance in the CLI

Cancel the live migration of a virtual machine instance by deleting the **VirtualMachineInstanceMigration** object associated with the migration.

#### Procedure

- Delete the **VirtualMachineInstanceMigration** object that triggered the live migration, **migration-job** in this example:

```
$ oc delete vmim migration-job
```

## 12.6. CONFIGURING VIRTUAL MACHINE EVICTION STRATEGY

The **LiveMigrate** eviction strategy ensures that a virtual machine instance is not interrupted if the node is placed into maintenance or drained. Virtual machines instances with this eviction strategy will be live migrated to another node.

### 12.6.1. Configuring custom virtual machines with the LiveMigration eviction strategy

You only need to configure the **LiveMigration** eviction strategy on custom virtual machines. Common templates have this eviction strategy configured by default.

#### Procedure

- Add the **evictionStrategy: LiveMigrate** option to the **spec.template.spec** section in the virtual machine configuration file. This example uses **oc edit** to update the relevant snippet of the **VirtualMachine** configuration file:

```
$ oc edit vm <custom-vm> -n <my-namespace>
```

```
apiVersion: kubevirt.io/v1
kind: VirtualMachine
metadata:
  name: custom-vm
spec:
  template:
    spec:
      evictionStrategy: LiveMigrate
# ...
```

- Restart the virtual machine for the update to take effect:

```
$ virtctl restart <custom-vm> -n <my-namespace>
```

## 12.7. CONFIGURING LIVE MIGRATION POLICIES

You can define different migration configurations for specified groups of virtual machine instances (VMIs) by using a live migration policy.



### IMPORTANT

Live migration policy 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](#).

To configure a live migration policy by using the web console, see the [MigrationPolicies page documentation](#).

### 12.7.1. Configuring a live migration policy from the command line

Use the **MigrationPolicy** custom resource definition (CRD) to define migration policies for one or more groups of selected virtual machine instances (VMIs).

You can specify groups of VMIs by using any combination of the following:

- Virtual machine instance labels such as **size**, **os**, **gpu**, and other VMI labels.
- Namespace labels such as **priority**, **bandwidth**, **hpc-workload**, and other namespace labels.

For the policy to apply to a specific group of VMIs, all labels on the group of VMIs must match the labels in the policy.



## NOTE

If multiple live migration policies apply to a VMI, the policy with the highest number of matching labels takes precedence. If multiple policies meet this criteria, the policies are sorted by lexicographic order of the matching labels keys, and the first one in that order takes precedence.

### Procedure

- 1 Create a **MigrationPolicy** CRD for your specified group of VMIs. The following example YAML configures a group with the labels **hpc-workloads:true**, **xyz-workloads-type:""**, **workload-type: db**, and **operating-system: ""**:

```
apiVersion: migrations.kubevirt.io/v1beta1
kind: MigrationPolicy
metadata:
  name: my-awesome-policy
spec:
  # Migration Configuration
  allowAutoConverge: true
  bandwidthPerMigration: 217Ki
  completionTimeoutPerGiB: 23
  allowPostCopy: false

  # Matching to VMIs
  selectors:
    namespaceSelector: ①
      hpc-workloads: "True"
      xyz-workloads-type: ""
    virtualMachineInstanceSelector: ②
      workload-type: "db"
      operating-system: ""
```

- 1 Use **namespaceSelector** to define a group of VMIs by using namespace labels.
- 2 Use **virtualMachineInstanceSelector** to define a group of VMIs by using VMI labels.

# CHAPTER 13. NODE MAINTENANCE

## 13.1. ABOUT NODE MAINTENANCE

### 13.1.1. About node maintenance mode

Nodes can be placed into maintenance mode using the **oc adm** utility, or using **NodeMaintenance** custom resources (CRs).



#### NOTE

The **node-maintenance-operator** (NMO) is no longer shipped with OpenShift Virtualization. It is now available to deploy as a standalone Operator from the **OperatorHub** in the OpenShift Container Platform web console, or by using the OpenShift CLI (**oc**).

Placing a node into maintenance marks the node as unschedulable and drains all the virtual machines and pods from it. Virtual machine instances that have a **LiveMigrate** eviction strategy are live migrated to another node without loss of service. This eviction strategy is configured by default in virtual machine created from common templates but must be configured manually for custom virtual machines.

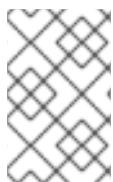
Virtual machine instances without an eviction strategy are shut down. Virtual machines with a **RunStrategy** of **Running** or **RerunOnFailure** are recreated on another node. Virtual machines with a **RunStrategy** of **Manual** are not automatically restarted.



#### IMPORTANT

Virtual machines must have a persistent volume claim (PVC) with a shared **ReadWriteMany** (RWX) access mode to be live migrated.

The Node Maintenance Operator watches for new or deleted **NodeMaintenance** CRs. When a new **NodeMaintenance** CR is detected, no new workloads are scheduled and the node is cordoned off from the rest of the cluster. All pods that can be evicted are evicted from the node. When a **NodeMaintenance** CR is deleted, the node that is referenced in the CR is made available for new workloads.



#### NOTE

Using a **NodeMaintenance** CR for node maintenance tasks achieves the same results as the **oc adm cordon** and **oc adm drain** commands using standard OpenShift Container Platform custom resource processing.

### 13.1.2. Maintaining bare metal nodes

When you deploy OpenShift Container Platform on bare metal infrastructure, there are additional considerations that must be taken into account compared to deploying on cloud infrastructure. Unlike in cloud environments where the cluster nodes are considered ephemeral, re-provisioning a bare metal node requires significantly more time and effort for maintenance tasks.

When a bare metal node fails, for example, if a fatal kernel error happens or a NIC card hardware failure occurs, workloads on the failed node need to be restarted elsewhere else on the cluster while the problem node is repaired or replaced. Node maintenance mode allows cluster administrators to

gracefully power down nodes, moving workloads to other parts of the cluster and ensuring workloads do not get interrupted. Detailed progress and node status details are provided during maintenance.

### 13.1.3. Additional resources

- [Installing the Node Maintenance Operator by using the CLI](#)
- [Setting a node to maintenance mode](#)
- [Resuming a node from maintenance mode](#)
- [About RunStrategies for virtual machines](#)
- [Virtual machine live migration](#)
- [Configuring virtual machine eviction strategy](#)

## 13.2. AUTOMATIC RENEWAL OF TLS CERTIFICATES

All TLS certificates for OpenShift Virtualization components are renewed and rotated automatically. You are not required to refresh them manually.

### 13.2.1. TLS certificates automatic renewal schedules

TLS certificates are automatically deleted and replaced according to the following schedule:

- KubeVirt certificates are renewed daily.
- Containerized Data Importer controller (CDI) certificates are renewed every 15 days.
- MAC pool certificates are renewed every year.

Automatic TLS certificate rotation does not disrupt any operations. For example, the following operations continue to function without any disruption:

- Migrations
- Image uploads
- VNC and console connections

## 13.3. MANAGING NODE LABELING FOR OBSOLETE CPU MODELS

You can schedule a virtual machine (VM) on a node as long as the VM CPU model and policy are supported by the node.

### 13.3.1. About node labeling for obsolete CPU models

The OpenShift Virtualization Operator uses a predefined list of obsolete CPU models to ensure that a node supports only valid CPU models for scheduled VMs.

By default, the following CPU models are eliminated from the list of labels generated for the node:

#### Example 13.1. Obsolete CPU models

```
"486"  
Conroe  
athlon  
core2duo  
coreduo  
kvm32  
kvm64  
n270  
pentium  
pentium2  
pentium3  
pentiumpro  
phenom  
qemu32  
qemu64
```

This predefined list is not visible in the **HyperConverged** CR. You cannot *remove* CPU models from this list, but you can add to the list by editing the **spec.obsoleteCPUs.cpuModels** field of the **HyperConverged** CR.

### 13.3.2. About node labeling for CPU features

Through the process of iteration, the base CPU features in the minimum CPU model are eliminated from the list of labels generated for the node.

For example:

- An environment might have two supported CPU models: **Penryn** and **Haswell**.
- If **Penryn** is specified as the CPU model for **minCPU**, each base CPU feature for **Penryn** is compared to the list of CPU features supported by **Haswell**.

#### Example 13.2. CPU features supported by Penryn

```
apic  
clflush  
cmov  
cx16  
cx8  
de  
fpu  
fxsr  
lahf_lm  
lm  
mca  
mce  
mmx  
msr  
mtrr  
nx  
pae  
pat  
pge  
pni  
pse
```

```
pse36  
sep  
sse  
sse2  
sse4.1  
ssse3  
syscall  
tsc
```

### Example 13.3. CPU features supported by Haswell

```
aes  
apic  
avx  
avx2  
bmi1  
bmi2  
clflush  
cmov  
cx16  
cx8  
de  
erms  
fma  
fpu  
fsbsbase  
fxsr  
hle  
invpcid  
lahf_lm  
lm  
mca  
mce  
mmx  
movbe  
msr  
mtrr  
nx  
pae  
pat  
pcid  
pclmuldq  
pge  
pni  
popcnt  
pse  
pse36  
rdtscp  
rtm  
sep  
smep  
sse  
sse2  
sse4.1
```

```
sse4.2
ssse3
syscall
tsc
tsc-deadline
x2apic
xsave
```

- If both **Penryn** and **Haswell** support a specific CPU feature, a label is not created for that feature. Labels are generated for CPU features that are supported only by **Haswell** and not by **Penryn**.

#### Example 13.4. Node labels created for CPU features after iteration

```
aes
avx
avx2
bmi1
bmi2
erms
fma
fsgsbase
hle
invpcid
movbe
pcid
pclmuldq
popcnt
rdtscp
rtm
sse4.2
tsc-deadline
x2apic
xsave
```

### 13.3.3. Configuring obsolete CPU models

You can configure a list of obsolete CPU models by editing the **HyperConverged** custom resource (CR).

#### Procedure

- Edit the **HyperConverged** custom resource, specifying the obsolete CPU models in the **obsoleteCPUs** array. For example:

```
apiVersion: hco.kubevirt.io/v1beta1
kind: HyperConverged
metadata:
  name: kubevirt-hyperconverged
  namespace: openshift-cnv
spec:
  obsoleteCPUs:
    - cpumodels: ①
```

```

    - "<obsolete_cpu_1>"
    - "<obsolete_cpu_2>"
```

minCPUModel: "<minimum\_cpu\_model>" **2**

- 1** Replace the example values in the **cpuModels** array with obsolete CPU models. Any value that you specify is added to a predefined list of obsolete CPU models. The predefined list is not visible in the CR.
- 2** Replace this value with the minimum CPU model that you want to use for basic CPU features. If you do not specify a value, **Penryn** is used by default.

## 13.4. PREVENTING NODE RECONCILIATION

Use **skip-node** annotation to prevent the **node-labeller** from reconciling a node.

### 13.4.1. Using skip-node annotation

If you want the **node-labeller** to skip a node, annotate that node by using the **oc** CLI.

#### Prerequisites

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

#### Procedure

- Annotate the node that you want to skip by running the following command:

```
$ oc annotate node <node_name> node-labeller.kubevirt.io/skip-node=true 1
```

- 1** Replace **<node\_name>** with the name of the relevant node to skip.

Reconciliation resumes on the next cycle after the node annotation is removed or set to false.

### 13.4.2. Additional resources

- [Managing node labeling for obsolete CPU models](#)

# CHAPTER 14. SUPPORT

## 14.1. SUPPORT OVERVIEW

You can collect data about your environment, monitor the health of your cluster and virtual machines (VMs), and troubleshoot OpenShift Virtualization resources with the following tools.

### 14.1.1. Web console

The OpenShift Container Platform web console displays resource usage, alerts, events, and trends for your cluster and for OpenShift Virtualization components and resources.

**Table 14.1. Web console pages for monitoring and troubleshooting**

| Page                                                                                                             | Description                                                    |
|------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|
| <b>Overview</b> page                                                                                             | Cluster details, status, alerts, inventory, and resource usage |
| <b>Virtualization</b> → <a href="#">Overview tab</a>                                                             | OpenShift Virtualization resources, usage, alerts, and status  |
| <b>Virtualization</b> → <a href="#">Top consumers</a> tab                                                        | Top consumers of CPU, memory, and storage                      |
| <b>Virtualization</b> → <a href="#">Migrations</a> tab                                                           | Progress of live migrations                                    |
| <b>VirtualMachines</b> → <b>VirtualMachine</b> → <b>VirtualMachine</b> details → <a href="#">Metrics</a> tab     | VM resource usage, storage, network, and migration             |
| <b>VirtualMachines</b> → <b>VirtualMachine</b> → <b>VirtualMachine</b> details → <a href="#">Events</a> tab      | List of VM events                                              |
| <b>VirtualMachines</b> → <b>VirtualMachine</b> → <b>VirtualMachine</b> details → <a href="#">Diagnostics</a> tab | VM status conditions and volume snapshot status                |

### 14.1.2. Collecting data for Red Hat Support

When you submit a [support case](#) to Red Hat Support, it is helpful to provide debugging information. You can gather debugging information by performing the following steps:

#### [Collecting data about your environment](#)

Configure Prometheus and Alertmanager and collect **must-gather** data for OpenShift Container Platform and OpenShift Virtualization.

#### [Collecting data about VMs](#)

Collect **must-gather** data and memory dumps from VMs.

#### [must-gather tool for OpenShift Virtualization](#)

Configure and use the **must-gather** tool.

## 14.1.3. Monitoring

You can monitor the health of your cluster and VMs. For details about monitoring tools, see the [Monitoring overview](#).

#### 14.1.4. Troubleshooting

Troubleshoot OpenShift Virtualization components and VMs and resolve issues that trigger alerts in the web console.

##### Events

View important life-cycle information for VMs, namespaces, and resources.

##### Logs

View and configure logs for OpenShift Virtualization components and VMs.

##### Runbooks

Diagnose and resolve issues that trigger OpenShift Virtualization alerts in the web console.

##### Troubleshooting data volumes

Troubleshoot data volumes by analyzing conditions and events.

## 14.2. COLLECTING DATA FOR RED HAT SUPPORT

When you submit a [support case](#) to Red Hat Support, it is helpful to provide debugging information for OpenShift Container Platform and OpenShift Virtualization by using the following tools:

##### must-gather tool

The **must-gather** tool collects diagnostic information, including resource definitions and service logs.

##### Prometheus

Prometheus is a time-series database and a rule evaluation engine for metrics. Prometheus sends alerts to Alertmanager for processing.

##### Alertmanager

The Alertmanager service handles alerts received from Prometheus. The Alertmanager is also responsible for sending the alerts to external notification systems.

For information about the OpenShift Container Platform monitoring stack, see [About OpenShift Container Platform monitoring](#).

#### 14.2.1. Collecting data about your environment

Collecting data about your environment minimizes the time required to analyze and determine the root cause.

##### Prerequisites

- Set the retention time for Prometheus metrics data to a minimum of seven days.
- Configure the Alertmanager to capture relevant alerts and to send alert notifications to a dedicated mailbox so that they can be viewed and persisted outside the cluster.
- Record the exact number of affected nodes and virtual machines.

##### Procedure

1. [Collect must-gather data for the cluster.](#)
2. [Collect must-gather data for Red Hat OpenShift Data Foundation](#), if necessary.
3. [Collect must-gather data for OpenShift Virtualization.](#)
4. [Collect Prometheus metrics for the cluster.](#)

#### 14.2.2. Collecting data about virtual machines

Collecting data about malfunctioning virtual machines (VMs) minimizes the time required to analyze and determine the root cause.

##### Prerequisites

- Linux VMs: [Install the latest QEMU guest agent](#) .
- Windows VMs:
  - Record the Windows patch update details.
  - [Install the latest VirtIO drivers](#).
  - [Install the latest QEMU guest agent](#) .
  - If Remote Desktop Protocol (RDP) is enabled, try to connect to the VMs with RDP by using the [web console](#) or the [command line](#) to determine whether there is a problem with the connection software.

##### Procedure

1. [Collect must-gather data for the VMs](#) using the **/usr/bin/gather** script.
2. Collect screenshots of VMs that have crashed *before* you restart them.
3. [Collect memory dumps from VMs](#) *before* remediation attempts.
4. Record factors that the malfunctioning VMs have in common. For example, the VMs have the same host or network.

#### 14.2.3. Using the must-gather tool for OpenShift Virtualization

You can collect data about OpenShift Virtualization resources by running the **must-gather** command with the OpenShift Virtualization image.

The default data collection includes information about the following resources:

- OpenShift Virtualization Operator namespaces, including child objects
- OpenShift Virtualization custom resource definitions
- Namespaces that contain virtual machines
- Basic virtual machine definitions

##### Procedure

- Run the following command to collect data about OpenShift Virtualization:

```
$ oc adm must-gather
--image=registry.redhat.io/container-native-virtualization/cnv-must-gather-rhel9:v4.13.4 \
-- /usr/bin/gather
```

### 14.2.3.1. must-gather tool options

You can specify a combination of scripts and environment variables for the following options:

- Collecting detailed virtual machine (VM) information from a namespace
- Collecting detailed information about specified VMs
- Collecting image, image-stream, and image-stream-tags information
- Limiting the maximum number of parallel processes used by the **must-gather** tool

#### 14.2.3.1.1. Parameters

##### Environment variables

You can specify environment variables for a compatible script.

##### **NS=<namespace\_name>**

Collect virtual machine information, including **virt-launcher** pod details, from the namespace that you specify. The **VirtualMachine** and **VirtualMachineInstance** CR data is collected for all namespaces.

##### **VM=<vm\_name>**

Collect details about a particular virtual machine. To use this option, you must also specify a namespace by using the **NS** environment variable.

##### **PROS=<number\_of\_processes>**

Modify the maximum number of parallel processes that the **must-gather** tool uses. The default value is **5**.



#### IMPORTANT

Using too many parallel processes can cause performance issues. Increasing the maximum number of parallel processes is not recommended.

## Scripts

Each script is compatible only with certain environment variable combinations.

### /usr/bin/gather

Use the default **must-gather** script, which collects cluster data from all namespaces and includes only basic VM information. This script is compatible only with the **PROS** variable.

### /usr/bin/gather --vms\_details

Collect VM log files, VM definitions, control-plane logs, and namespaces that belong to OpenShift Virtualization resources. Specifying namespaces includes their child objects. If you use this parameter without specifying a namespace or VM, the **must-gather** tool collects this data for all VMs in the

cluster. This script is compatible with all environment variables, but you must specify a namespace if you use the **VM** variable.

### /usr/bin/gather --images

Collect image, image-stream, and image-stream-tags custom resource information. This script is compatible only with the **PROS** variable.

#### 14.2.3.1.2. Usage and examples

Environment variables are optional. You can run a script by itself or with one or more compatible environment variables.

**Table 14.2. Compatible parameters**

| Script                        | Compatible environment variable                                                                                                                                                                                                   |
|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| /usr/bin/gather               | <ul style="list-style-type: none"> <li>● <b>PROS=&lt;number_of_processes&gt;</b></li> </ul>                                                                                                                                       |
| /usr/bin/gather --vms_details | <ul style="list-style-type: none"> <li>● For a namespace: <b>NS=&lt;namespace_name&gt;</b></li> <li>● For a VM: <b>VM=&lt;vm_name&gt; NS=&lt;namespace_name&gt;</b></li> <li>● <b>PROS=&lt;number_of_processes&gt;</b></li> </ul> |
| /usr/bin/gather --images      | <ul style="list-style-type: none"> <li>● <b>PROS=&lt;number_of_processes&gt;</b></li> </ul>                                                                                                                                       |

#### Syntax

```
$ oc adm must-gather \
--image=registry.redhat.io/container-native-virtualization/cnv-must-gather-rhel9:v4.13.4 \
-- <environment_variable_1> <environment_variable_2> <script_name>
```

#### Default data collection parallel processes

By default, five processes run in parallel.

```
$ oc adm must-gather \
--image=registry.redhat.io/container-native-virtualization/cnv-must-gather-rhel9:v4.13.4 \
-- PROS=5 /usr/bin/gather ①
```

① You can modify the number of parallel processes by changing the default.

#### Detailed VM information

The following command collects detailed VM information for the **my-vm** VM in the **mynamespace** namespace:

```
$ oc adm must-gather \
--image=registry.redhat.io/container-native-virtualization/cnv-must-gather-rhel9:v4.13.4 \
-- NS=mynamespace VM=my-vm /usr/bin/gather --vms_details ①
```

- 1 The **NS** environment variable is mandatory if you use the **VM** environment variable.

## Image, image-stream, and image-stream-tags information

The following command collects image, image-stream, and image-stream-tags information from the cluster:

```
$ oc adm must-gather \
--image=registry.redhat.io/container-native-virtualization/cnv-must-gather-rhel9:v4.13.4 \
/usr/bin/gather --images
```

## 14.3. MONITORING

### 14.3.1. Monitoring overview

You can monitor the health of your cluster and virtual machines (VMs) with the following tools:

#### [OpenShift Container Platform cluster checkup framework](#)

Run automated tests on your cluster with the OpenShift Container Platform cluster checkup framework to check the following conditions:

- Network connectivity and latency between two VMs attached to a secondary network interface
- VM running a Data Plane Development Kit (DPDK) workload with zero packet loss



#### IMPORTANT

The OpenShift Container Platform cluster checkup framework 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](#).

#### [Prometheus queries for virtual resources](#)

Query vCPU, network, storage, and guest memory swapping usage and live migration progress.

#### [VM custom metrics](#)

Configure the **node-exporter** service to expose internal VM metrics and processes.

#### [VM health checks](#)

Configure readiness, liveness, and guest agent ping probes and a watchdog for VMs.



## IMPORTANT

The guest agent ping probe 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](#).

### 14.3.2. OpenShift Container Platform cluster checkup framework

OpenShift Virtualization includes predefined checkups that can be used for cluster maintenance and troubleshooting.



## IMPORTANT

The OpenShift Container Platform cluster checkup framework 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](#).

#### 14.3.2.1. About the OpenShift Container Platform cluster checkup framework

A *checkup* is an automated test workload that allows you to verify if a specific cluster functionality works as expected. The cluster checkup framework uses native Kubernetes resources to configure and execute the checkup.

By using predefined checkups, cluster administrators and developers can improve cluster maintainability, troubleshoot unexpected behavior, minimize errors, and save time. They can also review the results of the checkup and share them with experts for further analysis. Vendors can write and publish checkups for features or services that they provide and verify that their customer environments are configured correctly.

Running a predefined checkup in an existing namespace involves setting up a service account for the checkup, creating the **Role** and **RoleBinding** objects for the service account, enabling permissions for the checkup, and creating the input config map and the checkup job. You can run a checkup multiple times.



## IMPORTANT

You must always:

- Verify that the checkup image is from a trustworthy source before applying it.
- Review the checkup permissions before creating the **Role** and **RoleBinding** objects.

#### 14.3.2.2. Virtual machine latency checkup

You use a predefined checkup to verify network connectivity and measure latency between two virtual machines (VMs) that are attached to a secondary network interface. The latency checkup uses the ping utility.

You run a latency checkup by performing the following steps:

1. Create a service account, roles, and rolebindings to provide cluster access permissions to the latency checkup.
2. Create a config map to provide the input to run the checkup and to store the results.
3. Create a job to run the checkup.
4. Review the results in the config map.
5. Optional: To rerun the checkup, delete the existing config map and job and then create a new config map and job.
6. When you are finished, delete the latency checkup resources.

## Prerequisites

- You installed the OpenShift CLI (**oc**).
- The cluster has at least two worker nodes.
- The Multus Container Network Interface (CNI) plugin is installed on the cluster.
- You configured a network attachment definition for a namespace.

## Procedure

1. Create a **ServiceAccount**, **Role**, and **RoleBinding** manifest for the latency checkup:

### Example 14.1. Example role manifest file

```
---
apiVersion: v1
kind: ServiceAccount
metadata:
  name: vm-latency-checkup-sa
---
apiVersion: rbac.authorization.k8s.io/v1
kind: Role
metadata:
  name: kubevirt-vm-latency-checker
rules:
- apiGroups: ["kubevirt.io"]
  resources: ["virtualmachineinstances"]
  verbs: ["get", "create", "delete"]
- apiGroups: ["subresources.kubevirt.io"]
  resources: ["virtualmachineinstances/console"]
  verbs: ["get"]
- apiGroups: ["k8s.cni.cncf.io"]
  resources: ["network-attachment-definitions"]
  verbs: ["get"]
---
```

```

apiVersion: rbac.authorization.k8s.io/v1
kind: RoleBinding
metadata:
  name: kubevirt-vm-latency-checker
subjects:
- kind: ServiceAccount
  name: vm-latency-checkup-sa
roleRef:
  kind: Role
  name: kubevirt-vm-latency-checker
  apiGroup: rbac.authorization.k8s.io
---
apiVersion: rbac.authorization.k8s.io/v1
kind: Role
metadata:
  name: kiagnose-configmap-access
rules:
- apiGroups: [ "" ]
  resources: [ "configmaps" ]
  verbs: ["get", "update"]
---
apiVersion: rbac.authorization.k8s.io/v1
kind: RoleBinding
metadata:
  name: kiagnose-configmap-access
subjects:
- kind: ServiceAccount
  name: vm-latency-checkup-sa
roleRef:
  kind: Role
  name: kiagnose-configmap-access
  apiGroup: rbac.authorization.k8s.io

```

2. Apply the **ServiceAccount**, **Role**, and **RoleBinding** manifest:

\$ oc apply -n <target\_namespace> -f <latency\_sa\_roles\_rolebinding>.yaml ①

- ① **<target\_namespace>** is the namespace where the checkup is to be run. This must be an existing namespace where the **NetworkAttachmentDefinition** object resides.

3. Create a **ConfigMap** manifest that contains the input parameters for the checkup:

#### Example input config map

```

apiVersion: v1
kind: ConfigMap
metadata:
  name: kubevirt-vm-latency-checkup-config
data:
  spec.timeout: 5m
  spec.param.networkAttachmentDefinitionNamespace: <target_namespace>
  spec.param.networkAttachmentDefinitionName: "blue-network" ①
  spec.param.maxDesiredLatencyMilliseconds: "10" ②

```

```
spec.param.sampleDurationSeconds: "5" ③
spec.param.sourceNode: "worker1" ④
spec.param.targetNode: "worker2" ⑤
```

- 1 The name of the **NetworkAttachmentDefinition** object.
- 2 Optional: The maximum desired latency, in milliseconds, between the virtual machines. If the measured latency exceeds this value, the checkup fails.
- 3 Optional: The duration of the latency check, in seconds.
- 4 Optional: When specified, latency is measured from this node to the target node. If the source node is specified, the **spec.param.targetNode** field cannot be empty.
- 5 Optional: When specified, latency is measured from the source node to this node.

4. Apply the config map manifest in the target namespace:

```
$ oc apply -n <target_namespace> -f <latency_config_map>.yaml
```

5. Create a **Job** manifest to run the checkup:

### Example job manifest

```
apiVersion: batch/v1
kind: Job
metadata:
  name: kubevirt-vm-latency-checkup
spec:
  backoffLimit: 0
  template:
    spec:
      serviceAccountName: vm-latency-checkup-sa
      restartPolicy: Never
      containers:
        - name: vm-latency-checkup
          image: registry.redhat.io/container-native-virtualization/vm-network-latency-checkup-
rhel9:v4.13.0
          securityContext:
            allowPrivilegeEscalation: false
            capabilities:
              drop: ["ALL"]
            runAsNonRoot: true
            seccompProfile:
              type: "RuntimeDefault"
      env:
        - name: CONFIGMAP_NAMESPACE
          value: <target_namespace>
        - name: CONFIGMAP_NAME
          value: kubevirt-vm-latency-checkup-config
        - name: POD_UID
          valueFrom:
            fieldRef:
              fieldPath: metadata.uid
```

6. Apply the **Job** manifest:

```
$ oc apply -n <target_namespace> -f <latency_job>.yaml
```

7. Wait for the job to complete:

```
$ oc wait job kubevirt-vm-latency-checkup -n <target_namespace> --for condition=complete -timeout 6m
```

8. Review the results of the latency checkup by running the following command. If the maximum measured latency is greater than the value of the **spec.param.maxDesiredLatencyMilliseconds** attribute, the checkup fails and returns an error.

```
$ oc get configmap kubevirt-vm-latency-checkup-config -n <target_namespace> -o yaml
```

#### Example output config map (success)

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: kubevirt-vm-latency-checkup-config
  namespace: <target_namespace>
data:
  spec.timeout: 5m
  spec.param.networkAttachmentDefinitionNamespace: <target_namespace>
  spec.param.networkAttachmentDefinitionName: "blue-network"
  spec.param.maxDesiredLatencyMilliseconds: "10"
  spec.param.sampleDurationSeconds: "5"
  spec.param.sourceNode: "worker1"
  spec.param.targetNode: "worker2"
  status.succeeded: "true"
  status.failureReason: ""
  status.completionTimestamp: "2022-01-01T09:00:00Z"
  status.startTimestamp: "2022-01-01T09:00:07Z"
  status.result.avgLatencyNanoSec: "177000"
  status.result.maxLatencyNanoSec: "244000" ①
  status.result.measurementDurationSec: "5"
  status.result.minLatencyNanoSec: "135000"
  status.result.sourceNode: "worker1"
  status.result.targetNode: "worker2"
```

① The maximum measured latency in nanoseconds.

9. Optional: To view the detailed job log in case of checkup failure, use the following command:

```
$ oc logs job.batch/kubevirt-vm-latency-checkup -n <target_namespace>
```

10. Delete the job and config map that you previously created by running the following commands:

```
$ oc delete job -n <target_namespace> kubevirt-vm-latency-checkup
```

```
$ oc delete config-map -n <target_namespace> kubevirt-vm-latency-checkup-config
```

11. Optional: If you do not plan to run another checkup, delete the roles manifest:

```
$ oc delete -f <latency_sa_roles_rolebinding>.yaml
```

### 14.3.2.3. DPDK checkup

Use a predefined checkup to verify that your OpenShift Container Platform cluster node can run a virtual machine (VM) with a Data Plane Development Kit (DPDK) workload with zero packet loss. The DPDK checkup runs traffic between a traffic generator pod and a VM running a test DPDK application.

You run a DPDK checkup by performing the following steps:

1. Create a service account, role, and role bindings for the DPDK checkup and a service account for the traffic generator pod.
2. Create a security context constraints resource for the traffic generator pod.
3. Create a config map to provide the input to run the checkup and to store the results.
4. Create a job to run the checkup.
5. Review the results in the config map.
6. Optional: To rerun the checkup, delete the existing config map and job and then create a new config map and job.
7. When you are finished, delete the DPDK checkup resources.

#### Prerequisites

- You have access to the cluster as a user with **cluster-admin** permissions.
- You have installed the OpenShift CLI (**oc**).
- You have configured the compute nodes to run DPDK applications on VMs with zero packet loss.



#### IMPORTANT

The traffic generator pod created by the checkup has elevated privileges:

- It runs as root.
- It has a bind mount to the node's file system.

The container image of the traffic generator is pulled from the upstream Project Quay container registry.

#### Procedure

1. Create a **ServiceAccount**, **Role**, and **RoleBinding** manifest for the DPDK checkup and the traffic generator pod:

**Example 14.2. Example service account, role, and rolebinding manifest file**

```
--
```

```
apiVersion: v1
kind: ServiceAccount
metadata:
  name: dpdk-checkup-sa
---
apiVersion: rbac.authorization.k8s.io/v1
kind: Role
metadata:
  name: kiagnose-configmap-access
rules:
  - apiGroups: [ "" ]
    resources: [ "configmaps" ]
    verbs: [ "get", "update" ]
---
apiVersion: rbac.authorization.k8s.io/v1
kind: RoleBinding
metadata:
  name: kiagnose-configmap-access
subjects:
  - kind: ServiceAccount
    name: dpdk-checkup-sa
roleRef:
  apiGroup: rbac.authorization.k8s.io
  kind: Role
  name: kiagnose-configmap-access
---
apiVersion: rbac.authorization.k8s.io/v1
kind: Role
metadata:
  name: kubevirt-dpdk-checker
rules:
  - apiGroups: [ "kubevirt.io" ]
    resources: [ "virtualmachineinstances" ]
    verbs: [ "create", "get", "delete" ]
  - apiGroups: [ "subresources.kubevirt.io" ]
    resources: [ "virtualmachineinstances/console" ]
    verbs: [ "get" ]
  - apiGroups: [ "" ]
    resources: [ "pods" ]
    verbs: [ "create", "get", "delete" ]
  - apiGroups: [ "" ]
    resources: [ "pods/exec" ]
    verbs: [ "create" ]
  - apiGroups: [ "k8s.cni.cncf.io" ]
    resources: [ "network-attachment-definitions" ]
    verbs: [ "get" ]
---
apiVersion: rbac.authorization.k8s.io/v1
kind: RoleBinding
metadata:
  name: kubevirt-dpdk-checker
subjects:
  - kind: ServiceAccount
    name: dpdk-checkup-sa
roleRef:
  apiGroup: rbac.authorization.k8s.io
```

```

kind: Role
name: kubevirt-dpdk-checker
---
apiVersion: v1
kind: ServiceAccount
metadata:
  name: dpdk-checkup-traffic-gen-sa

```

2. Apply the **ServiceAccount**, **Role**, and **RoleBinding** manifest:

```
$ oc apply -n <target_namespace> -f <dpdk_sa_roles_rolebinding>.yaml
```

3. Create a **SecurityContextConstraints** manifest for the traffic generator pod:

#### Example security context constraints manifest

```

apiVersion: security.openshift.io/v1
kind: SecurityContextConstraints
metadata:
  name: dpdk-checkup-traffic-gen
allowHostDirVolumePlugin: true
allowHostIPC: false
allowHostNetwork: false
allowHostPID: false
allowHostPorts: false
allowPrivilegeEscalation: false
allowPrivilegedContainer: false
allowedCapabilities:
- IPC_LOCK
- NET_ADMIN
- NET_RAW
- SYS_RESOURCE
defaultAddCapabilities: null
fsGroup:
  type: RunAsAny
groups: []
readOnlyRootFilesystem: false
requiredDropCapabilities: null
runAsUser:
  type: RunAsAny
seLinuxContext:
  type: RunAsAny
seccompProfiles:
- runtime/default
- unconfined
supplementalGroups:
  type: RunAsAny
users:
- system:serviceaccount:dpdk-checkup-ns:dpdk-checkup-traffic-gen-sa

```

4. Apply the **SecurityContextConstraints** manifest:

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

5. Create a **ConfigMap** manifest that contains the input parameters for the checkup:

#### Example input config map

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: dpdk-checkup-config
data:
  spec.timeout: 10m
  spec.param.networkAttachmentDefinitionName: <network_name> ①
  spec.param.trafficGeneratorRuntimeClassName: <runtimaclass_name> ②
  spec.param.trafficGeneratorImage: "quay.io/kiagnose/kubevirt-dpdk-checkup-traffic-
gen:v0.1.1" ③
  spec.param.vmContainerDiskImage: "quay.io/kiagnose/kubevirt-dpdk-checkup-vm:v0.1.1"
④
```

- ① The name of the **NetworkAttachmentDefinition** object.
- ② The **RuntimeClass** resource that the traffic generator pod uses.
- ③ The container image for the traffic generator. In this example, the image is pulled from the upstream Project Quay Container Registry.
- ④ The container disk image for the VM. In this example, the image is pulled from the upstream Project Quay Container Registry.

6. Apply the **ConfigMap** manifest in the target namespace:

```
$ oc apply -n <target_namespace> -f <dpdk_config_map>.yaml
```

7. Create a **Job** manifest to run the checkup:

#### Example job manifest

```
apiVersion: batch/v1
kind: Job
metadata:
  name: dpdk-checkup
spec:
  backoffLimit: 0
  template:
    spec:
      serviceAccountName: dpdk-checkup-sa
      restartPolicy: Never
      containers:
        - name: dpdk-checkup
          image: registry.redhat.io/container-native-virtualization/kubevirt-dpdk-checkup-
rhel9:v4.13.0
          imagePullPolicy: Always
          securityContext:
            allowPrivilegeEscalation: false
            capabilities:
              drop: ["ALL"]
```

```

    runAsNonRoot: true
    seccompProfile:
      type: "RuntimeDefault"
    env:
      - name: CONFIGMAP_NAMESPACE
        value: <target-namespace>
      - name: CONFIGMAP_NAME
        value: dpdk-checkup-config
      - name: POD_UID
        valueFrom:
          fieldRef:
            fieldPath: metadata.uid

```

8. Apply the **Job** manifest:

```
$ oc apply -n <target_namespace> -f <dpdk_job>.yaml
```

9. Wait for the job to complete:

```
$ oc wait job dpdk-checkup -n <target_namespace> --for condition=complete --timeout 10m
```

10. Review the results of the checkup by running the following command:

```
$ oc get configmap dpdk-checkup-config -n <target_namespace> -o yaml
```

### Example output config map (success)

```

apiVersion: v1
kind: ConfigMap
metadata:
  name: dpdk-checkup-config
data:
  spec.timeout: 1h2m
  spec.param.NetworkAttachmentDefinitionName: "mlx-dpdk-network-1"
  spec.param.trafficGeneratorRuntimeClassName: performance-performance-zeus10
  spec.param.trafficGeneratorImage: "quay.io/kiagnose/kubevirt-dpdk-checkup-traffic-gen:v0.1.1"
  spec.param.vmContainerDiskImage: "quay.io/kiagnose/kubevirt-dpdk-checkup-vm:v0.1.1"
  status.succeeded: true
  status.failureReason: ""
  status.startTimestamp: 2022-12-21T09:33:06+00:00
  status.completionTimestamp: 2022-12-21T11:33:06+00:00
  status.result.actualTrafficGeneratorTargetNode: worker-dpdk1
  status.result.actualDPDKVMTargetNode: worker-dpdk2
  status.result.dropRate: 0

```

11. Delete the job and config map that you previously created by running the following commands:

```
$ oc delete job -n <target_namespace> dpdk-checkup
```

```
$ oc delete config-map -n <target_namespace> dpdk-checkup-config
```

12. Optional: If you do not plan to run another checkup, delete the **ServiceAccount**, **Role**, and **RoleBinding** manifest:

```
$ oc delete -f <dpdk_sa_roles_rolebinding>.yaml
```

#### 14.3.2.3.1. DPDK checkup config map parameters

The following table shows the mandatory and optional parameters that you can set in the **data** stanza of the input **ConfigMap** manifest when you run a cluster DPDK readiness checkup:

Table 14.3. DPDK checkup config map parameters

| Parameter                                          | Description                                                                                                                                                 | Is Mandatory |
|----------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| <b>spec.timeout</b>                                | The time, in minutes, before the checkup fails.                                                                                                             | True         |
| <b>spec.param.networkAttachmentDefinitionName</b>  | The name of the <b>NetworkAttachmentDefinition</b> object of the SR-IOV NICs connected.                                                                     | True         |
| <b>spec.param.trafficGeneratorRuntimeClassName</b> | The RuntimeClass resource that the traffic generator pod uses.                                                                                              | True         |
| <b>spec.param.trafficGeneratorImage</b>            | The container image for the traffic generator. The default value is <b>quay.io/kiagnose/kubevirt-dpdk-checkup-traffic-gen:main</b> .                        | False        |
| <b>spec.param.trafficGeneratorNodeSelector</b>     | The node on which the traffic generator pod is to be scheduled. The node should be configured to allow DPDK traffic.                                        | False        |
| <b>spec.param.trafficGeneratorPacketsPerSecond</b> | The number of packets per second, in kilo (k) or million(m). The default value is 14m.                                                                      | False        |
| <b>spec.param.trafficGeneratorEastMacAddress</b>   | The MAC address of the NIC connected to the traffic generator pod or VM. The default value is a random MAC address in the format <b>50:xx:xx:xx:xx:01</b> . | False        |

| Parameter                                        | Description                                                                                                                                                 | Is Mandatory |
|--------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| <b>spec.param.trafficGeneratorWestMacAddress</b> | The MAC address of the NIC connected to the traffic generator pod or VM. The default value is a random MAC address in the format <b>50:xx:xx:xx:xx:02</b> . | False        |
| <b>spec.param.vmContainerDiskImage</b>           | The container disk image for the VM. The default value is <b>quay.io/kiagnose/kubevirt-dpdk-checkup-vm:main</b> .                                           | False        |
| <b>spec.param.DPDKLabelSelector</b>              | The label of the node on which the VM runs. The node should be configured to allow DPDK traffic.                                                            | False        |
| <b>spec.param.DPDKEastMacAddress</b>             | The MAC address of the NIC that is connected to the VM. The default value is a random MAC address in the format <b>60:xx:xx:xx:xx:01</b> .                  | False        |
| <b>spec.param.DPDKWestMacAddress</b>             | The MAC address of the NIC that is connected to the VM. The default value is a random MAC address in the format <b>60:xx:xx:xx:xx:02</b> .                  | False        |
| <b>spec.param.testDuration</b>                   | The duration, in minutes, for which the traffic generator runs. The default value is 5 minutes.                                                             | False        |
| <b>spec.param.portBandwidthGB</b>                | The maximum bandwidth of the SR-IOV NIC. The default value is 10GB.                                                                                         | False        |
| <b>spec.param.verbose</b>                        | When set to <b>true</b> , it increases the verbosity of the checkup log. The default value is <b>false</b> .                                                | False        |

#### 14.3.2.3.2. Building a container disk image for RHEL virtual machines

You can build a custom Red Hat Enterprise Linux (RHEL) 8 OS image in **qcow2** format and use it to create a container disk image. You can store the container disk image in a registry that is accessible from your cluster and specify the image location in the **spec.param.vmContainerDiskImage** attribute of the DPDK checkup config map.

To build a container disk image, you must create an image builder virtual machine (VM). The *image builder* VM is a RHEL 8 VM that can be used to build custom RHEL images.

## Prerequisites

- The image builder VM must run RHEL 8.7 and must have a minimum of 2 CPU cores, 4 GiB RAM, and 20 GB of free space in the `/var` directory.
- You have installed the image builder tool and its CLI (**composer-cli**) on the VM.
- You have installed the **virt-customize** tool:
 

```
# dnf install libguestfs-tools
```
- You have installed the Podman CLI tool (**podman**).

## Procedure

1. Verify that you can build a RHEL 8.7 image:

```
# composer-cli distros list
```



### NOTE

To run the **composer-cli** commands as non-root, add your user to the **weldr** or **root** groups:

```
# usermod -a -G weldr user
$ newgrp weldr
```

2. Enter the following command to create an image blueprint file in TOML format that contains the packages to be installed, kernel customizations, and the services to be disabled during boot time:

```
$ cat << EOF > dpdk-vm.toml
name = "dpdk_image"
description = "Image to use with the DPDK checkup"
version = "0.0.1"
distro = "rhel-87"

[[packages]]
name = "dpdk"

[[packages]]
name = "dpdk-tools"

[[packages]]
name = "driverctl"

[[packages]]
name = "tuned-profiles-cpu-partitioning"

[customizations.kernel]
append = "default_hugepagesz=1GB hugepagesz=1G hugepages=8 isolcpus=2-7"
```

```
[customizations.services]
disabled = ["NetworkManager-wait-online", "sshd"]
EOF
```

3. Push the blueprint file to the image builder tool by running the following command:

```
# composer-cli blueprints push dpdk-vm.toml
```

4. Generate the system image by specifying the blueprint name and output file format. The Universally Unique Identifier (UUID) of the image is displayed when you start the compose process.

```
# composer-cli compose start dpdk_image qcow2
```

5. Wait for the compose process to complete. The compose status must show **FINISHED** before you can continue to the next step.

```
# composer-cli compose status
```

6. Enter the following command to download the **qcow2** image file by specifying its UUID:

```
# composer-cli compose image <UUID>
```

7. Create the customization scripts by running the following commands:

```
$ cat <<EOF >customize-vm
echo isolated_cores=2-7 > /etc/tuned/cpu-partitioning-variables.conf
tuned-adm profile cpu-partitioning
echo "options vfio enable_unsafe_noiommu_mode=1" > /etc/modprobe.d/vfio-noiommu.conf
EOF
```

```
$ cat <<EOF >first-boot
driverctl set-override 0000:06:00.0 vfio-pci
driverctl set-override 0000:07:00.0 vfio-pci

mkdir /mnt/huge
mount /mnt/huge --source nodev -t hugetlbfs -o pagesize=1GB
EOF
```

8. Use the **virt-customize** tool to customize the image generated by the image builder tool:

```
$ virt-customize -a <UUID>.qcow2 --run=customize-vm --firstboot=first-boot --selinux-relabel
```

9. To create a Dockerfile that contains all the commands to build the container disk image, enter the following command:

```
$ cat << EOF > Dockerfile
FROM scratch
COPY <uuid>-disk.qcow2 /disk/
EOF
```

where:

**<uuid>-disk.qcow2**

Specifies the name of the custom image in **qcow2** format.

10. Build and tag the container by running the following command:

```
$ podman build . -t dpdk-rhel:latest
```

11. Push the container disk image to a registry that is accessible from your cluster by running the following command:

```
$ podman push dpdk-rhel:latest
```

12. Provide a link to the container disk image in the **spec.param.vmContainerDiskImage** attribute in the DPDK checkup config map.

#### 14.3.2.4. Additional resources

- [Attaching a virtual machine to multiple networks](#)
- [Using a virtual function in DPDK mode with an Intel NIC](#)
- [Using SR-IOV and the Node Tuning Operator to achieve a DPDK line rate](#)
- [Installing image builder](#)
- [How to register and subscribe a RHEL system to the Red Hat Customer Portal using Red Hat Subscription Manager](#)

#### 14.3.3. Prometheus queries for virtual resources

OpenShift Virtualization provides metrics that you can use to monitor the consumption of cluster infrastructure resources, including vCPU, network, storage, and guest memory swapping. You can also use metrics to query live migration status.

Use the OpenShift Container Platform monitoring dashboard to query virtualization metrics.

##### 14.3.3.1. Prerequisites

- To use the vCPU metric, the **schedstats=enable** kernel argument must be applied to the **MachineConfig** object. This kernel argument enables scheduler statistics used for debugging and performance tuning and adds a minor additional load to the scheduler. For more information, see [Adding kernel arguments to nodes](#) .
- For guest memory swapping queries to return data, memory swapping must be enabled on the virtual guests.

##### 14.3.3.2. Querying metrics

The OpenShift Container Platform monitoring dashboard enables you to run Prometheus Query Language (PromQL) queries to examine metrics visualized on a plot. This functionality provides information about the state of a cluster and any user-defined workloads that you are monitoring.

As a cluster administrator, you can query metrics for all core OpenShift Container Platform and user-defined projects.

As a developer, you must specify a project name when querying metrics. You must have the required privileges to view metrics for the selected project.

#### 14.3.3.2.1. Querying metrics for all projects as a cluster administrator

As a cluster administrator or as a user with view permissions for all projects, you can access metrics for all default OpenShift Container Platform and user-defined projects in the Metrics UI.

##### Prerequisites

- You have access to the cluster as a user with the **cluster-admin** cluster role or with view permissions for all projects.
- You have installed the OpenShift CLI (**oc**).

##### Procedure

1. From the **Administrator** perspective in the OpenShift Container Platform web console, select **Observe** → **Metrics**.
2. To add one or more queries, do any of the following:

| Option                          | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|---------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Create a custom query.          | <p>Add your Prometheus Query Language (PromQL) query to the <b>Expression</b> field.</p> <p>As you type a PromQL expression, autocomplete suggestions appear in a dropdown list. These suggestions include functions, metrics, labels, and time tokens. You can use the keyboard arrows to select one of these suggested items and then press Enter to add the item to your expression. You can also move your mouse pointer over a suggested item to view a brief description of that item.</p> |
| Add multiple queries.           | Select <b>Add query</b> .                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Duplicate an existing query.    | Select the Options menu  next to the query, then choose <b>Duplicate query</b> .                                                                                                                                                                                                                                                                                                                            |
| Disable a query from being run. | Select the Options menu  next to the query and choose <b>Disable query</b> .                                                                                                                                                                                                                                                                                                                                |

3. To run queries that you created, select **Run queries**. The metrics from the queries are visualized on the plot. If a query is invalid, the UI shows an error message.

**NOTE**

Queries that operate on large amounts of data might time out or overload the browser when drawing time series graphs. To avoid this, select **Hide graph** and calibrate your query using only the metrics table. Then, after finding a feasible query, enable the plot to draw the graphs.

**NOTE**

By default, the query table shows an expanded view that lists every metric and its current value. You can select **^** to minimize the expanded view for a query.

4. Optional: The page URL now contains the queries you ran. To use this set of queries again in the future, save this URL.
5. Explore the visualized metrics. Initially, all metrics from all enabled queries are shown on the plot. You can select which metrics are shown by doing any of the following:

| Option                                                       | Description                                                                                                                                                                                                              |
|--------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Hide all metrics from a query.                               | Click the Options menu  for the query and click <b>Hide all series</b> .                                                                                                                                                 |
| Hide a specific metric.                                      | Go to the query table and click the colored square near the metric name.                                                                                                                                                 |
| Zoom into the plot and change the time range.                | Either: <ul style="list-style-type: none"> <li>● Visually select the time range by clicking and dragging on the plot horizontally.</li> <li>● Use the menu in the left upper corner to select the time range.</li> </ul> |
| Reset the time range.                                        | Select <b>Reset zoom</b> .                                                                                                                                                                                               |
| Display outputs for all queries at a specific point in time. | Hold the mouse cursor on the plot at that point. The query outputs will appear in a pop-up box.                                                                                                                          |
| Hide the plot.                                               | Select <b>Hide graph</b> .                                                                                                                                                                                               |

#### 14.3.3.2.2. Querying metrics for user-defined projects as a developer

You can access metrics for a user-defined project as a developer or as a user with view permissions for the project.

In the **Developer** perspective, the Metrics UI includes some predefined CPU, memory, bandwidth, and network packet queries for the selected project. You can also run custom Prometheus Query Language (PromQL) queries for CPU, memory, bandwidth, network packet and application metrics for the project.



## NOTE

Developers can only use the **Developer** perspective and not the **Administrator** perspective. As a developer, you can only query metrics for one project at a time.

### Prerequisites

- You have access to the cluster as a developer or as a user with view permissions for the project that you are viewing metrics for.
- You have enabled monitoring for user-defined projects.
- You have deployed a service in a user-defined project.
- You have created a **ServiceMonitor** custom resource definition (CRD) for the service to define how the service is monitored.

### Procedure

1. From the **Developer** perspective in the OpenShift Container Platform web console, select **Observe** → **Metrics**.
2. Select the project that you want to view metrics for in the **Project:** list.
3. Select a query from the **Select query** list, or create a custom PromQL query based on the selected query by selecting **Show PromQL**. The metrics from the queries are visualized on the plot.



## NOTE

In the Developer perspective, you can only run one query at a time.

4. Explore the visualized metrics by doing any of the following:

| Option                                                       | Description                                                                                                                                                                                                                     |
|--------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Zoom into the plot and change the time range.                | <p>Either:</p> <ul style="list-style-type: none"> <li>• Visually select the time range by clicking and dragging on the plot horizontally.</li> <li>• Use the menu in the left upper corner to select the time range.</li> </ul> |
| Reset the time range.                                        | Select <b>Reset zoom</b> .                                                                                                                                                                                                      |
| Display outputs for all queries at a specific point in time. | Hold the mouse cursor on the plot at that point. The query outputs appear in a pop-up box.                                                                                                                                      |

#### 14.3.3.3. Virtualization metrics

The following metric descriptions include example Prometheus Query Language (PromQL) queries. These metrics are not an API and might change between versions.

**NOTE**

The following examples use **topk** queries that specify a time period. If virtual machines are deleted during that time period, they can still appear in the query output.

**14.3.3.3.1. vCPU metrics**

The following query can identify virtual machines that are waiting for Input/Output (I/O):

**kubevirt\_vmi\_vcpu\_wait\_seconds**

Returns the wait time (in seconds) for a virtual machine's vCPU. Type: Counter.

A value above '0' means that the vCPU wants to run, but the host scheduler cannot run it yet. This inability to run indicates that there is an issue with I/O.

**NOTE**

To query the vCPU metric, the **schedstats=enable** kernel argument must first be applied to the **MachineConfig** object. This kernel argument enables scheduler statistics used for debugging and performance tuning and adds a minor additional load to the scheduler.

**Example vCPU wait time query**

`topk(3, sum by (name, namespace) (rate(kubevirt_vmi_vcpu_wait_seconds[6m]))) > 0` ①

- ① This query returns the top 3 VMs waiting for I/O at every given moment over a six-minute time period.

**14.3.3.2. Network metrics**

The following queries can identify virtual machines that are saturating the network:

**kubevirt\_vmi\_network\_receive\_bytes\_total**

Returns the total amount of traffic received (in bytes) on the virtual machine's network. Type: Counter.

**kubevirt\_vmi\_network\_transmit\_bytes\_total**

Returns the total amount of traffic transmitted (in bytes) on the virtual machine's network. Type: Counter.

**Example network traffic query**

`topk(3, sum by (name, namespace) (rate(kubevirt_vmi_network_receive_bytes_total[6m])) + sum by (name, namespace) (rate(kubevirt_vmi_network_transmit_bytes_total[6m]))) > 0` ①

- ① This query returns the top 3 VMs transmitting the most network traffic at every given moment over a six-minute time period.

**14.3.3.3. Storage metrics****14.3.3.3.1. Storage-related traffic**

The following queries can identify VMs that are writing large amounts of data:

### **kubevirt\_vmi\_storage\_read\_traffic\_bytes\_total**

Returns the total amount (in bytes) of the virtual machine's storage-related traffic. Type: Counter.

### **kubevirt\_vmi\_storage\_write\_traffic\_bytes\_total**

Returns the total amount of storage writes (in bytes) of the virtual machine's storage-related traffic. Type: Counter.

#### **Example storage-related traffic query**

```
topk(3, sum by (name, namespace) (rate(kubevirt_vmi_storage_read_traffic_bytes_total[6m])) + sum  
by (name, namespace) (rate(kubevirt_vmi_storage_write_traffic_bytes_total[6m]))) > 0 ①
```

- ① This query returns the top 3 VMs performing the most storage traffic at every given moment over a six-minute time period.

#### **14.3.3.3.2. Storage snapshot data**

### **kubevirt\_vmsnapshot\_disks\_restored\_from\_source\_total**

Returns the total number of virtual machine disks restored from the source virtual machine. Type: Gauge.

### **kubevirt\_vmsnapshot\_disks\_restored\_from\_source\_bytes**

Returns the amount of space in bytes restored from the source virtual machine. Type: Gauge.

#### **Examples of storage snapshot data queries**

```
kubevirt_vmsnapshot_disks_restored_from_source_total{vm_name="simple-vm",  
vm_namespace="default"} ①
```

- ① This query returns the total number of virtual machine disks restored from the source virtual machine.

```
kubevirt_vmsnapshot_disks_restored_from_source_bytes{vm_name="simple-vm",  
vm_namespace="default"} ①
```

- ① This query returns the amount of space in bytes restored from the source virtual machine.

#### **14.3.3.3.3. I/O performance**

The following queries can determine the I/O performance of storage devices:

### **kubevirt\_vmi\_storage\_iops\_read\_total**

Returns the amount of write I/O operations the virtual machine is performing per second. Type: Counter.

### **kubevirt\_vmi\_storage\_iops\_write\_total**

Returns the amount of read I/O operations the virtual machine is performing per second. Type: Counter.

## Example I/O performance query

```
topk(3, sum by (name, namespace) (rate(kubevirt_vmi_storage_iops_read_total[6m])) + sum by (name, namespace) (rate(kubevirt_vmi_storage_iops_write_total[6m]))) > 0 ①
```

- ① This query returns the top 3 VMs performing the most I/O operations per second at every given moment over a six-minute time period.

### 14.3.3.4. Guest memory swapping metrics

The following queries can identify which swap-enabled guests are performing the most memory swapping:

#### **kubevirt\_vmi\_memory\_swap\_in\_traffic\_bytes\_total**

Returns the total amount (in bytes) of memory the virtual guest is swapping in. Type: Gauge.

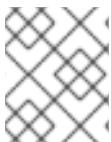
#### **kubevirt\_vmi\_memory\_swap\_out\_traffic\_bytes\_total**

Returns the total amount (in bytes) of memory the virtual guest is swapping out. Type: Gauge.

## Example memory swapping query

```
topk(3, sum by (name, namespace) (rate(kubevirt_vmi_memory_swap_in_traffic_bytes_total[6m])) + sum by (name, namespace) (rate(kubevirt_vmi_memory_swap_out_traffic_bytes_total[6m]))) > 0 ①
```

- ① This query returns the top 3 VMs where the guest is performing the most memory swapping at every given moment over a six-minute time period.



### NOTE

Memory swapping indicates that the virtual machine is under memory pressure. Increasing the memory allocation of the virtual machine can mitigate this issue.

### 14.3.3.5. Live migration metrics

The following metrics can be queried to show live migration status:

#### **kubevirt\_migrate\_vmi\_data\_processed\_bytes**

The amount of guest operating system data that has migrated to the new virtual machine (VM). Type: Gauge.

#### **kubevirt\_migrate\_vmi\_data\_remaining\_bytes**

The amount of guest operating system data that remains to be migrated. Type: Gauge.

#### **kubevirt\_migrate\_vmi\_dirty\_memory\_rate\_bytes**

The rate at which memory is becoming dirty in the guest operating system. Dirty memory is data that has been changed but not yet written to disk. Type: Gauge.

#### **kubevirt\_migrate\_vmi\_pending\_count**

The number of pending migrations. Type: Gauge.

#### **kubevirt\_migrate\_vmi\_scheduling\_count**

The number of scheduling migrations. Type: Gauge.

**kubevirt\_migrate\_vmi\_running\_count**

The number of running migrations. Type: Gauge.

**kubevirt\_migrate\_vmi\_succeeded**

The number of successfully completed migrations. Type: Gauge.

**kubevirt\_migrate\_vmi\_failed**

The number of failed migrations. Type: Gauge.

**14.3.3.4. Additional resources**

- [Monitoring overview](#)
- [Querying Prometheus](#)
- [Prometheus query examples](#)

**14.3.4. Exposing custom metrics for virtual machines**

OpenShift Container Platform includes a pre-configured, pre-installed, and self-updating monitoring stack that provides monitoring for core platform components. This monitoring stack is based on the Prometheus monitoring system. Prometheus is a time-series database and a rule evaluation engine for metrics.

In addition to using the OpenShift Container Platform monitoring stack, you can enable monitoring for user-defined projects by using the CLI and query custom metrics that are exposed for virtual machines through the **node-exporter** service.

**14.3.4.1. Configuring the node exporter service**

The node-exporter agent is deployed on every virtual machine in the cluster from which you want to collect metrics. Configure the node-exporter agent as a service to expose internal metrics and processes that are associated with virtual machines.

**Prerequisites**

- Install the OpenShift Container Platform CLI **oc**.
- Log in to the cluster as a user with **cluster-admin** privileges.
- Create the **cluster-monitoring-config** **ConfigMap** object in the **openshift-monitoring** project.
- Configure the **user-workload-monitoring-config** **ConfigMap** object in the **openshift-user-workload-monitoring** project by setting **enableUserWorkload** to **true**.

**Procedure**

1. Create the **Service** YAML file. In the following example, the file is called **node-exporter-service.yaml**.

```
kind: Service
apiVersion: v1
metadata:
  name: node-exporter-service 1
  namespace: dynamation 2
```

```

labels:
  servicetype: metrics 3
spec:
  ports:
    - name: exmet 4
      protocol: TCP
      port: 9100 5
      targetPort: 9100 6
  type: ClusterIP
  selector:
    monitor: metrics 7

```

- 1** The node-exporter service that exposes the metrics from the virtual machines.
- 2** The namespace where the service is created.
- 3** The label for the service. The **ServiceMonitor** uses this label to match this service.
- 4** The name given to the port that exposes metrics on port 9100 for the **ClusterIP** service.
- 5** The target port used by **node-exporter-service** to listen for requests.
- 6** The TCP port number of the virtual machine that is configured with the **monitor** label.
- 7** The label used to match the virtual machine's pods. In this example, any virtual machine's pod with the label **monitor** and a value of **metrics** will be matched.

## 2. Create the node-exporter service:

```
$ oc create -f node-exporter-service.yaml
```

### 14.3.4.2. Configuring a virtual machine with the node exporter service

Download the **node-exporter** file on to the virtual machine. Then, create a **systemd** service that runs the node-exporter service when the virtual machine boots.

#### Prerequisites

- The pods for the component are running in the **openshift-user-workload-monitoring** project.
- Grant the **monitoring-edit** role to users who need to monitor this user-defined project.

#### Procedure

1. Log on to the virtual machine.
2. Download the **node-exporter** file on to the virtual machine by using the directory path that applies to the version of **node-exporter** file.

```
$ wget
https://github.com/prometheus/node_exporter/releases/download/v1.3.1/node_exporter-1.3.1.linux-amd64.tar.gz
```

- Extract the executable and place it in the **/usr/bin** directory.

```
$ sudo tar xvf node_exporter-1.3.1.linux-amd64.tar.gz \
--directory /usr/bin --strip 1 */node_exporter"
```

- Create a **node\_exporter.service** file in this directory path: **/etc/systemd/system**. This **systemd** service file runs the node-exporter service when the virtual machine reboots.

```
[Unit]
Description=Prometheus Metrics Exporter
After=network.target
StartLimitIntervalSec=0

[Service]
Type=simple
Restart=always
RestartSec=1
User=root
ExecStart=/usr/bin/node_exporter

[Install]
WantedBy=multi-user.target
```

- Enable and start the **systemd** service.

```
$ sudo systemctl enable node_exporter.service
$ sudo systemctl start node_exporter.service
```

## Verification

- Verify that the node-exporter agent is reporting metrics from the virtual machine.

```
$ curl http://localhost:9100/metrics
```

## Example output

```
go_gc_duration_seconds{quantile="0"} 1.5244e-05
go_gc_duration_seconds{quantile="0.25"} 3.0449e-05
go_gc_duration_seconds{quantile="0.5"} 3.7913e-05
```

### 14.3.4.3. Creating a custom monitoring label for virtual machines

To enable queries to multiple virtual machines from a single service, add a custom label in the virtual machine's YAML file.

## Prerequisites

- Install the OpenShift Container Platform CLI **oc**.
- Log in as a user with **cluster-admin** privileges.
- Access to the web console for stop and restart a virtual machine.

## Procedure

1. Edit the **template** spec of your virtual machine configuration file. In this example, the label **monitor** has the value **metrics**.

```
spec:
  template:
    metadata:
      labels:
        monitor: metrics
```

2. Stop and restart the virtual machine to create a new pod with the label name given to the **monitor** label.

### 14.3.4.3.1. Querying the node-exporter service for metrics

Metrics are exposed for virtual machines through an HTTP service endpoint under the **/metrics** canonical name. When you query for metrics, Prometheus directly scrapes the metrics from the metrics endpoint exposed by the virtual machines and presents these metrics for viewing.

## Prerequisites

- You have access to the cluster as a user with **cluster-admin** privileges or the **monitoring-edit** role.
- You have enabled monitoring for the user-defined project by configuring the node-exporter service.

## Procedure

1. Obtain the HTTP service endpoint by specifying the namespace for the service:

```
$ oc get service -n <namespace> <node-exporter-service>
```

2. To list all available metrics for the node-exporter service, query the **metrics** resource.

```
$ curl http://<172.30.226.162:9100>/metrics | grep -vE "^#|^$"
```

## Example output

```
node_arp_entries{device="eth0"} 1
node_boot_time_seconds 1.643153218e+09
node_context_switches_total 4.4938158e+07
node_cooling_device_cur_state{name="0",type="Processor"} 0
node_cooling_device_max_state{name="0",type="Processor"} 0
node_cpu_guest_seconds_total{cpu="0",mode="nice"} 0
node_cpu_guest_seconds_total{cpu="0",mode="user"} 0
node_cpu_seconds_total{cpu="0",mode="idle"} 1.10586485e+06
node_cpu_seconds_total{cpu="0",mode="iowait"} 37.61
node_cpu_seconds_total{cpu="0",mode="irq"} 233.91
node_cpu_seconds_total{cpu="0",mode="nice"} 551.47
node_cpu_seconds_total{cpu="0",mode="softirq"} 87.3
node_cpu_seconds_total{cpu="0",mode="steal"} 86.12
node_cpu_seconds_total{cpu="0",mode="system"} 464.15
```

```

node_cpu_seconds_total{cpu="0",mode="user"} 1075.2
node_disk_discard_time_seconds_total{device="vda"} 0
node_disk_discard_time_seconds_total{device="vdb"} 0
node_disk_discarded_sectors_total{device="vda"} 0
node_disk_discarded_sectors_total{device="vdb"} 0
node_disk_discards_completed_total{device="vda"} 0
node_disk_discards_completed_total{device="vdb"} 0
node_disk_discards_merged_total{device="vda"} 0
node_disk_discards_merged_total{device="vdb"} 0
node_disk_info{device="vda",major="252",minor="0"} 1
node_disk_info{device="vdb",major="252",minor="16"} 1
node_disk_io_now{device="vda"} 0
node_disk_io_now{device="vdb"} 0
node_disk_io_time_seconds_total{device="vda"} 174
node_disk_io_time_seconds_total{device="vdb"} 0.054
node_disk_io_time_weighted_seconds_total{device="vda"} 259.79200000000003
node_disk_io_time_weighted_seconds_total{device="vdb"} 0.039
node_disk_read_bytes_total{device="vda"} 3.71867136e+08
node_disk_read_bytes_total{device="vdb"} 366592
node_disk_read_time_seconds_total{device="vda"} 19.128
node_disk_read_time_seconds_total{device="vdb"} 0.039
node_disk_reads_completed_total{device="vda"} 5619
node_disk_reads_completed_total{device="vdb"} 96
node_disk_reads_merged_total{device="vda"} 5
node_disk_reads_merged_total{device="vdb"} 0
node_disk_write_time_seconds_total{device="vda"} 240.66400000000002
node_disk_write_time_seconds_total{device="vdb"} 0
node_disk_writes_completed_total{device="vda"} 71584
node_disk_writes_completed_total{device="vdb"} 0
node_disk_writes_merged_total{device="vda"} 19761
node_disk_writes_merged_total{device="vdb"} 0
node_disk_written_bytes_total{device="vda"} 2.007924224e+09
node_disk_written_bytes_total{device="vdb"} 0

```

#### 14.3.4.4. Creating a ServiceMonitor resource for the node exporter service

You can use a Prometheus client library and scrape metrics from the `/metrics` endpoint to access and view the metrics exposed by the node-exporter service. Use a **ServiceMonitor** custom resource definition (CRD) to monitor the node exporter service.

##### Prerequisites

- You have access to the cluster as a user with **cluster-admin** privileges or the **monitoring-edit** role.
- You have enabled monitoring for the user-defined project by configuring the node-exporter service.

##### Procedure

1. Create a YAML file for the **ServiceMonitor** resource configuration. In this example, the service monitor matches any service with the label **metrics** and queries the **exmet** port every 30 seconds.

```

apiVersion: monitoring.coreos.com/v1

```

```

kind: ServiceMonitor
metadata:
  labels:
    k8s-app: node-exporter-metrics-monitor
  name: node-exporter-metrics-monitor 1
  namespace: dynamation 2
spec:
  endpoints:
    - interval: 30s 3
      port: exmet 4
      scheme: http
  selector:
    matchLabels:
      servicetype: metrics

```

- 1** The name of the **ServiceMonitor**.
- 2** The namespace where the **ServiceMonitor** is created.
- 3** The interval at which the port will be queried.
- 4** The name of the port that is queried every 30 seconds

## 2. Create the **ServiceMonitor** configuration for the node-exporter service.

```
$ oc create -f node-exporter-metrics-monitor.yaml
```

### 14.3.4.4.1. Accessing the node exporter service outside the cluster

You can access the node-exporter service outside the cluster and view the exposed metrics.

#### Prerequisites

- You have access to the cluster as a user with **cluster-admin** privileges or the **monitoring-edit** role.
- You have enabled monitoring for the user-defined project by configuring the node-exporter service.

#### Procedure

1. Expose the node-exporter service.

```
$ oc expose service -n <namespace> <node_exporter_service_name>
```

2. Obtain the FQDN (Fully Qualified Domain Name) for the route.

```
$ oc get route -o=custom-columns=NAME:.metadata.name,DNS:.spec.host
```

#### Example output

| NAME                  | DNS                                                       |
|-----------------------|-----------------------------------------------------------|
| node-exporter-service | node-exporter-service-dynamation.apps.cluster.example.org |

- 3. Use the **curl** command to display metrics for the node-exporter service.

```
$ curl -s http://node-exporter-service-dynamation.apps.cluster.example.org/metrics
```

### Example output

```
go_gc_duration_seconds{quantile="0"} 1.5382e-05
go_gc_duration_seconds{quantile="0.25"} 3.1163e-05
go_gc_duration_seconds{quantile="0.5"} 3.8546e-05
go_gc_duration_seconds{quantile="0.75"} 4.9139e-05
go_gc_duration_seconds{quantile="1"} 0.000189423
```

#### 14.3.4.5. Additional resources

- [Configuring the monitoring stack](#)
- [Enabling monitoring for user-defined projects](#)
- [Managing metrics](#)
- [Reviewing monitoring dashboards](#)
- [Monitoring application health by using health checks](#)
- [Creating and using config maps](#)
- [Controlling virtual machine states](#)

#### 14.3.5. Virtual machine health checks

You can configure virtual machine (VM) health checks by defining readiness and liveness probes in the **VirtualMachine** resource.

##### 14.3.5.1. About readiness and liveness probes

Use readiness and liveness probes to detect and handle unhealthy virtual machines (VMs). You can include one or more probes in the specification of the VM to ensure that traffic does not reach a VM that is not ready for it and that a new VM is created when a VM becomes unresponsive.

A *readiness probe* determines whether a VM is ready to accept service requests. If the probe fails, the VM is removed from the list of available endpoints until the VM is ready.

A *liveness probe* determines whether a VM is responsive. If the probe fails, the VM is deleted and a new VM is created to restore responsiveness.

You can configure readiness and liveness probes by setting the **spec.readinessProbe** and the **spec.livenessProbe** fields of the **VirtualMachine** object. These fields support the following tests:

##### HTTP GET

The probe determines the health of the VM by using a web hook. The test is successful if the HTTP response code is between 200 and 399. You can use an HTTP GET test with applications that return HTTP status codes when they are completely initialized.

##### TCP socket

The probe attempts to open a socket to the VM. The VM is only considered healthy if the probe can establish a connection. You can use a TCP socket test with applications that do not start listening until initialization is complete.

### Guest agent ping

The probe uses the **guest-ping** command to determine if the QEMU guest agent is running on the virtual machine.

#### 14.3.5.1.1. Defining an HTTP readiness probe

Define an HTTP readiness probe by setting the **spec.readinessProbe.httpGet** field of the virtual machine (VM) configuration.

### Procedure

- Include details of the readiness probe in the VM configuration file.

#### Sample readiness probe with an HTTP GET test

```
# ...
spec:
readinessProbe:
  httpGet: ①
    port: 1500 ②
    path: /healthz ③
  httpHeaders:
    - name: Custom-Header
      value: Awesome
  initialDelaySeconds: 120 ④
  periodSeconds: 20 ⑤
  timeoutSeconds: 10 ⑥
  failureThreshold: 3 ⑦
  successThreshold: 3 ⑧
# ...
```

- ① The HTTP GET request to perform to connect to the VM.
- ② The port of the VM that the probe queries. In the above example, the probe queries port 1500.
- ③ The path to access on the HTTP server. In the above example, if the handler for the server's /healthz path returns a success code, the VM is considered to be healthy. If the handler returns a failure code, the VM is removed from the list of available endpoints.
- ④ The time, in seconds, after the VM starts before the readiness probe is initiated.
- ⑤ The delay, in seconds, between performing probes. The default delay is 10 seconds. This value must be greater than **timeoutSeconds**.
- ⑥ The number of seconds of inactivity after which the probe times out and the VM is assumed to have failed. The default value is 1. This value must be lower than **periodSeconds**.
- ⑦ The number of times that the probe is allowed to fail. The default is 3. After the specified number of attempts, the pod is marked **Unready**.

- 8** The number of times that the probe must report success, after a failure, to be considered successful. The default is 1.

- Create the VM by running the following command:

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

#### 14.3.5.1.2. Defining a TCP readiness probe

Define a TCP readiness probe by setting the **spec.readinessProbe.tcpSocket** field of the virtual machine (VM) configuration.

#### Procedure

- Include details of the TCP readiness probe in the VM configuration file.

##### Sample readiness probe with a TCP socket test

```
# ...
spec:
readinessProbe:
  initialDelaySeconds: 120 1
  periodSeconds: 20 2
  tcpSocket: 3
  port: 1500 4
  timeoutSeconds: 10 5
# ...
```

- 1** The time, in seconds, after the VM starts before the readiness probe is initiated.
- 2** The delay, in seconds, between performing probes. The default delay is 10 seconds. This value must be greater than **timeoutSeconds**.
- 3** The TCP action to perform.
- 4** The port of the VM that the probe queries.
- 5** The number of seconds of inactivity after which the probe times out and the VM is assumed to have failed. The default value is 1. This value must be lower than **periodSeconds**.

- Create the VM by running the following command:

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

#### 14.3.5.1.3. Defining an HTTP liveness probe

Define an HTTP liveness probe by setting the **spec.livenessProbe.httpGet** field of the virtual machine (VM) configuration. You can define both HTTP and TCP tests for liveness probes in the same way as readiness probes. This procedure configures a sample liveness probe with an HTTP GET test.

## Procedure

- Include details of the HTTP liveness probe in the VM configuration file.

### Sample liveness probe with an HTTP GET test

```
# ...
spec:
livenessProbe:
  initialDelaySeconds: 120 ①
  periodSeconds: 20 ②
  httpGet: ③
    port: 1500 ④
    path: /healthz ⑤
    httpHeaders:
      - name: Custom-Header
        value: Awesome
  timeoutSeconds: 10 ⑥
# ...
```

- ① The time, in seconds, after the VM starts before the liveness probe is initiated.
- ② The delay, in seconds, between performing probes. The default delay is 10 seconds. This value must be greater than **timeoutSeconds**.
- ③ The HTTP GET request to perform to connect to the VM.
- ④ The port of the VM that the probe queries. In the above example, the probe queries port 1500. The VM installs and runs a minimal HTTP server on port 1500 via cloud-init.
- ⑤ The path to access on the HTTP server. In the above example, if the handler for the server's **/healthz** path returns a success code, the VM is considered to be healthy. If the handler returns a failure code, the VM is deleted and a new VM is created.
- ⑥ The number of seconds of inactivity after which the probe times out and the VM is assumed to have failed. The default value is 1. This value must be lower than **periodSeconds**.

- Create the VM by running the following command:

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

### 14.3.5.2. Defining a watchdog

You can define a watchdog to monitor the health of the guest operating system by performing the following steps:

- Configure a watchdog device for the virtual machine (VM).
- Install the watchdog agent on the guest.

The watchdog device monitors the agent and performs one of the following actions if the guest operating system is unresponsive:

- **poweroff**: The VM powers down immediately. If **spec.running** is set to **true** or **spec.runStrategy** is not set to **manual**, then the VM reboots.
- **reset**: The VM reboots in place and the guest operating system cannot react.

**NOTE**

The reboot time might cause liveness probes to time out. If cluster-level protections detect a failed liveness probe, the VM might be forcibly rescheduled, increasing the reboot time.

- **shutdown**: The VM gracefully powers down by stopping all services.

**NOTE**

Watchdog is not available for Windows VMs.

#### 14.3.5.2.1. Configuring a watchdog device for the virtual machine

You configure a watchdog device for the virtual machine (VM).

##### Prerequisites

- The VM must have kernel support for an **i6300esb** watchdog device. Red Hat Enterprise Linux (RHEL) images support **i6300esb**.

##### Procedure

- 1 Create a **YAML** file with the following contents:

```
apiVersion: kubevirt.io/v1
kind: VirtualMachine
metadata:
  labels:
    kubevirt.io/vm: vm2-rhel84-watchdog
  name: <vm-name>
spec:
  running: false
  template:
    metadata:
      labels:
        kubevirt.io/vm: vm2-rhel84-watchdog
    spec:
      domain:
        devices:
          watchdog:
            name: <watchdog>
            i6300esb:
              action: "poweroff" ①
# ...
```

- 1 Specify **poweroff**, **reset**, or **shutdown**.

The example above configures the **i6300esb** watchdog device on a RHEL8 VM with the poweroff action and exposes the device as **/dev/watchdog**.

This device can now be used by the watchdog binary.

2. Apply the YAML file to your cluster by running the following command:

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



### IMPORTANT

This procedure is provided for testing watchdog functionality only and must not be run on production machines.

1. Run the following command to verify that the VM is connected to the watchdog device:

```
$ lspci | grep watchdog -i
```

2. Run one of the following commands to confirm the watchdog is active:

- Trigger a kernel panic:

```
# echo c > /proc/sysrq-trigger
```

- Stop the watchdog service:

```
# pkill -9 watchdog
```

#### 14.3.5.2.2. Installing the watchdog agent on the guest

You install the watchdog agent on the guest and start the **watchdog** service.

##### Procedure

1. Log in to the virtual machine as root user.
2. Install the **watchdog** package and its dependencies:

```
# yum install watchdog
```

3. Uncomment the following line in the **/etc/watchdog.conf** file and save the changes:

```
#watchdog-device = /dev/watchdog
```

4. Enable the **watchdog** service to start on boot:

```
# systemctl enable --now watchdog.service
```

#### 14.3.5.3. Defining a guest agent ping probe

Define a guest agent ping probe by setting the **spec.readinessProbe.guestAgentPing** field of the virtual machine (VM) configuration.



## IMPORTANT

The guest agent ping probe 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](#).

### Prerequisites

- The QEMU guest agent must be installed and enabled on the virtual machine.

### Procedure

1. Include details of the guest agent ping probe in the VM configuration file. For example:

#### Sample guest agent ping probe

```
# ...
spec:
readinessProbe:
  guestAgentPing: {} ①
  initialDelaySeconds: 120 ②
  periodSeconds: 20 ③
  timeoutSeconds: 10 ④
  failureThreshold: 3 ⑤
  successThreshold: 3 ⑥
# ...
```

- 1 The guest agent ping probe to connect to the VM.
- 2 Optional: The time, in seconds, after the VM starts before the guest agent probe is initiated.
- 3 Optional: The delay, in seconds, between performing probes. The default delay is 10 seconds. This value must be greater than **timeoutSeconds**.
- 4 Optional: The number of seconds of inactivity after which the probe times out and the VM is assumed to have failed. The default value is 1. This value must be lower than **periodSeconds**.
- 5 Optional: The number of times that the probe is allowed to fail. The default is 3. After the specified number of attempts, the pod is marked **Unready**.
- 6 Optional: The number of times that the probe must report success, after a failure, to be considered successful. The default is 1.

2. Create the VM by running the following command:

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

#### 14.3.5.4. Additional resources

- [Monitoring application health by using health checks](#)

## 14.4. TROUBLESHOOTING

OpenShift Virtualization provides tools and logs for troubleshooting virtual machines and virtualization components.

You can troubleshoot OpenShift Virtualization components by using the [tools provided in the web console](#) or by using the `oc` CLI tool.

### 14.4.1. Events

[OpenShift Container Platform events](#) are records of important life-cycle information and are useful for monitoring and troubleshooting virtual machine, namespace, and resource issues.

- VM events: Navigate to the [Events tab](#) of the [VirtualMachine details](#) page in the web console.

#### Namespace events

You can view namespace events by running the following command:

```
$ oc get events -n <namespace>
```

See the [list of events](#) for details about specific events.

#### Resource events

You can view resource events by running the following command:

```
$ oc describe <resource> <resource_name>
```

### 14.4.2. Logs

You can review the following logs for troubleshooting:

- [Virtual machine](#)
- [OpenShift Virtualization pod](#)
- [Aggregated OpenShift Virtualization logs](#)

#### 14.4.2.1. Viewing virtual machine logs with the web console

You can view virtual machine logs with the OpenShift Container Platform web console.

##### Procedure

1. Navigate to **Virtualization** → **VirtualMachines**.
2. Select a virtual machine to open the **VirtualMachine details** page.
3. On the **Details** tab, click the pod name to open the **Pod details** page.

- Click the **Logs** tab to view the logs.

#### 14.4.2.2. Viewing OpenShift Virtualization pod logs

You can view logs for OpenShift Virtualization pods by using the **oc** CLI tool.

You can configure the verbosity level of the logs by editing the **HyperConverged** custom resource (CR).

##### 14.4.2.2.1. Viewing OpenShift Virtualization pod logs with the CLI

You can view logs for the OpenShift Virtualization pods by using the **oc** CLI tool.

#### Procedure

- View a list of pods in the OpenShift Virtualization namespace by running the following command:

```
$ oc get pods -n openshift-cnv
```

#### Example 14.3. Example output

| NAME                             | READY | STATUS  | RESTARTS | AGE |
|----------------------------------|-------|---------|----------|-----|
| disks-images-provider-7gqbc      | 1/1   | Running | 0        | 32m |
| disks-images-provider-vg4kx      | 1/1   | Running | 0        | 32m |
| virt-api-57fcc4497b-7qfmc        | 1/1   | Running | 0        | 31m |
| virt-api-57fcc4497b-tx9nc        | 1/1   | Running | 0        | 31m |
| virt-controller-76c784655f-7fp6m | 1/1   | Running | 0        | 30m |
| virt-controller-76c784655f-f4pbd | 1/1   | Running | 0        | 30m |
| virt-handler-2m86x               | 1/1   | Running | 0        | 30m |
| virt-handler-9qs6z               | 1/1   | Running | 0        | 30m |
| virt-operator-7ccfdbf65f-q5snk   | 1/1   | Running | 0        | 32m |
| virt-operator-7ccfdbf65f-vllz8   | 1/1   | Running | 0        | 32m |

- View the pod log by running the following command:

```
$ oc logs -n openshift-cnv <pod_name>
```



#### NOTE

If a pod fails to start, you can use the **--previous** option to view logs from the last attempt.

To monitor log output in real time, use the **-f** option.

#### Example 14.4. Example output

```
{"component":"virt-handler","level":"info","msg":"set verbosity to 2","pos":"virt-handler.go:453","timestamp":"2022-04-17T08:58:37.373695Z"}  
{"component":"virt-handler","level":"info","msg":"set verbosity to 2","pos":"virt-handler.go:453","timestamp":"2022-04-17T08:58:37.373726Z"}
```

```
{"component":"virt-handler","level":"info","msg":"setting rate limiter to 5 QPS and 10 Burst","pos":"virt-handler.go:462","timestamp":"2022-04-17T08:58:37.373782Z"}  
{"component":"virt-handler","level":"info","msg":"CPU features of a minimum baseline CPU model: map[apic:true clflush:true cmov:true cx16:true cx8:true de:true fpu:true fxsr:true lahf_lm:true lm:true mca:true mce:true mmx:true msr:true mttr:true nx:true pae:true pat:true pge:true pni:true pse:true pse36:true sep:true sse:true sse2:true sse4.1:true ssse3:true syscall:true tsc:true]","pos":"cpu_plugin.go:96","timestamp":"2022-04-17T08:58:37.390221Z"}  
{"component":"virt-handler","level":"warning","msg":"host model mode is expected to contain only one model!","pos":"cpu_plugin.go:103","timestamp":"2022-04-17T08:58:37.390263Z"}  
{"component":"virt-handler","level":"info","msg":"node-labeller is running","pos":"node_labeller.go:94","timestamp":"2022-04-17T08:58:37.391011Z"}
```

#### 14.4.2.2.2. Configuring OpenShift Virtualization pod log verbosity

You can configure the verbosity level of OpenShift Virtualization pod logs by editing the **HyperConverged** custom resource (CR).

##### Procedure

- To set log verbosity for specific components, open the **HyperConverged** CR in your default text editor by running the following command:

```
$ oc edit hyperconverged kubevirt-hyperconverged -n openshift-cnv
```

- Set the log level for one or more components by editing the **spec.logVerbosityConfig** stanza. For example:

```
apiVersion: hco.kubevirt.io/v1beta1  
kind: HyperConverged  
metadata:  
  name: kubevirt-hyperconverged  
spec:  
  logVerbosityConfig:  
    kubevirt:  
      virtAPI: 5 ①  
      virtController: 4  
      virtHandler: 3  
      virtLauncher: 2  
      virtOperator: 6
```

- ① The log verbosity value must be an integer in the range **1–9**, where a higher number indicates a more detailed log. In this example, the **virtAPI** component logs are exposed if their priority level is **5** or higher.

- Apply your changes by saving and exiting the editor.

#### 14.4.2.2.3. Common error messages

The following error messages might appear in OpenShift Virtualization logs:

## ErrImagePull or ImagePullBackOff

Indicates an incorrect deployment configuration or problems with the images that are referenced.

### 14.4.2.3. Viewing aggregated OpenShift Virtualization logs with the LokiStack

You can view aggregated logs for OpenShift Virtualization pods and containers by using the LokiStack in the web console.

#### Prerequisites

- You deployed the LokiStack.

#### Procedure

1. Navigate to **Observe** → **Logs** in the web console.
2. Select **application**, for **virt-launcher** pod logs, or **infrastructure**, for OpenShift Virtualization control plane pods and containers, from the log type list.
3. Click **Show Query** to display the query field.
4. Enter the LogQL query in the query field and click **Run Query** to display the filtered logs.

#### 14.4.2.3.1. OpenShift Virtualization LogQL queries

You can view and filter aggregated logs for OpenShift Virtualization components by running Loki Query Language (LogQL) queries on the **Observe** → **Logs** page in the web console.

The default log type is *infrastructure*. The **virt-launcher** log type is *application*.

Optional: You can include or exclude strings or regular expressions by using line filter expressions.



#### NOTE

If the query matches a large number of logs, the query might time out.

**Table 14.4. OpenShift Virtualization LogQL example queries**

| Component                                                            | LogQL query                                                                                                                                                     |
|----------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| All                                                                  | <pre>{log_type=~".+"} json  kubernetes_labels_app_kubernetes_io_part_of="hyperconverged-cluster"</pre>                                                          |
| <b>cdi-apiserver</b><br><b>cdi-deployment</b><br><b>cdi-operator</b> | <pre>{log_type=~".+"} json  kubernetes_labels_app_kubernetes_io_part_of="hyperconverged-cluster"  kubernetes_labels_app_kubernetes_io_component="storage"</pre> |

| Component              | LogQL query                                                                                                                                                  |
|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>hco-operator</b>    | {log_type=~".+"}json<br> kubernetes_labels_app_kubernetes_io_part_of="hyperconverged-cluster"<br> kubernetes_labels_app_kubernetes_io_component="deployment" |
| <b>kubemacpool</b>     | {log_type=~".+"}json<br> kubernetes_labels_app_kubernetes_io_part_of="hyperconverged-cluster"<br> kubernetes_labels_app_kubernetes_io_component="network"    |
| <b>virt-api</b>        | {log_type=~".+"}json                                                                                                                                         |
| <b>virt-controller</b> | kubernetes_labels_app_kubernetes_io_part_of="hyperconverged-cluster"<br> kubernetes_labels_app_kubernetes_io_component="compute"                             |
| <b>virt-handler</b>    |                                                                                                                                                              |
| <b>virt-operator</b>   |                                                                                                                                                              |
| <b>ssp-operator</b>    | {log_type=~".+"}json<br> kubernetes_labels_app_kubernetes_io_part_of="hyperconverged-cluster"<br> kubernetes_labels_app_kubernetes_io_component="schedule"   |
| Container              | {log_type=~".+",kubernetes_container_name=~"<container> <container>"} ①<br> json kubernetes_labels_app_kubernetes_io_part_of="hyperconverged-cluster"        |
|                        | ① Specify one or more containers separated by a pipe ( ).                                                                                                    |
| <b>virt-launcher</b>   | You must select <b>application</b> from the log type list before running this query.                                                                         |
|                        | {log_type=~".+", kubernetes_container_name="compute"}json<br> != "custom-ga-command" ①                                                                       |
|                        | ① <b>!= "custom-ga-command"</b> excludes libvirt logs that contain the string <b>custom-ga-command</b> . ( <a href="#">BZ#2177684</a> )                      |

You can filter log lines to include or exclude strings or regular expressions by using line filter expressions.

Table 14.5. Line filter expressions

| Line filter expression           | Description                                  |
|----------------------------------|----------------------------------------------|
| <code> = "&lt;string&gt;"</code> | Log line contains string                     |
| <code>!= "&lt;string&gt;"</code> | Log line does not contain string             |
| <code> ~ "&lt;regex&gt;"</code>  | Log line contains regular expression         |
| <code>!~ "&lt;regex&gt;"</code>  | Log line does not contain regular expression |

### Example line filter expression

```
{log_type=~".+"}json
|kubernetes_labels_app_kubernetes_io_part_of="hyperconverged-cluster"
|= "error" != "timeout"
```

#### 14.4.2.3.2. Additional resources for LokiStack and LogQL

- [About the LokiStack](#)
- [Deploying the LokiStack](#) on OpenShift Container Platform
- [LogQL log queries](#) in the Grafana documentation

### 14.4.3. Troubleshooting data volumes

You can check the **Conditions** and **Events** sections of the **DataVolume** object to analyze and resolve issues.

#### 14.4.3.1. About data volume conditions and events

You can diagnose data volume issues by examining the output of the **Conditions** and **Events** sections generated by the command:

```
$ oc describe dv <DataVolume>
```

The **Conditions** section displays the following **Types**:

- **Bound**
- **Running**
- **Ready**

The **Events** section provides the following additional information:

- **Type** of event
- **Reason** for logging

- **Source** of the event
- **Message** containing additional diagnostic information.

The output from **oc describe** does not always contain **Events**.

An event is generated when the **Status**, **Reason**, or **Message** changes. Both conditions and events react to changes in the state of the data volume.

For example, if you misspell the URL during an import operation, the import generates a 404 message. That message change generates an event with a reason. The output in the **Conditions** section is updated as well.

#### 14.4.3.2. Analyzing data volume conditions and events

By inspecting the **Conditions** and **Events** sections generated by the **describe** command, you determine the state of the data volume in relation to persistent volume claims (PVCs), and whether or not an operation is actively running or completed. You might also receive messages that offer specific details about the status of the data volume, and how it came to be in its current state.

There are many different combinations of conditions. Each must be evaluated in its unique context.

Examples of various combinations follow.

- **Bound** – A successfully bound PVC displays in this example.

Note that the **Type** is **Bound**, so the **Status** is **True**. If the PVC is not bound, the **Status** is **False**.

When the PVC is bound, an event is generated stating that the PVC is bound. In this case, the **Reason** is **Bound** and **Status** is **True**. The **Message** indicates which PVC owns the data volume.

**Message**, in the **Events** section, provides further details including how long the PVC has been bound (**Age**) and by what resource (**From**), in this case **datavolume-controller**:

#### Example output

```

Status:
Conditions:
  Last Heart Beat Time: 2020-07-15T03:58:24Z
  Last Transition Time: 2020-07-15T03:58:24Z
  Message:           PVC win10-rootdisk Bound
  Reason:            Bound
  Status:            True
  Type:              Bound
...
Events:
  Type  Reason  Age   From          Message
  ----  -----  ---  ----- 
  Normal Bound  24s  datavolume-controller PVC example-dv Bound

```

- **Running** – In this case, note that **Type** is **Running** and **Status** is **False**, indicating that an event has occurred that caused an attempted operation to fail, changing the Status from **True** to **False**. However, note that **Reason** is **Completed** and the **Message** field indicates **Import Complete**.

In the **Events** section, the **Reason** and **Message** contain additional troubleshooting information about the failed operation. In this example, the **Message** displays an inability to connect due to a **404**, listed in the **Events** section's first **Warning**.

From this information, you conclude that an import operation was running, creating contention for other operations that are attempting to access the data volume:

### Example output

```
Status:
Conditions:
Last Heart Beat Time: 2020-07-15T04:31:39Z
Last Transition Time: 2020-07-15T04:31:39Z
Message: Import Complete
Reason: Completed
Status: False
Type: Running
...
Events:
Type Reason Age From Message
--- --- --- -----
Warning Error 12s (x2 over 14s) datavolume-controller Unable to connect
to http data source: expected status code 200, got 404. Status: 404 Not Found
```

- **Ready** – If **Type** is **Ready** and **Status** is **True**, then the data volume is ready to be used, as in the following example. If the data volume is not ready to be used, the **Status** is **False**:

### Example output

```
Status:
Conditions:
Last Heart Beat Time: 2020-07-15T04:31:39Z
Last Transition Time: 2020-07-15T04:31:39Z
Status: True
Type: Ready
```

## 14.5. OPENSPLIT VIRTUALIZATION RUNBOOKS

You can use the procedures in these runbooks to diagnose and resolve issues that trigger OpenShift Virtualization [alerts](#).

OpenShift Virtualization alerts are displayed on the [Virtualization](#) → [Overview](#) → [Overview](#) tab in the web console.

### 14.5.1. CDIDataImportCronOutdated

#### Meaning

This alert fires when **DataImportCron** cannot poll or import the latest disk image versions.

**DataImportCron** polls disk images, checking for the latest versions, and imports the images as persistent volume claims (PVCs). This process ensures that PVCs are updated to the latest version so that they can be used as reliable clone sources or golden images for virtual machines (VMs).

For golden images, *latest* refers to the latest operating system of the distribution. For other disk images, *latest* refers to the latest hash of the image that is available.

## Impact

VMs might be created from outdated disk images.

VMs might fail to start because no source PVC is available for cloning.

## Diagnosis

1. Check the cluster for a default storage class:

```
$ oc get sc
```

The output displays the storage classes with **(default)** beside the name of the default storage class. You must set a default storage class, either on the cluster or in the **DataImportCron** specification, in order for the **DataImportCron** to poll and import golden images. If no storage class is defined, the DataVolume controller fails to create PVCs and the following event is displayed: **DataVolume.storage spec is missing accessMode and no storageClass to choose profile**.

2. Obtain the **DataImportCron** namespace and name:

```
$ oc get dataimportcron -A -o json | jq -r '.items[] | \
select(.status.conditions[] | select(.type == "UpToDate" and \
.status == "False")) | .metadata.namespace + "/" + .metadata.name'
```

3. If a default storage class is not defined on the cluster, check the **DataImportCron** specification for a default storage class:

```
$ oc get dataimportcron <dataimportcron> -o yaml | \
grep -B 5 storageClassName
```

## Example output

```
url: docker://.../cdi-func-test-tinycore
storage:
  resources:
    requests:
      storage: 5Gi
  storageClassName: rook-ceph-block
```

4. Obtain the name of the **DataVolume** associated with the **DataImportCron** object:

```
$ oc -n <namespace> get dataimportcron <dataimportcron> -o json | \
jq .status.lastImportedPVC.name
```

5. Check the **DataVolume** log for error messages:

```
$ oc -n <namespace> get dv <datavolume> -o yaml
```

6. Set the **CDI\_NAMESPACE** environment variable:

```
$ export CDI_NAMESPACE="$(oc get deployment -A | \
grep cdi-operator | awk '{print $1}')"
```

7. Check the **cdi-deployment** log for error messages:

```
$ oc logs -n $CDI_NAMESPACE deployment/cdi-deployment
```

## Mitigation

1. Set a default storage class, either on the cluster or in the **DataImportCron** specification, to poll and import golden images. The updated Containerized Data Importer (CDI) will resolve the issue within a few seconds.
2. If the issue does not resolve itself, delete the data volumes associated with the affected **DataImportCron** objects. The CDI will recreate the data volumes with the default storage class.
3. If your cluster is installed in a restricted network environment, disable the **enableCommonBootImageImport** feature gate in order to opt out of automatic updates:

```
$ oc patch hco kubevirt-hyperconverged -n $CDI_NAMESPACE --type json \
-p '[{"op": "replace", "path": \
"/spec/featureGates/enableCommonBootImageImport", "value": false}]'
```

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the diagnosis procedure.

### 14.5.2. CDIDataVolumeUnusualRestartCount

#### Meaning

This alert fires when a **DataVolume** object restarts more than three times.

#### Impact

Data volumes are responsible for importing and creating a virtual machine disk on a persistent volume claim. If a data volume restarts more than three times, these operations are unlikely to succeed. You must diagnose and resolve the issue.

#### Diagnosis

1. Obtain the name and namespace of the data volume:

```
$ oc get dv -A -o json | jq -r '.items[] | \
select(.status.restartCount>3)' | jq '.metadata.name, .metadata.namespace'
```

2. Check the status of the pods associated with the data volume:

```
$ oc get pods -n <namespace> -o json | jq -r '.items[] | \
select(.metadata.ownerReferences[] | \
select(.name=="<dv_name>").metadata.name'
```

3. Obtain the details of the pods:

```
$ oc -n <namespace> describe pods <pod>
```

4. Check the pod logs for error messages:

```
$ oc -n <namespace> describe logs <pod>
```

### Mitigation

Delete the data volume, resolve the issue, and create a new data volume.

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the diagnosis procedure.

## 14.5.3. CDINotReady

### Meaning

This alert fires when the Containerized Data Importer (CDI) is in a degraded state:

- Not progressing
- Not available to use

### Impact

CDI is not usable, so users cannot build virtual machine disks on persistent volume claims (PVCs) using CDI's data volumes. CDI components are not ready and they stopped progressing towards a ready state.

### Diagnosis

1. Set the **CDI\_NAMESPACE** environment variable:

```
$ export CDI_NAMESPACE=$(oc get deployment -A | \
grep cdi-operator | awk '{print $1}')"
```

2. Check the CDI deployment for components that are not ready:

```
$ oc -n $CDI_NAMESPACE get deploy -l cdi.kubevirt.io
```

3. Check the details of the failing pod:

```
$ oc -n $CDI_NAMESPACE describe pods <pod>
```

4. Check the logs of the failing pod:

```
$ oc -n $CDI_NAMESPACE logs <pod>
```

### Mitigation

Try to identify the root cause and resolve the issue.

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the diagnosis procedure.

## 14.5.4. CDIOperatorDown

### Meaning

This alert fires when the Containerized Data Importer (CDI) Operator is down. The CDI Operator deploys and manages the CDI infrastructure components, such as data volume and persistent volume claim (PVC) controllers. These controllers help users build virtual machine disks on PVCs.

### Impact

The CDI components might fail to deploy or to stay in a required state. The CDI installation might not function correctly.

## Diagnosis

- Set the **CDI\_NAMESPACE** environment variable:

```
$ export CDI_NAMESPACE=$(oc get deployment -A | grep cdi-operator | \
awk '{print $1}')"
```

- Check whether the **cdi-operator** pod is currently running:

```
$ oc -n $CDI_NAMESPACE get pods -l name=cdi-operator
```

- Obtain the details of the **cdi-operator** pod:

```
$ oc -n $CDI_NAMESPACE describe pods -l name=cdi-operator
```

- Check the log of the **cdi-operator** pod for errors:

```
$ oc -n $CDI_NAMESPACE logs -l name=cdi-operator
```

## Mitigation

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the diagnosis procedure.

### 14.5.5. CDIStorageProfilesIncomplete

#### Meaning

This alert fires when a Containerized Data Importer (CDI) storage profile is incomplete.

If a storage profile is incomplete, the CDI cannot infer persistent volume claim (PVC) fields, such as **volumeMode** and **accessModes**, which are required to create a virtual machine (VM) disk.

#### Impact

The CDI cannot create a VM disk on the PVC.

## Diagnosis

- Identify the incomplete storage profile:

```
$ oc get storageprofile <storage_class>
```

## Mitigation

- Add the missing storage profile information as in the following example:

```
$ oc patch storageprofile local --type=merge -p '{"spec": \
{"claimPropertySets": [{"accessModes": ["ReadWriteOnce"], \
"volumeMode": "Filesystem"}]}'}'
```

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the diagnosis procedure.

## 14.5.6. CnaoDown

### Meaning

This alert fires when the Cluster Network Addons Operator (CNAO) is down. The CNAO deploys additional networking components on top of the cluster.

### Impact

If the CNAO is not running, the cluster cannot reconcile changes to virtual machine components. As a result, the changes might fail to take effect.

### Diagnosis

1. Set the **NAMESPACE** environment variable:

```
$ export NAMESPACE=$(oc get deployment -A | \
grep cluster-network-addons-operator | awk '{print $1}')"
```

2. Check the status of the **cluster-network-addons-operator** pod:

```
$ oc -n $NAMESPACE get pods -l name=cluster-network-addons-operator
```

3. Check the **cluster-network-addons-operator** logs for error messages:

```
$ oc -n $NAMESPACE logs -l name=cluster-network-addons-operator
```

4. Obtain the details of the **cluster-network-addons-operator** pods:

```
$ oc -n $NAMESPACE describe pods -l name=cluster-network-addons-operator
```

### Mitigation

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the diagnosis procedure.

## 14.5.7. HPPNotReady

### Meaning

This alert fires when a hostpath provisioner (HPP) installation is in a degraded state.

The HPP dynamically provisions hostpath volumes to provide storage for persistent volume claims (PVCs).

### Impact

HPP is not usable. Its components are not ready and they are not progressing towards a ready state.

### Diagnosis

1. Set the **HPP\_NAMESPACE** environment variable:

```
$ export HPP_NAMESPACE=$(oc get deployment -A | \
grep hostpath-provisioner-operator | awk '{print $1}')"
```

2. Check for HPP components that are currently not ready:

```
$ oc -n $HPP_NAMESPACE get all -l k8s-app=hostpath-provisioner
```

3. Obtain the details of the failing pod:

```
$ oc -n $HPP_NAMESPACE describe pods <pod>
```

4. Check the logs of the failing pod:

```
$ oc -n $HPP_NAMESPACE logs <pod>
```

#### Mitigation

Based on the information obtained during the diagnosis procedure, try to identify the root cause and resolve the issue.

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the diagnosis procedure.

### 14.5.8. HPOperatorDown

#### Meaning

This alert fires when the hostpath provisioner (HPP) Operator is down.

The HPP Operator deploys and manages the HPP infrastructure components, such as the daemon set that provisions hostpath volumes.

#### Impact

The HPP components might fail to deploy or to remain in the required state. As a result, the HPP installation might not work correctly in the cluster.

#### Diagnosis

1. Configure the **HPP\_NAMESPACE** environment variable:

```
$ HPP_NAMESPACE=$(oc get deployment -A | grep \
hostpath-provisioner-operator | awk '{print $1}')"
```

2. Check whether the **hostpath-provisioner-operator** pod is currently running:

```
$ oc -n $HPP_NAMESPACE get pods -l name=hostpath-provisioner-operator
```

3. Obtain the details of the **hostpath-provisioner-operator** pod:

```
$ oc -n $HPP_NAMESPACE describe pods -l name=hostpath-provisioner-operator
```

4. Check the log of the **hostpath-provisioner-operator** pod for errors:

```
$ oc -n $HPP_NAMESPACE logs -l name=hostpath-provisioner-operator
```

#### Mitigation

Based on the information obtained during the diagnosis procedure, try to identify the root cause and resolve the issue.

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the diagnosis procedure.

## 14.5.9. HPPSharingPoolWithOS

### Meaning

This alert fires when the hostpath provisioner (HPP) shares a file system with other critical components, such as **kubelet** or the operating system (OS).

HPP dynamically provisions hostpath volumes to provide storage for persistent volume claims (PVCs).

### Impact

A shared hostpath pool puts pressure on the node's disks. The node might have degraded performance and stability.

### Diagnosis

1. Configure the **HPP\_NAMESPACE** environment variable:

```
$ export HPP_NAMESPACE="$(oc get deployment -A | \
grep hostpath-provisioner-operator | awk '{print $1}')"
```

2. Obtain the status of the **hostpath-provisioner-csi** daemon set pods:

```
$ oc -n $HPP_NAMESPACE get pods | grep hostpath-provisioner-csi
```

3. Check the **hostpath-provisioner-csi** logs to identify the shared pool and path:

```
$ oc -n $HPP_NAMESPACE logs <csi_daemonset> -c hostpath-provisioner
```

### Example output

```
I0208 15:21:03.769731      1 utils.go:221] pool (<legacy, csi-data-dir>/csi),  
shares path with OS which can lead to node disk pressure
```

### Mitigation

Using the data obtained in the Diagnosis section, try to prevent the pool path from being shared with the OS. The specific steps vary based on the node and other circumstances.

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the diagnosis procedure.

## 14.5.10. KubeMacPoolDown

### Meaning

**KubeMacPool** is down. **KubeMacPool** is responsible for allocating MAC addresses and preventing MAC address conflicts.

### Impact

If **KubeMacPool** is down, **VirtualMachine** objects cannot be created.

### Diagnosis

1. Set the **KMP\_NAMESPACE** environment variable:

```
$ export KMP_NAMESPACE="$(oc get pod -A --no-headers -l \
control-plane=mac-controller-manager | awk '{print $1}')"
```

- Set the **KMP\_NAME** environment variable:

```
$ export KMP_NAME=$(oc get pod -A --no-headers -l \
control-plane=mac-controller-manager | awk '{print $2}')"
```

- Obtain the **KubeMacPool-manager** pod details:

```
$ oc describe pod -n $KMP_NAMESPACE $KMP_NAME
```

- Check the **KubeMacPool-manager** logs for error messages:

```
$ oc logs -n $KMP_NAMESPACE $KMP_NAME
```

### Mitigation

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the diagnosis procedure.

#### 14.5.11. KubeMacPoolDuplicateMacsFound

##### Meaning

This alert fires when **KubeMacPool** detects duplicate MAC addresses.

**KubeMacPool** is responsible for allocating MAC addresses and preventing MAC address conflicts. When **KubeMacPool** starts, it scans the cluster for the MAC addresses of virtual machines (VMs) in managed namespaces.

##### Impact

Duplicate MAC addresses on the same LAN might cause network issues.

##### Diagnosis

- Obtain the namespace and the name of the **kubemacpool-mac-controller** pod:

```
$ oc get pod -A -l control-plane=mac-controller-manager --no-headers \
-o custom-columns=:metadata.namespace,:metadata.name"
```

- Obtain the duplicate MAC addresses from the **kubemacpool-mac-controller** logs:

```
$ oc logs -n <namespace> <kubemacpool_mac_controller> | \
grep "already allocated"
```

##### Example output

```
mac address 02:00:ff:ff:ff:ff already allocated to
vm/kubemacpool-test/testvm, br1,
conflict with: vm/kubemacpool-test/testvm2, br1
```

### Mitigation

- Update the VMs to remove the duplicate MAC addresses.
- Restart the **kubemacpool-mac-controller** pod:

```
$ oc delete pod -n <namespace> <kubemacpool_mac_controller>
```

## 14.5.12. KubeVirtComponentExceedsRequestedCPU

### Meaning

This alert fires when a component's CPU usage exceeds the requested limit.

### Impact

Usage of CPU resources is not optimal and the node might be overloaded.

### Diagnosis

1. Set the **NAMESPACE** environment variable:

```
$ export NAMESPACE=$(oc get kubevirt -A \
-o custom-columns=""::metadata.namespace)"
```

2. Check the component's CPU request limit:

```
$ oc -n $NAMESPACE get deployment <component> -o yaml | grep requests: -A 2
```

3. Check the actual CPU usage by using a PromQL query:

```
node_namespace_pod_container:container_cpu_usage_seconds_total:sum_rate
{namespace="$NAMESPACE",container="<component>"}
```

See the [Prometheus documentation](#) for more information.

### Mitigation

Update the CPU request limit in the **HCO** custom resource.

## 14.5.13. KubeVirtComponentExceedsRequestedMemory

### Meaning

This alert fires when a component's memory usage exceeds the requested limit.

### Impact

Usage of memory resources is not optimal and the node might be overloaded.

### Diagnosis

1. Set the **NAMESPACE** environment variable:

```
$ export NAMESPACE=$(oc get kubevirt -A \
-o custom-columns=""::metadata.namespace)"
```

2. Check the component's memory request limit:

```
$ oc -n $NAMESPACE get deployment <component> -o yaml | \
grep requests: -A 2
```

3. Check the actual memory usage by using a PromQL query:

```
container_memory_usage_bytes{namespace="$NAMESPACE",container="<component>"}
```

See the [Prometheus documentation](#) for more information.

### Mitigation

Update the memory request limit in the **HCO** custom resource.

## 14.5.14. KubevirtHyperconvergedClusterOperatorCRModification

### Meaning

This alert fires when an operand of the HyperConverged Cluster Operator (HCO) is changed by someone or something other than HCO.

HCO configures OpenShift Virtualization and its supporting operators in an opinionated way and overwrites its operands when there is an unexpected change to them. Users must not modify the operands directly. The **HyperConverged** custom resource is the source of truth for the configuration.

### Impact

Changing the operands manually causes the cluster configuration to fluctuate and might lead to instability.

### Diagnosis

- Check the **component\_name** value in the alert details to determine the operand kind (**kubevirt**) and the operand name (**kubevirt-kubevirt-hyperconverged**) that are being changed:

#### Labels

```
alertname=KubevirtHyperconvergedClusterOperatorCRModification
component_name=kubevirt/kubevirt-kubevirt-hyperconverged
severity=warning
```

### Mitigation

Do not change the HCO operands directly. Use **HyperConverged** objects to configure the cluster.

The alert resolves itself after 10 minutes if the operands are not changed manually.

## 14.5.15. KubevirtHyperconvergedClusterOperatorInstallationNotCompletedAlert

### Meaning

This alert fires when the HyperConverged Cluster Operator (HCO) runs for more than an hour without a **HyperConverged** custom resource (CR).

This alert has the following causes:

- During the installation process, you installed the HCO but you did not create the **HyperConverged** CR.
- During the uninstall process, you removed the **HyperConverged** CR before uninstalling the HCO and the HCO is still running.

### Mitigation

The mitigation depends on whether you are installing or uninstalling the HCO:

- Complete the installation by creating a **HyperConverged** CR with its default values:

```
$ cat <<EOF | oc apply -f -
apiVersion: operators.coreos.com/v1
```

```

kind: OperatorGroup
metadata:
  name: hco-operatorgroup
  namespace: kubevirt-hyperconverged
spec: {}
EOF

```

- Uninstall the HCO. If the uninstall process continues to run, you must resolve that issue in order to cancel the alert.

#### 14.5.16. KubevirtHyperconvergedClusterOperatorUSModification

##### Meaning

This alert fires when a JSON Patch annotation is used to change an operand of the HyperConverged Cluster Operator (HCO).

HCO configures OpenShift Virtualization and its supporting operators in an opinionated way and overwrites its operands when there is an unexpected change to them. Users must not modify the operands directly.

However, if a change is required and it is not supported by the HCO API, you can force HCO to set a change in an operator by using JSON Patch annotations. These changes are not reverted by HCO during its reconciliation process.

##### Impact

Incorrect use of JSON Patch annotations might lead to unexpected results or an unstable environment.

Upgrading a system with JSON Patch annotations is dangerous because the structure of the component custom resources might change.

##### Diagnosis

- Check the **annotation\_name** in the alert details to identify the JSON Patch annotation:

```

Labels
alertname=KubevirtHyperconvergedClusterOperatorUSModification
annotation_name=kubevirt.kubevirt.io/jsonpatch
severity=info

```

##### Mitigation

It is best to use the HCO API to change an operand. However, if the change can only be done with a JSON Patch annotation, proceed with caution.

Remove JSON Patch annotations before upgrade to avoid potential issues.

#### 14.5.17. KubevirtVmHighMemoryUsage

##### Meaning

This alert fires when a container hosting a virtual machine (VM) has less than 20 MB free memory.

##### Impact

The virtual machine running inside the container is terminated by the runtime if the container's memory limit is exceeded.

##### Diagnosis

- Obtain the **virt-launcher** pod details:

```
$ oc get pod <virt-launcher> -o yaml
```

- Identify **compute** container processes with high memory usage in the **virt-launcher** pod:

```
$ oc exec -it <virt-launcher> -c compute -- top
```

## Mitigation

- Increase the memory limit in the **VirtualMachine** specification as in the following example:

```
spec:
  running: false
  template:
    metadata:
      labels:
        kubevirt.io/vm: vm-name
    spec:
      domain:
        resources:
          limits:
            memory: 200Mi
          requests:
            memory: 128Mi
```

### 14.5.18. KubeVirtVMIExcessiveMigrations

#### Meaning

This alert fires when a virtual machine instance (VMI) live migrates more than 12 times over a period of 24 hours.

This migration rate is abnormally high, even during an upgrade. This alert might indicate a problem in the cluster infrastructure, such as network disruptions or insufficient resources.

#### Impact

A virtual machine (VM) that migrates too frequently might experience degraded performance because memory page faults occur during the transition.

#### Diagnosis

- Verify that the worker node has sufficient resources:

```
$ oc get nodes -l node-role.kubernetes.io/worker= -o json | \
  jq .items[].status.allocatable
```

#### Example output

```
{
  "cpu": "3500m",
  "devices.kubevirt.io/kvm": "1k",
  "devices.kubevirt.io/sev": "0",
  "devices.kubevirt.io/tun": "1k",
  "devices.kubevirt.io/vhost-net": "1k",
```

```

    "ephemeral-storage": "38161122446",
    "hugepages-1Gi": "0",
    "hugepages-2Mi": "0",
    "memory": "7000128Ki",
    "pods": "250"
}

```

- Check the status of the worker node:

```
$ oc get nodes -l node-role.kubernetes.io/worker= -o json | \
jq .items[].status.conditions
```

### Example output

```
{
  "lastHeartbeatTime": "2022-05-26T07:36:01Z",
  "lastTransitionTime": "2022-05-23T08:12:02Z",
  "message": "kubelet has sufficient memory available",
  "reason": "KubeletHasSufficientMemory",
  "status": "False",
  "type": "MemoryPressure"
},
{
  "lastHeartbeatTime": "2022-05-26T07:36:01Z",
  "lastTransitionTime": "2022-05-23T08:12:02Z",
  "message": "kubelet has no disk pressure",
  "reason": "KubeletHasNoDiskPressure",
  "status": "False",
  "type": "DiskPressure"
},
{
  "lastHeartbeatTime": "2022-05-26T07:36:01Z",
  "lastTransitionTime": "2022-05-23T08:12:02Z",
  "message": "kubelet has sufficient PID available",
  "reason": "KubeletHasSufficientPID",
  "status": "False",
  "type": "PIDPressure"
},
{
  "lastHeartbeatTime": "2022-05-26T07:36:01Z",
  "lastTransitionTime": "2022-05-23T08:24:15Z",
  "message": "kubelet is posting ready status",
  "reason": "KubeletReady",
  "status": "True",
  "type": "Ready"
}
```

- Log in to the worker node and verify that the **kubelet** service is running:

```
$ systemctl status kubelet
```

- Check the **kubelet** journal log for error messages:

```
$ journalctl -r -u kubelet
```

## Mitigation

Ensure that the worker nodes have sufficient resources (CPU, memory, disk) to run VM workloads without interruption.

If the problem persists, try to identify the root cause and resolve the issue.

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the diagnosis procedure.

### 14.5.19. LowKVMNodesCount

#### Meaning

This alert fires when fewer than two nodes in the cluster have KVM resources.

#### Impact

The cluster must have at least two nodes with KVM resources for live migration.

Virtual machines cannot be scheduled or run if no nodes have KVM resources.

#### Diagnosis

- Identify the nodes with KVM resources:

```
$ oc get nodes -o jsonpath='{.items[*].status.allocatable}' | \
grep devices.kubevirt.io/kvm
```

#### Mitigation

Install KVM on the nodes without KVM resources.

### 14.5.20. LowReadyVirtControllersCount

#### Meaning

This alert fires when one or more **virt-controller** pods are running, but none of these pods has been in the **Ready** state for the past 5 minutes.

A **virt-controller** device monitors the custom resource definitions (CRDs) of a virtual machine instance (VMI) and manages the associated pods. The device creates pods for VMIs and manages their lifecycle. The device is critical for cluster-wide virtualization functionality.

#### Impact

This alert indicates that a cluster-level failure might occur. Actions related to VM lifecycle management, such as launching a new VMI or shutting down an existing VMI, will fail.

#### Diagnosis

1. Set the **NAMESPACE** environment variable:

```
$ export NAMESPACE=$(oc get kubevirt -A \
-o custom-columns=""..metadata.namespace")
```

2. Verify a **virt-controller** device is available:

```
$ oc get deployment -n $NAMESPACE virt-controller \
-o jsonpath='{.status.readyReplicas}'
```

3. Check the status of the **virt-controller** deployment:

```
$ oc -n $NAMESPACE get deploy virt-controller -o yaml
```

4. Obtain the details of the **virt-controller** deployment to check for status conditions, such as crashing pods or failures to pull images:

```
$ oc -n $NAMESPACE describe deploy virt-controller
```

5. Check if any problems occurred with the nodes. For example, they might be in a **NotReady** state:

```
$ oc get nodes
```

### Mitigation

This alert can have multiple causes, including the following:

- The cluster has insufficient memory.
- The nodes are down.
- The API server is overloaded. For example, the scheduler might be under a heavy load and therefore not completely available.
- There are network issues.

Try to identify the root cause and resolve the issue.

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the diagnosis procedure.

## 14.5.21. LowReadyVirtOperatorsCount

### Meaning

This alert fires when one or more **virt-operator** pods are running, but none of these pods has been in a **Ready** state for the last 10 minutes.

The **virt-operator** is the first Operator to start in a cluster. The **virt-operator** deployment has a default replica of two **virt-operator** pods.

Its primary responsibilities include the following:

- Installing, live-updating, and live-upgrading a cluster
- Monitoring the lifecycle of top-level controllers, such as **virt-controller**, **virt-handler**, **virt-launcher**, and managing their reconciliation
- Certain cluster-wide tasks, such as certificate rotation and infrastructure management

### Impact

A cluster-level failure might occur. Critical cluster-wide management functionalities, such as certification rotation, upgrade, and reconciliation of controllers, might become unavailable. Such a state also triggers the **NoReadyVirtOperator** alert.

The **virt-operator** is not directly responsible for virtual machines (VMs) in the cluster. Therefore, its temporary unavailability does not significantly affect VM workloads.

## Diagnosis

- Set the **NAMESPACE** environment variable:

```
$ export NAMESPACE=$(oc get kubevirt -A \
-o custom-columns=""::metadata.namespace)"
```

- Obtain the name of the **virt-operator** deployment:

```
$ oc -n $NAMESPACE get deploy virt-operator -o yaml
```

- Obtain the details of the **virt-operator** deployment:

```
$ oc -n $NAMESPACE describe deploy virt-operator
```

- Check for node issues, such as a **NotReady** state:

```
$ oc get nodes
```

## Mitigation

Based on the information obtained during the diagnosis procedure, try to identify the root cause and resolve the issue.

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the diagnosis procedure.

### 14.5.22. LowVirtAPICount

#### Meaning

This alert fires when only one available **virt-api** pod is detected during a 60-minute period, although at least two nodes are available for scheduling.

#### Impact

An API call outage might occur during node eviction because the **virt-api** pod becomes a single point of failure.

## Diagnosis

- Set the **NAMESPACE** environment variable:

```
$ export NAMESPACE=$(oc get kubevirt -A \
-o custom-columns=""::metadata.namespace)"
```

- Check the number of available **virt-api** pods:

```
$ oc get deployment -n $NAMESPACE virt-api \
-o jsonpath='{.status.readyReplicas}'
```

- Check the status of the **virt-api** deployment for error conditions:

```
$ oc -n $NAMESPACE get deploy virt-api -o yaml
```

4. Check the nodes for issues such as nodes in a **NotReady** state:

```
$ oc get nodes
```

#### Mitigation

Try to identify the root cause and to resolve the issue.

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the diagnosis procedure.

### 14.5.23. LowVirtControllersCount

#### Meaning

This alert fires when a low number of **virt-controller** pods is detected. At least one **virt-controller** pod must be available in order to ensure high availability. The default number of replicas is 2.

A **virt-controller** device monitors the custom resource definitions (CRDs) of a virtual machine instance (VMI) and manages the associated pods. The device creates pods for VMIs and manages the lifecycle of the pods. The device is critical for cluster-wide virtualization functionality.

#### Impact

The responsiveness of OpenShift Virtualization might become negatively affected. For example, certain requests might be missed.

In addition, if another **virt-launcher** instance terminates unexpectedly, OpenShift Virtualization might become completely unresponsive.

#### Diagnosis

1. Set the **NAMESPACE** environment variable:

```
$ export NAMESPACE=$(oc get kubevirt -A \
-o custom-columns=""::metadata.namespace)"
```

2. Verify that running **virt-controller** pods are available:

```
$ oc -n $NAMESPACE get pods -l kubevirt.io=virt-controller
```

3. Check the **virt-launcher** logs for error messages:

```
$ oc -n $NAMESPACE logs <virt-launcher>
```

4. Obtain the details of the **virt-launcher** pod to check for status conditions such as unexpected termination or a **NotReady** state.

```
$ oc -n $NAMESPACE describe pod/<virt-launcher>
```

#### Mitigation

This alert can have a variety of causes, including:

- Not enough memory on the cluster
- Nodes are down

- The API server is overloaded. For example, the scheduler might be under a heavy load and therefore not completely available.
- Networking issues

Identify the root cause and fix it, if possible.

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the diagnosis procedure.

#### 14.5.24. LowVirtOperatorCount

##### Meaning

This alert fires when only one **virt-operator** pod in a **Ready** state has been running for the last 60 minutes.

The **virt-operator** is the first Operator to start in a cluster. Its primary responsibilities include the following:

- Installing, live-updating, and live-upgrading a cluster
- Monitoring the lifecycle of top-level controllers, such as **virt-controller**, **virt-handler**, **virt-launcher**, and managing their reconciliation
- Certain cluster-wide tasks, such as certificate rotation and infrastructure management

##### Impact

The **virt-operator** cannot provide high availability (HA) for the deployment. HA requires two or more **virt-operator** pods in a **Ready** state. The default deployment is two pods.

The **virt-operator** is not directly responsible for virtual machines (VMs) in the cluster. Therefore, its decreased availability does not significantly affect VM workloads.

##### Diagnosis

1. Set the **NAMESPACE** environment variable:

```
$ export NAMESPACE="$(oc get kubevirt -A \
-o custom-columns=""::metadata.namespace)"
```

2. Check the states of the **virt-operator** pods:

```
$ oc -n $NAMESPACE get pods -l kubevirt.io=virt-operator
```

3. Review the logs of the affected **virt-operator** pods:

```
$ oc -n $NAMESPACE logs <virt-operator>
```

4. Obtain the details of the affected **virt-operator** pods:

```
$ oc -n $NAMESPACE describe pod <virt-operator>
```

##### Mitigation

Based on the information obtained during the diagnosis procedure, try to identify the root cause and resolve the issue.

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the Diagnosis procedure.

### 14.5.25. NetworkAddonsConfigNotReady

#### Meaning

This alert fires when the **NetworkAddonsConfig** custom resource (CR) of the Cluster Network Addons Operator (CNAO) is not ready.

CNAO deploys additional networking components on the cluster. This alert indicates that one of the deployed components is not ready.

#### Impact

Network functionality is affected.

#### Diagnosis

1. Check the status conditions of the **NetworkAddonsConfig** CR to identify the deployment or daemon set that is not ready:

```
$ oc get networkaddonsconfig \
-o custom-columns=""::status.conditions[*].message
```

#### Example output

```
DaemonSet "cluster-network-addons/macvtap-cni" update is being processed...
```

2. Check the component's pod for errors:

```
$ oc -n cluster-network-addons get daemonset <pod> -o yaml
```

3. Check the component's logs:

```
$ oc -n cluster-network-addons logs <pod>
```

4. Check the component's details for error conditions:

```
$ oc -n cluster-network-addons describe <pod>
```

#### Mitigation

Try to identify the root cause and resolve the issue.

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the diagnosis procedure.

### 14.5.26. NoLeadingVirtOperator

#### Meaning

This alert fires when no **virt-operator** pod with a leader lease has been detected for 10 minutes, although the **virt-operator** pods are in a **Ready** state. The alert indicates that no leader pod is available.

The **virt-operator** is the first Operator to start in a cluster. Its primary responsibilities include the following:

- Installing, live updating, and live upgrading a cluster
- Monitoring the lifecycle of top-level controllers, such as **virt-controller**, **virt-handler**, **virt-launcher**, and managing their reconciliation
- Certain cluster-wide tasks, such as certificate rotation and infrastructure management

The **virt-operator** deployment has a default replica of 2 pods, with one pod holding a leader lease.

### Impact

This alert indicates a failure at the level of the cluster. As a result, critical cluster-wide management functionalities, such as certification rotation, upgrade, and reconciliation of controllers, might not be available.

### Diagnosis

1. Set the **NAMESPACE** environment variable:

```
$ export NAMESPACE=$(oc get kubevirt -A -o \
custom-columns=""::metadata.namespace)"
```

2. Obtain the status of the **virt-operator** pods:

```
$ oc -n $NAMESPACE get pods -l kubevirt.io=virt-operator
```

3. Check the **virt-operator** pod logs to determine the leader status:

```
$ oc -n $NAMESPACE logs | grep lead
```

Leader pod example:

```
{"component":"virt-operator","level":"info","msg":"Attempting to acquire
leader status","pos":"application.go:400","timestamp":"2021-11-30T12:15:18.635387Z"}
I1130 12:15:18.635452      1 leaderelection.go:243] attempting to acquire
leader lease <namespace>/virt-operator...
I1130 12:15:19.216582      1 leaderelection.go:253] successfully acquired
lease <namespace>/virt-operator
{"component":"virt-operator","level":"info","msg":"Started leading",
"pos":"application.go:385","timestamp":"2021-11-30T12:15:19.216836Z"}
```

Non-leader pod example:

```
{"component":"virt-operator","level":"info","msg":"Attempting to acquire
leader status","pos":"application.go:400","timestamp":"2021-11-30T12:15:20.533696Z"}
I1130 12:15:20.533792      1 leaderelection.go:243] attempting to acquire
leader lease <namespace>/virt-operator...
```

4. Obtain the details of the affected **virt-operator** pods:

```
$ oc -n $NAMESPACE describe pod <virt-operator>
```

### Mitigation

Based on the information obtained during the diagnosis procedure, try to find the root cause and resolve the issue.

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the diagnosis procedure.

### 14.5.27. NoReadyVirtController

#### Meaning

This alert fires when no available **virt-controller** devices have been detected for 5 minutes.

The **virt-controller** devices monitor the custom resource definitions of virtual machine instances (VMIs) and manage the associated pods. The devices create pods for VMIs and manage the lifecycle of the pods.

Therefore, **virt-controller** devices are critical for all cluster-wide virtualization functionality.

#### Impact

Any actions related to VM lifecycle management fail. This notably includes launching a new VMI or shutting down an existing VMI.

#### Diagnosis

1. Set the **NAMESPACE** environment variable:

```
$ export NAMESPACE=$(oc get kubevirt -A \
-o custom-columns=""::metadata.namespace)"
```

2. Verify the number of **virt-controller** devices:

```
$ oc get deployment -n $NAMESPACE virt-controller \
-o jsonpath='{.status.readyReplicas}'
```

3. Check the status of the **virt-controller** deployment:

```
$ oc -n $NAMESPACE get deploy virt-controller -o yaml
```

4. Obtain the details of the **virt-controller** deployment to check for status conditions such as crashing pods or failure to pull images:

```
$ oc -n $NAMESPACE describe deploy virt-controller
```

5. Obtain the details of the **virt-controller** pods:

```
$ get pods -n $NAMESPACE | grep virt-controller
```

6. Check the logs of the **virt-controller** pods for error messages:

```
$ oc logs -n $NAMESPACE <virt-controller>
```

7. Check the nodes for problems, such as a **NotReady** state:

```
$ oc get nodes
```

#### Mitigation

Based on the information obtained during the diagnosis procedure, try to find the root cause and resolve the issue.

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the diagnosis procedure.

### 14.5.28. NoReadyVirtOperator

#### Meaning

This alert fires when no **virt-operator** pod in a **Ready** state has been detected for 10 minutes.

The **virt-operator** is the first Operator to start in a cluster. Its primary responsibilities include the following:

- Installing, live-updating, and live-upgrading a cluster
- Monitoring the life cycle of top-level controllers, such as **virt-controller**, **virt-handler**, **virt-launcher**, and managing their reconciliation
- Certain cluster-wide tasks, such as certificate rotation and infrastructure management

The default deployment is two **virt-operator** pods.

#### Impact

This alert indicates a cluster-level failure. Critical cluster management functionalities, such as certification rotation, upgrade, and reconciliation of controllers, might not be available.

The **virt-operator** is not directly responsible for virtual machines in the cluster. Therefore, its temporary unavailability does not significantly affect workloads.

#### Diagnosis

1. Set the **NAMESPACE** environment variable:

```
$ export NAMESPACE="$(oc get kubevirt -A \
-o custom-columns='\"::metadata.namespace\")"
```

2. Obtain the name of the **virt-operator** deployment:

```
$ oc -n $NAMESPACE get deploy virt-operator -o yaml
```

3. Generate the description of the **virt-operator** deployment:

```
$ oc -n $NAMESPACE describe deploy virt-operator
```

4. Check for node issues, such as a **NotReady** state:

```
$ oc get nodes
```

#### Mitigation

Based on the information obtained during the diagnosis procedure, try to identify the root cause and resolve the issue.

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the Diagnosis procedure.

## 14.5.29. OrphanedVirtualMachineInstances

### Meaning

This alert fires when a virtual machine instance (VMI), or **virt-launcher** pod, runs on a node that does not have a running **virt-handler** pod. Such a VMI is called *orphaned*.

### Impact

Orphaned VMIs cannot be managed.

### Diagnosis

1. Check the status of the **virt-handler** pods to view the nodes on which they are running:

```
$ oc get pods --all-namespaces -o wide -l kubevirt.io=virt-handler
```

2. Check the status of the VMIs to identify VMIs running on nodes that do not have a running **virt-handler** pod:

```
$ oc get vmis --all-namespaces
```

3. Check the status of the **virt-handler** daemon:

```
$ oc get daemonset virt-handler --all-namespaces
```

### Example output

| NAME         | DESIRED | CURRENT | READY | UP-TO-DATE | AVAILABLE | ... |
|--------------|---------|---------|-------|------------|-----------|-----|
| virt-handler | 2       | 2       | 2     | 2          | 2         | ... |

The daemon set is considered healthy if the **Desired**, **Ready**, and **Available** columns contain the same value.

4. If the **virt-handler** daemon set is not healthy, check the **virt-handler** daemon set for pod deployment issues:

```
$ oc get daemonset virt-handler --all-namespaces -o yaml | jq .status
```

5. Check the nodes for issues such as a **NotReady** status:

```
$ oc get nodes
```

6. Check the **spec.workloads** stanza of the **KubeVirt** custom resource (CR) for a workloads placement policy:

```
$ oc get kubevirt kubevirt --all-namespaces -o yaml
```

### Mitigation

If a workloads placement policy is configured, add the node with the VMI to the policy.

Possible causes for the removal of a **virt-handler** pod from a node include changes to the node's taints and tolerations or to a pod's scheduling rules.

Try to identify the root cause and resolve the issue.

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the diagnosis procedure.

### 14.5.30. OutdatedVirtualMachineInstanceWorkloads

#### Meaning

This alert fires when running virtual machine instances (VMIs) in outdated **virt-launcher** pods are detected 24 hours after the OpenShift Virtualization control plane has been updated.

#### Impact

Outdated VMIs might not have access to new OpenShift Virtualization features.

Outdated VMIs will not receive the security fixes associated with the **virt-launcher** pod update.

#### Diagnosis

1. Identify the outdated VMIs:

```
$ oc get vmi -l kubevirt.io/outdatedLauncherImage --all-namespaces
```

2. Check the **KubeVirt** custom resource (CR) to determine whether **workloadUpdateMethods** is configured in the **workloadUpdateStrategy** stanza:

```
$ oc get kubevirt kubevirt --all-namespaces -o yaml
```

3. Check each outdated VMI to determine whether it is live-migratable:

```
$ oc get vmi <vmi> -o yaml
```

#### Example output

```
apiVersion: kubevirt.io/v1
kind: VirtualMachineInstance
# ...
status:
  conditions:
    - lastProbeTime: null
      lastTransitionTime: null
      message: cannot migrate VMI which does not use masquerade
      to connect to the pod network
      reason: InterfaceNotLiveMigratable
      status: "False"
      type: LiveMigratable
```

#### Mitigation

##### Configuring automated workload updates

Update the **HyperConverged** CR to enable automatic workload updates.

##### Stopping a VM associated with a non-live-migratable VMI

- If a VMI is not live-migratable and if **runStrategy: always** is set in the corresponding **VirtualMachine** object, you can update the VMI by manually stopping the virtual machine (VM):

```
$ virctl stop --namespace <namespace> <vm>
```

A new VMI spins up immediately in an updated **virt-launcher** pod to replace the stopped VMI. This is the equivalent of a restart action.



### NOTE

Manually stopping a *live-migratable* VM is destructive and not recommended because it interrupts the workload.

#### Migrating a live-migratable VMI

If a VMI is live-migratable, you can update it by creating a **VirtualMachineInstanceMigration** object that targets a specific running VMI. The VMI is migrated into an updated **virt-launcher** pod.

1. Create a **VirtualMachineInstanceMigration** manifest and save it as **migration.yaml**:

```
apiVersion: kubevirt.io/v1
kind: VirtualMachineInstanceMigration
metadata:
  name: <migration_name>
  namespace: <namespace>
spec:
  vmiName: <vmi_name>
```

2. Create a **VirtualMachineInstanceMigration** object to trigger the migration:

```
$ oc create -f migration.yaml
```

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the diagnosis procedure.

### 14.5.31. SSPCommonTemplatesModificationReverted

#### Meaning

This alert fires when the Scheduling, Scale, and Performance (SSP) Operator reverts changes to common templates as part of its reconciliation procedure.

The SSP Operator deploys and reconciles the common templates and the Template Validator. If a user or script changes a common template, the changes are reverted by the SSP Operator.

#### Impact

Changes to common templates are overwritten.

#### Diagnosis

1. Set the **NAMESPACE** environment variable:

```
$ export NAMESPACE=$(oc get deployment -A | grep ssp-operator | \
awk '{print $1}')"
```

2. Check the **ssp-operator** logs for templates with reverted changes:

```
$ oc -n $NAMESPACE logs --tail=-1 -l control-plane=ssp-operator | \
grep 'common template' -C 3
```

#### Mitigation

Try to identify and resolve the cause of the changes.

Ensure that changes are made only to copies of templates, and not to the templates themselves.

### 14.5.32. SSPDown

#### Meaning

This alert fires when all the Scheduling, Scale and Performance (SSP) Operator pods are down.

The SSP Operator is responsible for deploying and reconciling the common templates and the Template Validator.

#### Impact

Dependent components might not be deployed. Changes in the components might not be reconciled. As a result, the common templates and/or the Template Validator might not be updated or reset if they fail.

#### Diagnosis

1. Set the **NAMESPACE** environment variable:

```
$ export NAMESPACE=$(oc get deployment -A | grep ssp-operator | \
awk '{print $1}')"
```

2. Check the status of the **ssp-operator** pods.

```
$ oc -n $NAMESPACE get pods -l control-plane=ssp-operator
```

3. Obtain the details of the **ssp-operator** pods:

```
$ oc -n $NAMESPACE describe pods -l control-plane=ssp-operator
```

4. Check the **ssp-operator** logs for error messages:

```
$ oc -n $NAMESPACE logs --tail=-1 -l control-plane=ssp-operator
```

#### Mitigation

Try to identify the root cause and resolve the issue.

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the diagnosis procedure.

### 14.5.33. SSPFailingToReconcile

#### Meaning

This alert fires when the reconcile cycle of the Scheduling, Scale and Performance (SSP) Operator fails repeatedly, although the SSP Operator is running.

The SSP Operator is responsible for deploying and reconciling the common templates and the Template Validator.

#### Impact

Dependent components might not be deployed. Changes in the components might not be reconciled. As a result, the common templates or the Template Validator might not be updated or reset if they fail.

## Diagnosis

1. Export the **NAMESPACE** environment variable:

```
$ export NAMESPACE=$(oc get deployment -A | grep ssp-operator | \
awk '{print $1}')"
```

2. Obtain the details of the **ssp-operator** pods:

```
$ oc -n $NAMESPACE describe pods -l control-plane=ssp-operator
```

3. Check the **ssp-operator** logs for errors:

```
$ oc -n $NAMESPACE logs --tail=-1 -l control-plane=ssp-operator
```

4. Obtain the status of the **virt-template-validator** pods:

```
$ oc -n $NAMESPACE get pods -l name=virt-template-validator
```

5. Obtain the details of the **virt-template-validator** pods:

```
$ oc -n $NAMESPACE describe pods -l name=virt-template-validator
```

6. Check the **virt-template-validator** logs for errors:

```
$ oc -n $NAMESPACE logs --tail=-1 -l name=virt-template-validator
```

## Mitigation

Try to identify the root cause and resolve the issue.

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the diagnosis procedure.

### 14.5.34. SSPHighRateRejectedVms

#### Meaning

This alert fires when a user or script attempts to create or modify a large number of virtual machines (VMs), using an invalid configuration.

#### Impact

The VMs are not created or modified. As a result, the environment might not behave as expected.

## Diagnosis

1. Export the **NAMESPACE** environment variable:

```
$ export NAMESPACE=$(oc get deployment -A | grep ssp-operator | \
awk '{print $1}')"
```

2. Check the **virt-template-validator** logs for errors that might indicate the cause:

```
$ oc -n $NAMESPACE logs --tail=-1 -l name=virt-template-validator
```

## Example output

```
{"component":"kubevirt-template-validator","level":"info","msg":"evalution summary for ubuntu-3166wmdbbfkroku0:\nminimal-required-memory applied: FAIL, value 1073741824 is lower than minimum [2147483648]\n\nsucceeded=false", "pos":"admission.go:25","timestamp":"2021-09-28T17:59:10.934470Z"}
```

## Mitigation

Try to identify the root cause and resolve the issue.

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the diagnosis procedure.

### 14.5.35. SSPTemplateValidatorDown

#### Meaning

This alert fires when all the Template Validator pods are down.

The Template Validator checks virtual machines (VMs) to ensure that they do not violate their templates.

#### Impact

VMs are not validated against their templates. As a result, VMs might be created with specifications that do not match their respective workloads.

#### Diagnosis

1. Set the **NAMESPACE** environment variable:

```
$ export NAMESPACE=$(oc get deployment -A | grep ssp-operator | \
awk '{print $1}')"
```

2. Obtain the status of the **virt-template-validator** pods:

```
$ oc -n $NAMESPACE get pods -l name=virt-template-validator
```

3. Obtain the details of the **virt-template-validator** pods:

```
$ oc -n $NAMESPACE describe pods -l name=virt-template-validator
```

4. Check the **virt-template-validator** logs for error messages:

```
$ oc -n $NAMESPACE logs --tail=-1 -l name=virt-template-validator
```

#### Mitigation

Try to identify the root cause and resolve the issue.

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the diagnosis procedure.

### 14.5.36. VirtAPIDown

#### Meaning

This alert fires when all the API Server pods are down.

## Impact

OpenShift Virtualization objects cannot send API calls.

## Diagnosis

1. Set the **NAMESPACE** environment variable:

```
$ export NAMESPACE=$(oc get kubevirt -A \
-o custom-columns=""..metadata.namespace)"
```

2. Check the status of the **virt-api** pods:

```
$ oc -n $NAMESPACE get pods -l kubevirt.io=virt-api
```

3. Check the status of the **virt-api** deployment:

```
$ oc -n $NAMESPACE get deploy virt-api -o yaml
```

4. Check the **virt-api** deployment details for issues such as crashing pods or image pull failures:

```
$ oc -n $NAMESPACE describe deploy virt-api
```

5. Check for issues such as nodes in a **NotReady** state:

```
$ oc get nodes
```

## Mitigation

Try to identify the root cause and resolve the issue.

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the diagnosis procedure.

### 14.5.37. VirtApiRESTErrorsBurst

#### Meaning

More than 80% of REST calls have failed in the **virt-api** pods in the last 5 minutes.

#### Impact

A very high rate of failed REST calls to **virt-api** might lead to slow response and execution of API calls, and potentially to API calls being completely dismissed.

However, currently running virtual machine workloads are not likely to be affected.

## Diagnosis

1. Set the **NAMESPACE** environment variable:

```
$ export NAMESPACE=$(oc get kubevirt -A \
-o custom-columns=""..metadata.namespace)"
```

2. Obtain the list of **virt-api** pods on your deployment:

```
$ oc -n $NAMESPACE get pods -l kubevirt.io=virt-api
```

3. Check the **virt-api** logs for error messages:

```
$ oc logs -n $NAMESPACE <virt-api>
```

4. Obtain the details of the **virt-api** pods:

```
$ oc describe -n $NAMESPACE <virt-api>
```

5. Check if any problems occurred with the nodes. For example, they might be in a **NotReady** state:

```
$ oc get nodes
```

6. Check the status of the **virt-api** deployment:

```
$ oc -n $NAMESPACE get deploy virt-api -o yaml
```

7. Obtain the details of the **virt-api** deployment:

```
$ oc -n $NAMESPACE describe deploy virt-api
```

### Mitigation

Based on the information obtained during the diagnosis procedure, try to identify the root cause and resolve the issue.

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the diagnosis procedure.

### 14.5.38. VirtApiRESTErrorsHigh

#### Meaning

More than 5% of REST calls have failed in the **virt-api** pods in the last 60 minutes.

#### Impact

A high rate of failed REST calls to **virt-api** might lead to slow response and execution of API calls.

However, currently running virtual machine workloads are not likely to be affected.

#### Diagnosis

1. Set the **NAMESPACE** environment variable as follows:

```
$ export NAMESPACE=$(oc get kubevirt -A \
-o custom-columns=""::metadata.namespace)"
```

2. Check the status of the **virt-api** pods:

```
$ oc -n $NAMESPACE get pods -l kubevirt.io=virt-api
```

3. Check the **virt-api** logs:

```
$ oc logs -n $NAMESPACE <virt-api>
```

4. Obtain the details of the **virt-api** pods:

```
$ oc describe -n $NAMESPACE <virt-api>
```

5. Check if any problems occurred with the nodes. For example, they might be in a **NotReady** state:

```
$ oc get nodes
```

6. Check the status of the **virt-api** deployment:

```
$ oc -n $NAMESPACE get deploy virt-api -o yaml
```

7. Obtain the details of the **virt-api** deployment:

```
$ oc -n $NAMESPACE describe deploy virt-api
```

#### Mitigation

Based on the information obtained during the diagnosis procedure, try to identify the root cause and resolve the issue.

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the diagnosis procedure.

### 14.5.39. VirtControllerDown

#### Meaning

No running **virt-controller** pod has been detected for 5 minutes.

#### Impact

Any actions related to virtual machine (VM) lifecycle management fail. This notably includes launching a new virtual machine instance (VMI) or shutting down an existing VMI.

#### Diagnosis

1. Set the **NAMESPACE** environment variable:

```
$ export NAMESPACE=$(oc get kubevirt -A \
-o custom-columns=""..metadata.namespace)"
```

2. Check the status of the **virt-controller** deployment:

```
$ oc get deployment -n $NAMESPACE virt-controller -o yaml
```

3. Review the logs of the **virt-controller** pod:

```
$ oc get logs <virt-controller>
```

#### Mitigation

This alert can have a variety of causes, including the following:

- Node resource exhaustion

- Not enough memory on the cluster
- Nodes are down
- The API server is overloaded. For example, the scheduler might be under a heavy load and therefore not completely available.
- Networking issues

Identify the root cause and fix it, if possible.

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the diagnosis procedure.

#### 14.5.40. VirtControllerRESTErrorsBurst

##### Meaning

More than 80% of REST calls in **virt-controller** pods failed in the last 5 minutes.

The **virt-controller** has likely fully lost the connection to the API server.

This error is frequently caused by one of the following problems:

- The API server is overloaded, which causes timeouts. To verify if this is the case, check the metrics of the API server, and view its response times and overall calls.
- The **virt-controller** pod cannot reach the API server. This is commonly caused by DNS issues on the node and networking connectivity issues.

##### Impact

Status updates are not propagated and actions like migrations cannot take place. However, running workloads are not impacted.

##### Diagnosis

1. Set the **NAMESPACE** environment variable:

```
$ export NAMESPACE=$(oc get kubevirt -A \
-o custom-columns=""::metadata.namespace)"
```

2. List the available **virt-controller** pods:

```
$ oc get pods -n $NAMESPACE -l=kubevirt.io=virt-controller
```

3. Check the **virt-controller** logs for error messages when connecting to the API server:

```
$ oc logs -n $NAMESPACE <virt-controller>
```

##### Mitigation

- If the **virt-controller** pod cannot connect to the API server, delete the pod to force a restart:

```
$ oc delete -n $NAMESPACE <virt-controller>
```

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the diagnosis procedure.

#### 14.5.41. VirtControllerRESTErrorsHigh

##### Meaning

More than 5% of REST calls failed in **virt-controller** in the last 60 minutes.

This is most likely because **virt-controller** has partially lost connection to the API server.

This error is frequently caused by one of the following problems:

- The API server is overloaded, which causes timeouts. To verify if this is the case, check the metrics of the API server, and view its response times and overall calls.
- The **virt-controller** pod cannot reach the API server. This is commonly caused by DNS issues on the node and networking connectivity issues.

##### Impact

Node-related actions, such as starting and migrating, and scheduling virtual machines, are delayed. Running workloads are not affected, but reporting their current status might be delayed.

##### Diagnosis

1. Set the **NAMESPACE** environment variable:

```
$ export NAMESPACE=$(oc get kubevirt -A \
-o custom-columns=""..metadata.namespace)"
```

2. List the available **virt-controller** pods:

```
$ oc get pods -n $NAMESPACE -l=kubevirt.io=virt-controller
```

3. Check the **virt-controller** logs for error messages when connecting to the API server:

```
$ oc logs -n $NAMESPACE <virt-controller>
```

##### Mitigation

- If the **virt-controller** pod cannot connect to the API server, delete the pod to force a restart:

```
$ oc delete -n $NAMESPACE <virt-controller>
```

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the diagnosis procedure.

#### 14.5.42. VirtHandlerDaemonSetRolloutFailing

##### Meaning

The **virt-handler** daemon set has failed to deploy on one or more worker nodes after 15 minutes.

##### Impact

This alert is a warning. It does not indicate that all **virt-handler** daemon sets have failed to deploy. Therefore, the normal lifecycle of virtual machines is not affected unless the cluster is overloaded.

## Diagnosis

Identify worker nodes that do not have a running **virt-handler** pod:

1. Export the **NAMESPACE** environment variable:

```
$ export NAMESPACE=$(oc get kubevirt -A \
-o custom-columns=""::metadata.namespace)"
```

2. Check the status of the **virt-handler** pods to identify pods that have not deployed:

```
$ oc get pods -n $NAMESPACE -l=kubevirt.io=virt-handler
```

3. Obtain the name of the worker node of the **virt-handler** pod:

```
$ oc -n $NAMESPACE get pod <virt-handler> -o jsonpath='{.spec.nodeName}'
```

## Mitigation

If the **virt-handler** pods failed to deploy because of insufficient resources, you can delete other pods on the affected worker node.

### 14.5.43. VirtHandlerRESTErrorsBurst

#### Meaning

More than 80% of REST calls failed in **virt-handler** in the last 5 minutes. This alert usually indicates that the **virt-handler** pods cannot connect to the API server.

This error is frequently caused by one of the following problems:

- The API server is overloaded, which causes timeouts. To verify if this is the case, check the metrics of the API server, and view its response times and overall calls.
- The **virt-handler** pod cannot reach the API server. This is commonly caused by DNS issues on the node and networking connectivity issues.

#### Impact

Status updates are not propagated and node-related actions, such as migrations, fail. However, running workloads on the affected node are not impacted.

## Diagnosis

1. Set the **NAMESPACE** environment variable:

```
$ export NAMESPACE=$(oc get kubevirt -A \
-o custom-columns=""::metadata.namespace)"
```

2. Check the status of the **virt-handler** pod:

```
$ oc get pods -n $NAMESPACE -l=kubevirt.io=virt-handler
```

3. Check the **virt-handler** logs for error messages when connecting to the API server:

```
$ oc logs -n $NAMESPACE <virt-handler>
```

## Mitigation

- If the **virt-handler** cannot connect to the API server, delete the pod to force a restart:

```
$ oc delete -n $NAMESPACE <virt-handler>
```

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the diagnosis procedure.

#### 14.5.44. VirtHandlerRESTErrorsHigh

##### Meaning

More than 5% of REST calls failed in **virt-handler** in the last 60 minutes. This alert usually indicates that the **virt-handler** pods have partially lost connection to the API server.

This error is frequently caused by one of the following problems:

- The API server is overloaded, which causes timeouts. To verify if this is the case, check the metrics of the API server, and view its response times and overall calls.
- The **virt-handler** pod cannot reach the API server. This is commonly caused by DNS issues on the node and networking connectivity issues.

##### Impact

Node-related actions, such as starting and migrating workloads, are delayed on the node that **virt-handler** is running on. Running workloads are not affected, but reporting their current status might be delayed.

##### Diagnosis

1. Set the **NAMESPACE** environment variable:

```
$ export NAMESPACE=$(oc get kubevirt -A \
-o custom-columns=""..metadata.namespace)"
```

2. Check the status of the **virt-handler** pod:

```
$ oc get pods -n $NAMESPACE -l=kubevirt.io=virt-handler
```

3. Check the **virt-handler** logs for error messages when connecting to the API server:

```
$ oc logs -n $NAMESPACE <virt-handler>
```

##### Mitigation

- If the **virt-handler** cannot connect to the API server, delete the pod to force a restart:

```
$ oc delete -n $NAMESPACE <virt-handler>
```

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the diagnosis procedure.

#### 14.5.45. VirtOperatorDown

##### Meaning

This alert fires when no **virt-operator** pod in the **Running** state has been detected for 10 minutes.

The **virt-operator** is the first Operator to start in a cluster. Its primary responsibilities include the following:

- Installing, live-updating, and live-upgrading a cluster
- Monitoring the life cycle of top-level controllers, such as **virt-controller**, **virt-handler**, **virt-launcher**, and managing their reconciliation
- Certain cluster-wide tasks, such as certificate rotation and infrastructure management

The **virt-operator** deployment has a default replica of 2 pods.

### Impact

This alert indicates a failure at the level of the cluster. Critical cluster-wide management functionalities, such as certification rotation, upgrade, and reconciliation of controllers, might not be available.

The **virt-operator** is not directly responsible for virtual machines (VMs) in the cluster. Therefore, its temporary unavailability does not significantly affect VM workloads.

### Diagnosis

1. Set the **NAMESPACE** environment variable:

```
$ export NAMESPACE=$(oc get kubevirt -A \
-o custom-columns=""::metadata.namespace)"
```

2. Check the status of the **virt-operator** deployment:

```
$ oc -n $NAMESPACE get deploy virt-operator -o yaml
```

3. Obtain the details of the **virt-operator** deployment:

```
$ oc -n $NAMESPACE describe deploy virt-operator
```

4. Check the status of the **virt-operator** pods:

```
$ oc get pods -n $NAMESPACE -l=kubevirt.io=virt-operator
```

5. Check for node issues, such as a **NotReady** state:

```
$ oc get nodes
```

### Mitigation

Based on the information obtained during the diagnosis procedure, try to find the root cause and resolve the issue.

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the diagnosis procedure.

## 14.5.46. VirtOperatorRESTErrorsBurst

### Meaning

This alert fires when more than 80% of the REST calls in the **virt-operator** pods failed in the last 5 minutes. This usually indicates that the **virt-operator** pods cannot connect to the API server.

This error is frequently caused by one of the following problems:

- The API server is overloaded, which causes timeouts. To verify if this is the case, check the metrics of the API server, and view its response times and overall calls.
- The **virt-operator** pod cannot reach the API server. This is commonly caused by DNS issues on the node and networking connectivity issues.

### Impact

Cluster-level actions, such as upgrading and controller reconciliation, might not be available.

However, workloads such as virtual machines (VMs) and VM instances (VMIs) are not likely to be affected.

### Diagnosis

1. Set the **NAMESPACE** environment variable:

```
$ export NAMESPACE=$(oc get kubevirt -A \
-o custom-columns=""..metadata.namespace")"
```

2. Check the status of the **virt-operator** pods:

```
$ oc -n $NAMESPACE get pods -l kubevirt.io=virt-operator
```

3. Check the **virt-operator** logs for error messages when connecting to the API server:

```
$ oc -n $NAMESPACE logs <virt-operator>
```

4. Obtain the details of the **virt-operator** pod:

```
$ oc -n $NAMESPACE describe pod <virt-operator>
```

### Mitigation

- If the **virt-operator** pod cannot connect to the API server, delete the pod to force a restart:

```
$ oc delete -n $NAMESPACE <virt-operator>
```

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the diagnosis procedure.

## 14.5.47. VirtOperatorRESTErrorsHigh

### Meaning

This alert fires when more than 5% of the REST calls in **virt-operator** pods failed in the last 60 minutes. This usually indicates the **virt-operator** pods cannot connect to the API server.

This error is frequently caused by one of the following problems:

- The API server is overloaded, which causes timeouts. To verify if this is the case, check the metrics of the API server, and view its response times and overall calls.
- The **virt-operator** pod cannot reach the API server. This is commonly caused by DNS issues on the node and networking connectivity issues.

**Impact**

Cluster-level actions, such as upgrading and controller reconciliation, might be delayed.

However, workloads such as virtual machines (VMs) and VM instances (VMIs) are not likely to be affected.

**Diagnosis**

- Set the **NAMESPACE** environment variable:

```
$ export NAMESPACE=$(oc get kubevirt -A \
-o custom-columns=""..metadata.namespace)"
```

- Check the status of the **virt-operator** pods:

```
$ oc -n $NAMESPACE get pods -l kubevirt.io=virt-operator
```

- Check the **virt-operator** logs for error messages when connecting to the API server:

```
$ oc -n $NAMESPACE logs <virt-operator>
```

- Obtain the details of the **virt-operator** pod:

```
$ oc -n $NAMESPACE describe pod <virt-operator>
```

**Mitigation**

- If the **virt-operator** pod cannot connect to the API server, delete the pod to force a restart:

```
$ oc delete -n $NAMESPACE <virt-operator>
```

If you cannot resolve the issue, log in to the [Customer Portal](#) and open a support case, attaching the artifacts gathered during the diagnosis procedure.

**14.5.48. VMCannotBeEvicted****Meaning**

This alert fires when the eviction strategy of a virtual machine (VM) is set to **LiveMigration** but the VM is not migratable.

**Impact**

Non-migratable VMs prevent node eviction. This condition affects operations such as node drain and updates.

**Diagnosis**

- Check the VMI configuration to determine whether the value of **evictionStrategy** is **LiveMigrate**:

```
$ oc get vmis -o yaml
```

- Check for a **False** status in the **LIVE-MIGRATABLE** column to identify VMIs that are not migratable:

```
$ oc get vmis -o wide
```

3. Obtain the details of the VMI and check **spec.conditions** to identify the issue:

```
$ oc get vmi <vmi> -o yaml
```

#### Example output

```
status:  
conditions:  
- lastProbeTime: null  
lastTransitionTime: null  
message: cannot migrate VMI which does not use masquerade to connect  
to the pod network  
reason: InterfaceNotLiveMigratable  
status: "False"  
type: LiveMigratable
```

#### Mitigation

Set the **evictionStrategy** of the VMI to **shutdown** or resolve the issue that prevents the VMI from migrating.

# CHAPTER 15. BACKUP AND RESTORE

## 15.1. INSTALLING AND CONFIGURING OADP

As a cluster administrator, you install the OpenShift API for Data Protection (OADP) by installing the OADP Operator. The Operator installs [Velero 1.11](#).

You create a default **Secret** for your backup storage provider and then you install the Data Protection Application.

### 15.1.1. Installing the OADP Operator

You install the OpenShift API for Data Protection (OADP) Operator on OpenShift Container Platform 4.13 by using Operator Lifecycle Manager (OLM).

The OADP Operator installs [Velero 1.11](#).

#### Prerequisites

- You must be logged in as a user with **cluster-admin** privileges.

#### Procedure

1. In the OpenShift Container Platform web console, click **Operators** → **OperatorHub**.
2. Use the **Filter by keyword** field to find the **OADP Operator**.
3. Select the **OADP Operator** and click **Install**.
4. Click **Install** to install the Operator in the **openshift-adp** project.
5. Click **Operators** → **Installed Operators** to verify the installation.

### 15.1.2. About backup and snapshot locations and their secrets

You specify backup and snapshot locations and their secrets in the **DataProtectionApplication** custom resource (CR).

#### Backup locations

You specify S3-compatible object storage, such as Multicloud Object Gateway, Noobaa, or Minio, as a backup location.

Velero backs up OpenShift Container Platform resources, Kubernetes objects, and internal images as an archive file on object storage.

#### Snapshot locations

If you use your cloud provider's native snapshot API to back up persistent volumes, you must specify the cloud provider as the snapshot location.

If you use Container Storage Interface (CSI) snapshots, you do not need to specify a snapshot location because you will create a **VolumeSnapshotClass** CR to register the CSI driver.

If you use Restic, you do not need to specify a snapshot location because Restic backs up the file system on object storage.

## Secrets

If the backup and snapshot locations use the same credentials or if you do not require a snapshot location, you create a default **Secret**.

If the backup and snapshot locations use different credentials, you create two secret objects:

- Custom **Secret** for the backup location, which you specify in the **DataProtectionApplication** CR.
- Default **Secret** for the snapshot location, which is not referenced in the **DataProtectionApplication** CR.



### IMPORTANT

The Data Protection Application requires a default **Secret**. Otherwise, the installation will fail.

If you do not want to specify backup or snapshot locations during the installation, you can create a default **Secret** with an empty **credentials-velero** file.

#### 15.1.2.1. Creating a default Secret

You create a default **Secret** if your backup and snapshot locations use the same credentials or if you do not require a snapshot location.



### NOTE

The **DataProtectionApplication** custom resource (CR) requires a default **Secret**. Otherwise, the installation will fail. If the name of the backup location **Secret** is not specified, the default name is used.

If you do not want to use the backup location credentials during the installation, you can create a **Secret** with the default name by using an empty **credentials-velero** file.

## Prerequisites

- Your object storage and cloud storage, if any, must use the same credentials.
- You must configure object storage for Velero.
- You must create a **credentials-velero** file for the object storage in the appropriate format.

## Procedure

- Create a **Secret** with the default name:

```
$ oc create secret generic cloud-credentials -n openshift-adp --from-file cloud=credentials-velero
```

The **Secret** is referenced in the **spec.backupLocations.credential** block of the **DataProtectionApplication** CR when you install the Data Protection Application.

#### 15.1.3. Configuring the Data Protection Application

You can configure the Data Protection Application by setting Velero resource allocations or enabling self-signed CA certificates.

### 15.1.3.1. Setting Velero CPU and memory resource allocations

You set the CPU and memory resource allocations for the **Velero** pod by editing the **DataProtectionApplication** custom resource (CR) manifest.

#### Prerequisites

- You must have the OpenShift API for Data Protection (OADP) Operator installed.

#### Procedure

- Edit the values in the **spec.configuration.velero.podConfig.ResourceAllocations** block of the **DataProtectionApplication** CR manifest, as in the following example:

```
apiVersion: oadp.openshift.io/v1alpha1
kind: DataProtectionApplication
metadata:
  name: <dpa_sample>
spec:
...
  configuration:
    velero:
      podConfig:
        nodeSelector: <node selector> ①
        resourceAllocations: ②
          limits:
            cpu: "1"
            memory: 1024Mi
          requests:
            cpu: 200m
            memory: 256Mi
```

- ① Specify the node selector to be supplied to Velero podSpec.
- ② The **resourceAllocations** listed are for average usage.

### 15.1.3.2. Enabling self-signed CA certificates

You must enable a self-signed CA certificate for object storage by editing the **DataProtectionApplication** custom resource (CR) manifest to prevent a **certificate signed by unknown authority** error.

#### Prerequisites

- You must have the OpenShift API for Data Protection (OADP) Operator installed.

#### Procedure

- Edit the **spec.backupLocations.velero.objectStorage.caCert** parameter and **spec.backupLocations.velero.config** parameters of the **DataProtectionApplication** CR manifest:

```
apiVersion: oadp.openshift.io/v1alpha1
kind: DataProtectionApplication
metadata:
  name: <dpa_sample>
spec:
...
  backupLocations:
    - name: default
      velero:
        provider: aws
        default: true
        objectStorage:
          bucket: <bucket>
          prefix: <prefix>
          caCert: <base64_encoded_cert_string> ①
        config:
          insecureSkipTLSVerify: "false" ②
...

```

- ① Specify the Base64-encoded CA certificate string.
- ② The **insecureSkipTLSVerify** configuration can be set to either "**true**" or "**false**". If set to "**true**", SSL/TLS security is disabled. If set to "**false**", SSL/TLS security is enabled.

#### 15.1.4. Installing the Data Protection Application

You install the Data Protection Application (DPA) by creating an instance of the **DataProtectionApplication** API.

##### Prerequisites

- You must install the OADP Operator.
- You must configure object storage as a backup location.
- If you use snapshots to back up PVs, your cloud provider must support either a native snapshot API or Container Storage Interface (CSI) snapshots.
- If the backup and snapshot locations use the same credentials, you must create a **Secret** with the default name, **cloud-credentials**.
- If the backup and snapshot locations use different credentials, you must create two **Secrets**:
  - **Secret** with a custom name for the backup location. You add this **Secret** to the **DataProtectionApplication** CR.
  - **Secret** with the default name, **cloud-credentials**, for the snapshot location. This **Secret** is not referenced in the **DataProtectionApplication** CR.

**NOTE**

If you do not want to specify backup or snapshot locations during the installation, you can create a default **Secret** with an empty **credentials-velero** file. If there is no default **Secret**, the installation will fail.

**Procedure**

1. Click **Operators** → **Installed Operators** and select the OADP Operator.
2. Under **Provided APIs**, click **Create instance** in the **DataProtectionApplication** box.
3. Click **YAML View** and update the parameters of the **DataProtectionApplication** manifest:

```
apiVersion: oadp.openshift.io/v1alpha1
kind: DataProtectionApplication
metadata:
  name: <dpa_sample>
  namespace: openshift-adp
spec:
  configuration:
    velero:
      defaultPlugins:
        - kubevirt ①
        - gcp ②
        - csi ③
        - openshift ④
      resourceTimeout: 10m ⑤
    restic:
      enable: true ⑥
      podConfig:
        nodeSelector: <node_selector> ⑦
    backupLocations:
      - velero:
          provider: gcp ⑧
          default: true
          credential:
            key: cloud
            name: <default_secret> ⑨
          objectStorage:
            bucket: <bucket_name> ⑩
            prefix: <prefix> ⑪
```

- ① The **kubevirt** plugin is mandatory for OpenShift Virtualization.
- ② Specify the plugin for the backup provider, for example, **gcp**, if it exists.
- ③ The **csi** plugin is mandatory for backing up PVs with CSI snapshots. The **csi** plugin uses the [Velero CSI beta snapshot APIs](#). You do not need to configure a snapshot location.
- ④ The **openshift** plugin is mandatory.
- ⑤ Specify how many minutes to wait for several Velero resources before timeout occurs, such as Velero CRD availability, volumeSnapshot deletion, and backup repository availability. The default is 10m.

- 6 Set to **false**, if you want to disable the Restic installation. Restic deploys a daemon set, which means that each worker node has **Restic** pods running. You can configure Restic for
- 7 Specify on which nodes Restic is available. By default, Restic runs on all nodes.
- 8 Specify the backup provider.
- 9 Specify the correct default name for the **Secret**, for example, **cloud-credentials-gcp**, if you use a default plugin for the backup provider. If specifying a custom name, then the custom name is used for the backup location. If you do not specify a **Secret** name, the default name is used.
- 10 Specify a bucket as the backup storage location. If the bucket is not a dedicated bucket for Velero backups, you must specify a prefix.
- 11 Specify a prefix for Velero backups, for example, **velero**, if the bucket is used for multiple purposes.

4. Click **Create**.

5. Verify the installation by viewing the OADP resources:

```
$ oc get all -n openshift-adp
```

#### Example output

| NAME                                                  | READY | STATUS  | RESTARTS | AGE  |
|-------------------------------------------------------|-------|---------|----------|------|
| pod/oadp-operator-controller-manager-67d9494d47-6l8z8 | 2/2   | Running | 0        | 2m8s |
| pod/restic-9cq4q                                      | 1/1   | Running | 0        | 94s  |
| pod/restic-m4lts                                      | 1/1   | Running | 0        | 94s  |
| pod/restic-pv4kr                                      | 1/1   | Running | 0        | 95s  |
| pod/velero-588db7f655-n842v                           | 1/1   | Running | 0        | 95s  |

| NAME                                                     | TYPE      | CLUSTER-IP    | EXTERNAL-IP |
|----------------------------------------------------------|-----------|---------------|-------------|
| service/oadp-operator-controller-manager-metrics-service | ClusterIP | 172.30.70.140 |             |
| <none>                                                   | 8443/TCP  | 2m8s          |             |

| NAME                  | DESIRED | CURRENT | READY | UP-TO-DATE | AVAILABLE | NODE SELECTOR | AGE |
|-----------------------|---------|---------|-------|------------|-----------|---------------|-----|
| daemonset.apps/restic | 3       | 3       | 3     | 3          | <none>    |               | 96s |

| NAME                                             | READY | UP-TO-DATE | AVAILABLE | AGE  |
|--------------------------------------------------|-------|------------|-----------|------|
| deployment.apps/oadp-operator-controller-manager | 1/1   | 1          | 1         | 2m9s |
| deployment.apps/velero                           | 1/1   | 1          | 1         | 96s  |

| NAME                                                        | DESIRED | CURRENT | READY | AGE  |
|-------------------------------------------------------------|---------|---------|-------|------|
| replicaset.apps/oadp-operator-controller-manager-67d9494d47 | 1       | 1       | 1     | 2m9s |
| replicaset.apps/velero-588db7f655                           | 1       | 1       | 1     | 96s  |

#### 15.1.4.1. Enabling CSI in the DataProtectionApplication CR

You enable the Container Storage Interface (CSI) in the **DataProtectionApplication** custom resource (CR) in order to back up persistent volumes with CSI snapshots.

## Prerequisites

- The cloud provider must support CSI snapshots.

## Procedure

- Edit the **DataProtectionApplication** CR, as in the following example:

```
apiVersion: oadp.openshift.io/v1alpha1
kind: DataProtectionApplication
...
spec:
  configuration:
    velero:
      defaultPlugins:
        - openshift
        - csi ①
```

- Add the **csi** default plugin.

### 15.1.5. Uninstalling OADP

You uninstall the OpenShift API for Data Protection (OADP) by deleting the OADP Operator. See [Deleting Operators from a cluster](#) for details.

## 15.2. BACKING UP AND RESTORING VIRTUAL MACHINES



### IMPORTANT

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

For more information about the support scope of Red Hat Technology Preview features, see [Technology Preview Features Support Scope](#).

You back up and restore virtual machines by using the [OpenShift API for Data Protection \(OADP\)](#).

## Prerequisites

- Access to the cluster as a user with the **cluster-admin** role.

## Procedure

- Install the [OADP Operator](#) according to the instructions for your storage provider.
- Install the [Data Protection Application](#) with the **kubevirt** and **openshift** plugins.
- Back up virtual machines by creating a [Backup](#) custom resource (CR).

4. Restore the **Backup** CR by creating a [Restore CR](#).

### 15.2.1. Additional resources

- [OADP features and plugins](#)
- [Troubleshooting](#)

## 15.3. BACKING UP VIRTUAL MACHINES



### IMPORTANT

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

For more information about the support scope of Red Hat Technology Preview features, see [Technology Preview Features Support Scope](#).

You back up virtual machines (VMs) by creating an OpenShift API for Data Protection (OADP) [Backup custom resource \(CR\)](#).

The **Backup** CR performs the following actions:

- Backs up OpenShift Virtualization resources by creating an archive file on S3-compatible object storage, such as [Multicloud Object Gateway](#), Noobaa, or Minio.
- Backs up VM disks by using one of the following options:
  - [Container Storage Interface \(CSI\) snapshots](#) on CSI-enabled cloud storage, such as Ceph RBD or Ceph FS.
  - [Restic file system backups](#) on object storage.



### NOTE

OADP provides backup hooks to freeze the VM file system before the backup operation and unfreeze it when the backup is complete.

The **kubevirt-controller** creates the **virt-launcher** pods with annotations that enable Velero to run the **virt-freezer** binary before and after the backup operation.

The **freeze** and **unfreeze** APIs are subresources of the VM snapshot API. See [About virtual machine snapshots](#) for details.

You can add [hooks](#) to the **Backup** CR to run commands on specific VMs before or after the backup operation.

You schedule a backup by creating a [Schedule CR](#) instead of a **Backup** CR.

### 15.3.1. Creating a Backup CR

You back up Kubernetes images, internal images, and persistent volumes (PVs) by creating a **Backup** custom resource (CR).

## Prerequisites

- You must install the OpenShift API for Data Protection (OADP) Operator.
- The **DataProtectionApplication** CR must be in a **Ready** state.
- Backup location prerequisites:
  - You must have S3 object storage configured for Velero.
  - You must have a backup location configured in the **DataProtectionApplication** CR.
- Snapshot location prerequisites:
  - Your cloud provider must have a native snapshot API or support Container Storage Interface (CSI) snapshots.
  - For CSI snapshots, you must create a **VolumeSnapshotClass** CR to register the CSI driver.
  - You must have a volume location configured in the **DataProtectionApplication** CR.

## Procedure

1. Retrieve the **backupStorageLocations** CRs by entering the following command:

```
$ oc get backupStorageLocations -n openshift-adp
```

### Example output

| NAMESPACE     | NAME            | PHASE     | LAST VALIDATED | AGE | DEFAULT |
|---------------|-----------------|-----------|----------------|-----|---------|
| openshift-adp | velero-sample-1 | Available | 11s            | 31m |         |

2. Create a **Backup** CR, as in the following example:

```
apiVersion: velero.io/v1
kind: Backup
metadata:
  name: <backup>
  labels:
    velero.io/storage-location: default
    namespace: openshift-adp
spec:
  hooks: {}
  includedNamespaces:
  - <namespace> ①
  includedResources: [] ②
  excludedResources: [] ③
  storageLocation: <velero-sample-1> ④
  ttl: 720h0m0s
  labelSelector: ⑤
  matchLabels:
    app=<label_1>
```

```

app=<label_2>
app=<label_3>
orLabelSelectors: ⑥
- matchLabels:
  app=<label_1>
  app=<label_2>
  app=<label_3>

```

- ① Specify an array of namespaces to back up.
- ② Optional: Specify an array of resources to include in the backup. Resources might be shortcuts (for example, 'po' for 'pods') or fully-qualified. If unspecified, all resources are included.
- ③ Optional: Specify an array of resources to exclude from the backup. Resources might be shortcuts (for example, 'po' for 'pods') or fully-qualified.
- ④ Specify the name of the **backupStorageLocations** CR.
- ⑤ Map of {key,value} pairs of backup resources that have **all** of the specified labels.
- ⑥ Map of {key,value} pairs of backup resources that have **one or more** of the specified labels.

### 3. Verify that the status of the **Backup** CR is **Completed**:

```
$ oc get backup -n openshift-adp <backup> -o jsonpath='{.status.phase}'
```

#### 15.3.1.1. Backing up persistent volumes with CSI snapshots

You back up persistent volumes with Container Storage Interface (CSI) snapshots by editing the **VolumeSnapshotClass** custom resource (CR) of the cloud storage before you create the **Backup** CR.

##### Prerequisites

- The cloud provider must support CSI snapshots.
- You must enable CSI in the **DataProtectionApplication** CR.

##### Procedure

- Add the **metadata.labels.velero.io/csi-volumesnapshot-class: "true"** key-value pair to the **VolumeSnapshotClass** CR:

```

apiVersion: snapshot.storage.k8s.io/v1
kind: VolumeSnapshotClass
metadata:
  name: <volume_snapshot_class_name>
  labels:
    velero.io/csi-volumesnapshot-class: "true"
  driver: <csi_driver>
  deletionPolicy: Retain

```

You can now create a **Backup** CR.

### 15.3.1.2. Backing up applications with Restic

You back up Kubernetes resources, internal images, and persistent volumes with Restic by editing the **Backup** custom resource (CR).

You do not need to specify a snapshot location in the **DataProtectionApplication** CR.



#### IMPORTANT

Restic does not support backing up **hostPath** volumes. For more information, see [additional Restic limitations](#).

#### Prerequisites

- You must install the OpenShift API for Data Protection (OADP) Operator.
- You must not disable the default Restic installation by setting **spec.configuration.restic.enable** to **false** in the **DataProtectionApplication** CR.
- The **DataProtectionApplication** CR must be in a **Ready** state.

#### Procedure

- Edit the **Backup** CR, as in the following example:

```
apiVersion: velero.io/v1
kind: Backup
metadata:
  name: <backup>
  labels:
    velero.io/storage-location: default
    namespace: openshift-adp
spec:
  defaultVolumesToRestic: true ①
...

```

- ① Add **defaultVolumesToRestic: true** to the **spec** block.

### 15.3.1.3. Creating backup hooks

You create backup hooks to run commands in a container in a pod by editing the **Backup** custom resource (CR).

*Pre* hooks run before the pod is backed up. *Post* hooks run after the backup.

#### Procedure

- Add a hook to the **spec.hooks** block of the **Backup** CR, as in the following example:

```
apiVersion: velero.io/v1
kind: Backup
metadata:
  name: <backup>
  namespace: openshift-adp
spec:
  hooks:
    pre:
      - command: /bin/sh -c "echo Pre Backup"
    post:
      - command: /bin/sh -c "echo Post Backup"
```

```

spec:
  hooks:
    resources:
      - name: <hook_name>
        includedNamespaces:
          - <namespace> ①
        excludedNamespaces: ②
          - <namespace>
        includedResources: []
        - pods ③
        excludedResources: [] ④
      labelSelector: ⑤
      matchLabels:
        app: velero
        component: server
      pre: ⑥
        - exec:
          container: <container> ⑦
          command:
            - /bin/uname ⑧
            - -a
          onError: Fail ⑨
          timeout: 30s ⑩
      post: ⑪
...
  
```

- ① Optional: You can specify namespaces to which the hook applies. If this value is not specified, the hook applies to all namespaces.
- ② Optional: You can specify namespaces to which the hook does not apply.
- ③ Currently, pods are the only supported resource that hooks can apply to.
- ④ Optional: You can specify resources to which the hook does not apply.
- ⑤ Optional: This hook only applies to objects matching the label. If this value is not specified, the hook applies to all namespaces.
- ⑥ Array of hooks to run before the backup.
- ⑦ Optional: If the container is not specified, the command runs in the first container in the pod.
- ⑧ This is the entrypoint for the init container being added.
- ⑨ Allowed values for error handling are **Fail** and **Continue**. The default is **Fail**.
- ⑩ Optional: How long to wait for the commands to run. The default is **30s**.
- ⑪ This block defines an array of hooks to run after the backup, with the same parameters as the pre-backup hooks.

### 15.3.2. Scheduling backups

You schedule backups by creating a **Schedule** custom resource (CR) instead of a **Backup** CR.



### WARNING

Leave enough time in your backup schedule for a backup to finish before another backup is created.

For example, if a backup of a namespace typically takes 10 minutes, do not schedule backups more frequently than every 15 minutes.

## Prerequisites

- You must install the OpenShift API for Data Protection (OADP) Operator.
- The **DataProtectionApplication** CR must be in a **Ready** state.

## Procedure

1. Retrieve the **backupStorageLocations** CRs:

```
$ oc get backupStorageLocations -n openshift-adp
```

### Example output

| NAMESPACE     | NAME            | PHASE     | LAST VALIDATED | AGE | DEFAULT |
|---------------|-----------------|-----------|----------------|-----|---------|
| openshift-adp | velero-sample-1 | Available | 11s            | 31m |         |

2. Create a **Schedule** CR, as in the following example:

```
$ cat << EOF | oc apply -f -
apiVersion: velero.io/v1
kind: Schedule
metadata:
  name: <schedule>
  namespace: openshift-adp
spec:
  schedule: 0 7 * * * 1
  template:
    hooks: {}
    includedNamespaces:
    - <namespace> 2
    storageLocation: <velero-sample-1> 3
    defaultVolumesToRestic: true 4
    ttl: 720h0m0s
EOF
```

**1** **cron** expression to schedule the backup, for example, **0 7 \* \* \*** to perform a backup every day at 7:00.

- 2 Array of namespaces to back up.
- 3 Name of the **backupStorageLocations** CR.
- 4 Optional: Add the **defaultVolumesToRestic: true** key-value pair if you are backing up volumes with Restic.

3. Verify that the status of the **Schedule** CR is **Completed** after the scheduled backup runs:

```
$ oc get schedule -n openshift-adp <schedule> -o jsonpath='{.status.phase}'
```

### 15.3.3. Additional resources

- [Overview of CSI volume snapshots](#)

## 15.4. RESTORING VIRTUAL MACHINES

You restore an OpenShift API for Data Protection (OADP) **Backup** custom resource (CR) by creating a [Restore CR](#).

You can add [hooks](#) to the **Restore** CR to run commands in init containers, before the application container starts, or in the application container itself.

### 15.4.1. Creating a Restore CR

You restore a **Backup** custom resource (CR) by creating a **Restore** CR.

#### Prerequisites

- You must install the OpenShift API for Data Protection (OADP) Operator.
- The **DataProtectionApplication** CR must be in a **Ready** state.
- You must have a Velero **Backup** CR.
- Adjust the requested size so the persistent volume (PV) capacity matches the requested size at backup time.

#### Procedure

1. Create a **Restore** CR, as in the following example:

```
apiVersion: velero.io/v1
kind: Restore
metadata:
  name: <restore>
  namespace: openshift-adp
spec:
  backupName: <backup> ①
  includedResources: [] ②
  excludedResources:
    - nodes
    - events
```

```

- events.events.k8s.io
- backups.velero.io
- restores.velero.io
- resticrepositories.velero.io
restorePVs: true ③

```

- 1 Name of the **Backup** CR.
- 2 Optional: Specify an array of resources to include in the restore process. Resources might be shortcuts (for example, **po** for **pods**) or fully-qualified. If unspecified, all resources are included.
- 3 Optional: The **restorePVs** parameter can be set to **false** in order to turn off restore of **PersistentVolumes** from **VolumeSnapshot** of Container Storage Interface (CSI) snapshots, or from native snapshots when **VolumeSnapshotLocation** is configured.

- 2 Verify that the status of the **Restore** CR is **Completed** by entering the following command:

```
$ oc get restore -n openshift-adp <restore> -o jsonpath='{.status.phase}'
```

- 3 Verify that the backup resources have been restored by entering the following command:

```
$ oc get all -n <namespace> ①
```

- 1 Namespace that you backed up.

- 4 If you use Restic to restore **DeploymentConfig** objects or if you use post-restore hooks, run the **dc-restic-post-restore.sh** cleanup script by entering the following command:

```
$ bash dc-restic-post-restore.sh <restore-name>
```



### NOTE

In the course of the restore process, the OADP Velero plug-ins scale down the **DeploymentConfig** objects and restore the pods as standalone pods to prevent the cluster from deleting the restored **DeploymentConfig** pods immediately on restore and to allow Restic and post-restore hooks to complete their actions on the restored pods. The cleanup script removes these disconnected pods and scale any **DeploymentConfig** objects back up to the appropriate number of replicas.

#### Example 15.1. **dc-restic-post-restore.sh** cleanup script

```

#!/bin/bash
set -e

# if sha256sum exists, use it to check the integrity of the file
if command -v sha256sum >/dev/null 2>&1; then
  CHECKSUM_CMD="sha256sum"
else
  CHECKSUM_CMD="shasum -a 256"
fi

```

```

label_name () {
    if [ "${#1}" -le "63" ]; then
        echo $1
        return
    fi
    sha=$(echo -n $1|$CHECKSUM_CMD)
    echo "${1:0:57}${sha:0:6}"
}
OADP_NAMESPACE=${OADP_NAMESPACE:=openshift-adp}

if [[ $# -ne 1 ]]; then
    echo "usage: ${BASH_SOURCE} restore-name"
    exit 1
fi

echo using OADP Namespace $OADP_NAMESPACE
echo restore: $1

label=$(label_name $1)
echo label: $label

echo Deleting disconnected restore pods
oc delete pods -l oadp.openshift.io/disconnected-from-dc=$label

for dc in $(oc get dc --all-namespaces -l oadp.openshift.io/replicas-modified=$label -o
jsonpath='{range .items[*]}.metadata.namespace{","}{.metadata.name}{","}
{.metadata.annotations.oadp\\.openshift\\.io/original-replicas}{","}
{.metadata.annotations.oadp\\.openshift\\.io/original-paused}{"\n"}')
do
    IFS='` read -ra dc_arr <<< "$dc"
    if [ ${#dc_arr[0]} -gt 0 ]; then
        echo Found deployment ${dc_arr[0]}/${dc_arr[1]}, setting replicas: ${dc_arr[2]}, paused:
${dc_arr[3]}
        cat <<EOF | oc patch dc -n ${dc_arr[0]} ${dc_arr[1]} --patch-file /dev/stdin
spec:
    replicas: ${dc_arr[2]}
    paused: ${dc_arr[3]}
EOF
    fi
done

```

#### 15.4.1.1. Creating restore hooks

You create restore hooks to run commands in a container in a pod while restoring your application by editing the **Restore** custom resource (CR).

You can create two types of restore hooks:

- An **init** hook adds an init container to a pod to perform setup tasks before the application container starts.  
If you restore a Restic backup, the **restic-wait** init container is added before the restore hook init container.

- An **exec** hook runs commands or scripts in a container of a restored pod.

## Procedure

- Add a hook to the **spec.hooks** block of the **Restore** CR, as in the following example:

```
apiVersion: velero.io/v1
kind: Restore
metadata:
  name: <restore>
  namespace: openshift-adp
spec:
  hooks:
    resources:
      - name: <hook_name>
        includedNamespaces:
          - <namespace> ①
        excludedNamespaces:
          - <namespace>
        includedResources:
          - pods ②
        excludedResources: []
        labelSelector: ③
        matchLabels:
          app: velero
          component: server
      postHooks:
        - init:
            initContainers:
              - name: restore-hook-init
                image: alpine:latest
                volumeMounts:
                  - mountPath: /restores/pvc1-vm
                    name: pvc1-vm
                command:
                  - /bin/ash
                  - -c
            timeout: ④
        - exec:
            container: <container> ⑤
            command:
              - /bin/bash ⑥
              - -c
              - "psql < /backup/backup.sql"
            waitTimeout: 5m ⑦
            execTimeout: 1m ⑧
            onError: Continue ⑨
```

- ① Optional: Array of namespaces to which the hook applies. If this value is not specified, the hook applies to all namespaces.
- ② Currently, pods are the only supported resource that hooks can apply to.
- ③ Optional: This hook only applies to objects matching the label selector.

- ④ Optional: Timeout specifies the maximum amount of time Velero waits for **initContainers** to complete.
- ⑤ Optional: If the container is not specified, the command runs in the first container in the pod.
- ⑥ This is the entrypoint for the init container being added.
- ⑦ Optional: How long to wait for a container to become ready. This should be long enough for the container to start and for any preceding hooks in the same container to complete. If not set, the restore process waits indefinitely.
- ⑧ Optional: How long to wait for the commands to run. The default is **30s**.
- ⑨ Allowed values for error handling are **Fail** and **Continue**:
  - **Continue**: Only command failures are logged.
  - **Fail**: No more restore hooks run in any container in any pod. The status of the **Restore** CR will be **PartiallyFailed**.