# Red Hat OpenShift Service on AWS 4

## Virtualization

OpenShift Virtualization installation and usage.

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OpenShift Virtualization installation and usage.

## Abstract

This document provides information about how to use OpenShift Virtualization in OpenShift Service on AWS.

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# CHAPTER 1. ABOUT

## 1.1. ABOUT OPENSHIFT VIRTUALIZATION

Documentation for OpenShift Virtualization will be available for Red Hat OpenShift Service on AWS 4 in the near future.

## 1.2. 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.
- TLS certificates for OpenShift Virtualization components are renewed and rotated automatically.

### 1.2.1. 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.

### 1.2.2. TLS certificates

TLS certificates for OpenShift Virtualization components are renewed and rotated automatically. You are not required to refresh them manually.

#### 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

### 1.2.3. Authorization

OpenShift Virtualization uses role-based access control (RBAC) to define permissions for human users and service accounts. The permissions defined for service accounts control the actions that OpenShift Virtualization components can perform.

You can also use RBAC roles to manage user access to virtualization features. 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 by binding the role to specific users.

#### 1.2.3.1. Default cluster roles for OpenShift Virtualization

By using cluster role aggregation, OpenShift Virtualization extends the default Red Hat OpenShift Service on AWS cluster roles to include permissions for accessing virtualization objects.

Table 1.1. OpenShift Virtualization cluster roles

| Default cluster role | OpenShift Virtualization cluster role | OpenShift Virtualization cluster role description |
|---|---|---|
| **view** | **kubevirt.io:view** | 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. |
| **edit** | **kubevirt.io:edit** | 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. |
| **admin** | **kubevirt.io:admin** | 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 **HyperConverged** custom resource in the **openshift-cnv** namespace. |

#### 1.2.3.2. RBAC roles for storage features in OpenShift Virtualization

The following permissions are granted to the Containerized Data Importer (CDI), including the **cdi-operator** and **cdi-controller** service accounts.

##### 1.2.3.2.1. Cluster-wide RBAC roles

Table 1.2. Aggregated cluster roles for the**cdi.kubevirt.io** API group

| CDI cluster role | Resources | Verbs |
|---|---|---|
| **cdi.kubevirt.io:admin** | **datavolumes**, **uploadtokenrequests** | * (all) |
| | **datavolumes/source** | **create** |

| CDI cluster role | Resources | Verbs |
|---|---|---|
| | | |
| **cdi.kubevirt.io:edit** | **datavolumes**, **uploadtokenrequests** | * |
| | **datavolumes/source** | **create** |
| **cdi.kubevirt.io:view** | **cdiconfigs**, **dataimportcrons**, **datasources**, **datavolumes**, **objecttransfers**, **storageprofiles**, **volumeimportsources**, **volumeuploadsources**, **volumeclonesources** | **get**, **list**, **watch** |
| | **datavolumes/source** | **create** |
| **cdi.kubevirt.io:config-reader** | **cdiconfigs**, **storageprofiles** | **get**, **list**, **watch** |

Table 1.3. Cluster-wide roles for the**cdi-operator** service account

| API group | Resources | Verbs |
|---|---|---|
| **rbac.authorization.k8s.io** | **clusterrolebindings**, **clusterroles** | **get**, **list**, **watch**, **create**, **update**, **delete** |
| **security.openshift.io** | **securitycontextconstraints** | **get**, **list**, **watch**, **update**, **create** |
| **apiextensions.k8s.io** | **customresourcedefinitions**, **customresourcedefinitions/status** | **get**, **list**, **watch**, **create**, **update**, **delete** |
| **cdi.kubevirt.io** | * | * |
| **upload.cdi.kubevirt.io** | * | * |
| **admissionregistration.k8s.io** | **validatingwebhookconfigurations**, **mutatingwebhookconfigurations** | **create**, **list**, **watch** |

| API group | Resources | Verbs |
|---|---|---|
| **admissionregistration.k8s.io** | **validatingwebhookconfigurations**<br><br>Allow list: **cdi-api-dataimportcron-validate, cdi-api-populator-validate, cdi-api-datavolume-validate, cdi-api-validate, objecttransfer-api-validate** | **get**, **update**, **delete** |
| **admissionregistration.k8s.io** | **mutatingwebhookconfigurations**<br><br>Allow list: **cdi-api-datavolume-mutate** | **get**, **update**, **delete** |
| **apiregistration.k8s.io** | **apiservices** | **get**, **list**, **watch**, **create**, **update**, **delete** |

Table 1.4. Cluster-wide roles for the**cdi-controller** service account

| API group | Resources | Verbs |
|---|---|---|
| **""** (core) | **events** | **create**, **patch** |
| **""** (core) | **persistentvolumeclaims** | **get**, **list**, **watch**, **create**, **update**, **delete**, **deletecollection**, **patch** |
| **""** (core) | **persistentvolumes** | **get**, **list**, **watch**, **update** |
| **""** (core) | **persistentvolumeclaims/finalizers**, **pods/finalizers** | **update** |
| **""** (core) | **pods**, **services** | **get**, **list**, **watch**, **create**, **delete** |
| **""** (core) | **configmaps** | **get**, **create** |
| **storage.k8s.io** | **storageclasses**, **csidrivers** | **get**, **list**, **watch** |
| **config.openshift.io** | **proxies** | **get**, **list**, **watch** |
| **cdi.kubevirt.io** | * | * |

| API group | Resources | Verbs |
|---|---|---|
| **snapshot.storage.k8s.io** | **volumesnapshots**, **volumesnapshotclasses**, **volumesnapshotcontents** | **get**, **list**, **watch**, **create**, **delete** |
| **snapshot.storage.k8s.io** | **volumesnapshots** | **update**, **deletecollection** |
| **apiextensions.k8s.io** | **customresourcedefinitions** | **get**, **list**, **watch** |
| **scheduling.k8s.io** | **priorityclasses** | **get**, **list**, **watch** |
| **image.openshift.io** | **imagestreams** | **get**, **list**, **watch** |
| **""** (core) | **secrets** | **create** |
| **kubevirt.io** | **virtualmachines/finalizers** | **update** |

1.2.3.2.2. Namespaced RBAC roles

Table 1.5. Namespaced roles for the**cdi-operator** service account

| API group | Resources | Verbs |
|---|---|---|
| **rbac.authorization.k8s.io** | **rolebindings**, **roles** | **get**, **list**, **watch**, **create**, **update**, **delete** |
| **""** (core) | **serviceaccounts**, **configmaps**, **events**, **secrets**, **services** | **get**, **list**, **watch**, **create**, **update**, **patch**, **delete** |
| **apps** | **deployments**, **deployments/finalizers** | **get**, **list**, **watch**, **create**, **update**, **delete** |
| **route.openshift.io** | **routes**, **routes/custom-host** | **get**, **list**, **watch**, **create**, **update** |
| **config.openshift.io** | **proxies** | **get**, **list**, **watch** |
| **monitoring.coreos.com** | **servicemonitors**, **prometheusrules** | **get**, **list**, **watch**, **create**, **delete**, **update**, **patch** |

| API group | Resources | Verbs |
|---|---|---|
| **coordination.k8s.io** | **leases** | **get**, **create**, **update** |

Table 1.6. Namespaced roles for the**cdi-controller** service account

| API group | Resources | Verbs |
|---|---|---|
| **""** (core) | **configmaps** | **get**, **list**, **watch**, **create**, **update**, **delete** |
| **""** (core) | **secrets** | **get**, **list**, **watch** |
| **batch** | **cronjobs** | **get**, **list**, **watch**, **create**, **update**, **delete** |
| **batch** | **jobs** | **create**, **delete**, **list**, **watch** |
| **coordination.k8s.io** | **leases** | **get**, **create**, **update** |
| **networking.k8s.io** | **ingresses** | **get**, **list**, **watch** |
| **route.openshift.io** | **routes** | **get**, **list**, **watch** |

#### 1.2.3.3. Additional SCCs and permissions 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.

##### 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
```

### 1.2.4. 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

## 1.3. OPENSHIFT VIRTUALIZATION ARCHITECTURE

The Operator Lifecycle Manager (OLM) deploys operator pods for each component of OpenShift Virtualization:

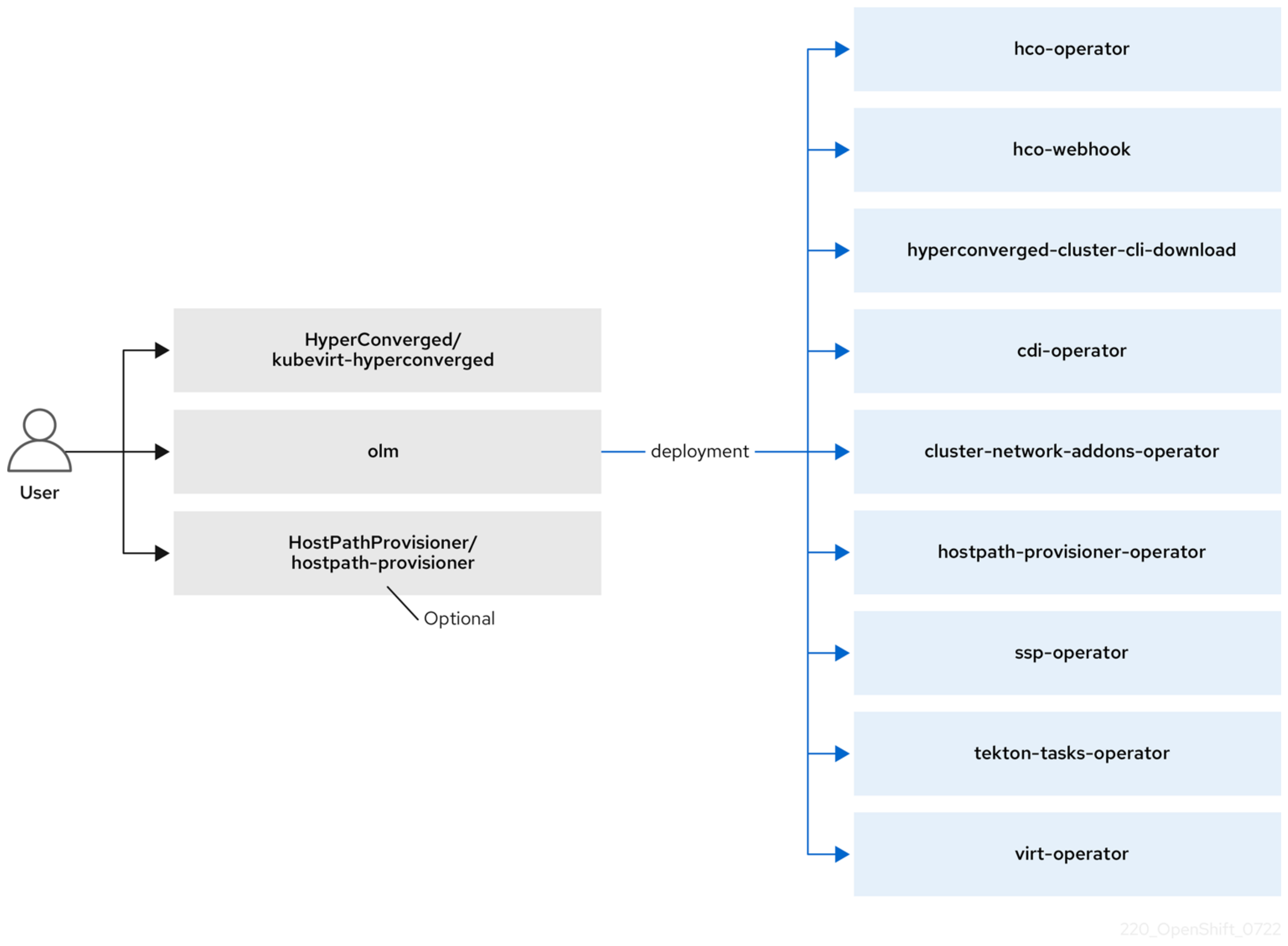
- Compute: **virt-operator**
- Storage: **cdi-operator**
- Network: **cluster-network-addons-operator**
- Scaling: **ssp-operator**
- Templating: **tekton-tasks-operator**

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 HyperConverged Operator (HCO) creates the **KubeVirt** CR, the OpenShift Virtualization Operator reconciles it and creates additional resources such as **virt-controller**, **virt-handler**, and **virt-api**.

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



- Virtctl client commands

### 1.3.1. About the HyperConverged Operator (HCO)

The HCO, **hco-operator**, 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.

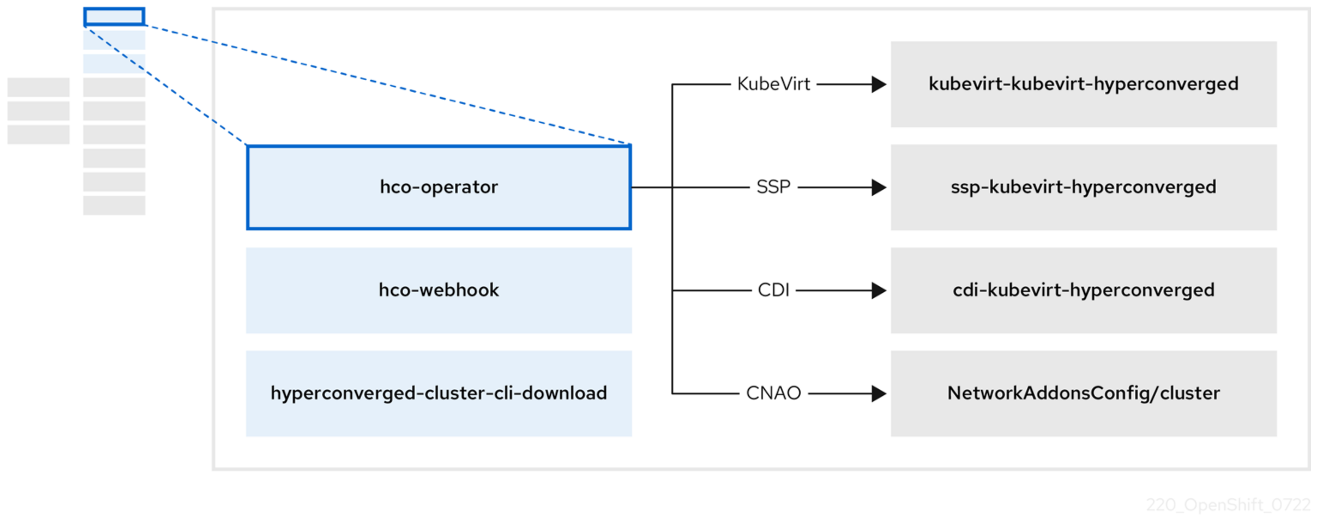

hco-operator
hco-webhook
hyperconverged-cluster-cli-download
KubeVirt
SSP
CDI
CNAO
kubevirt-kubevirt-hyperconverged
ssp-kubevirt-hyperconverged
cdi-kubevirt-hyperconverged
NetworkAddonsConfig/cluster
220_OpenShift_0722

Table 1.7. HyperConverged Operator components

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

### 1.3.2. About the Containerized Data Importer (CDI) Operator

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

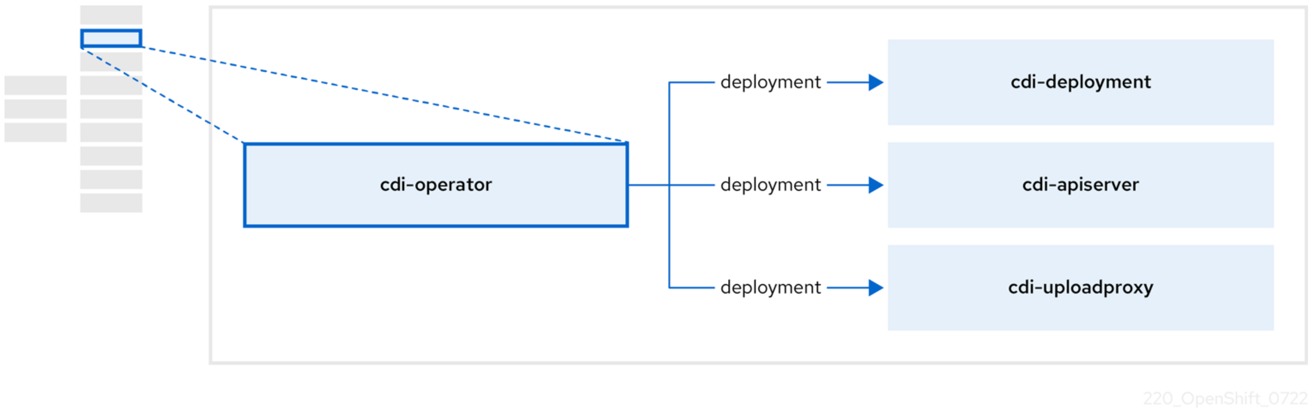


Table 1.8. CDI Operator components

| Component | Description |
|---|---|
| **deployment/cdi-apiserver** | Manages the authorization to upload VM disks into PVCs by issuing secure upload tokens. |
| **deployment/cdi-uploadproxy** | 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. |

| Component | Description |
|---|---|
| **pod/cdi-importer** | Helper pod that imports a virtual machine image into a PVC when creating a data volume. |

### 1.3.3. About the Cluster Network Addons Operator

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

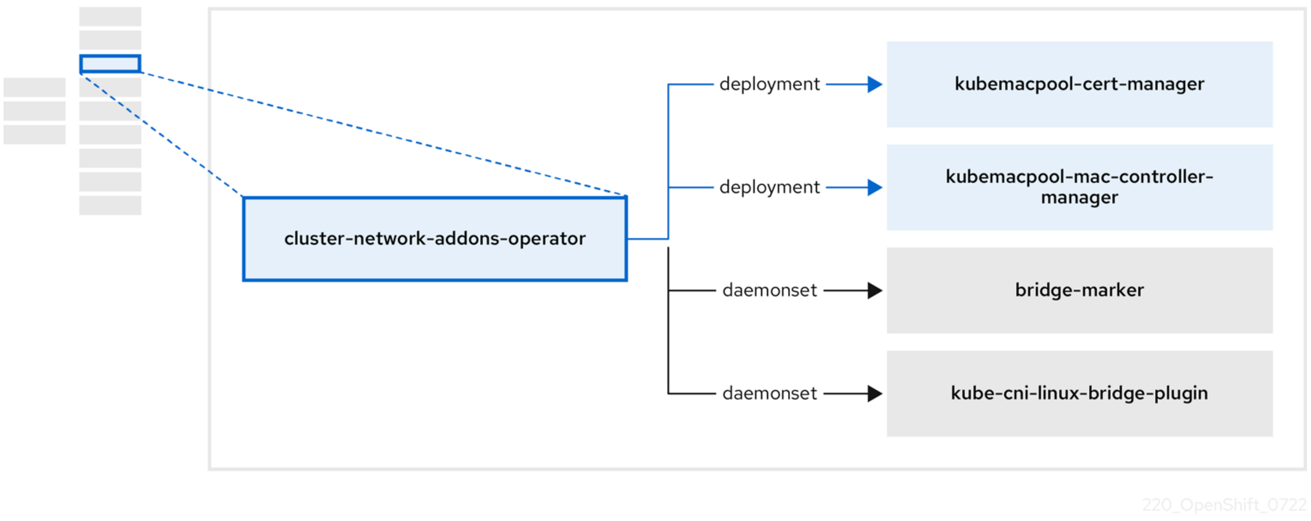

cluster-network-addons-operator
deployment
kubemacpool-cert-manager
deployment
kubemacpool-mac-controller-manager
daemonset
bridge-marker
daemonset
kube-cni-linux-bridge-plugin
220_OpenShift_0722

Table 1.9. Cluster Network Addons Operator components

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

### 1.3.4. About the Hostpath Provisioner (HPP) Operator

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

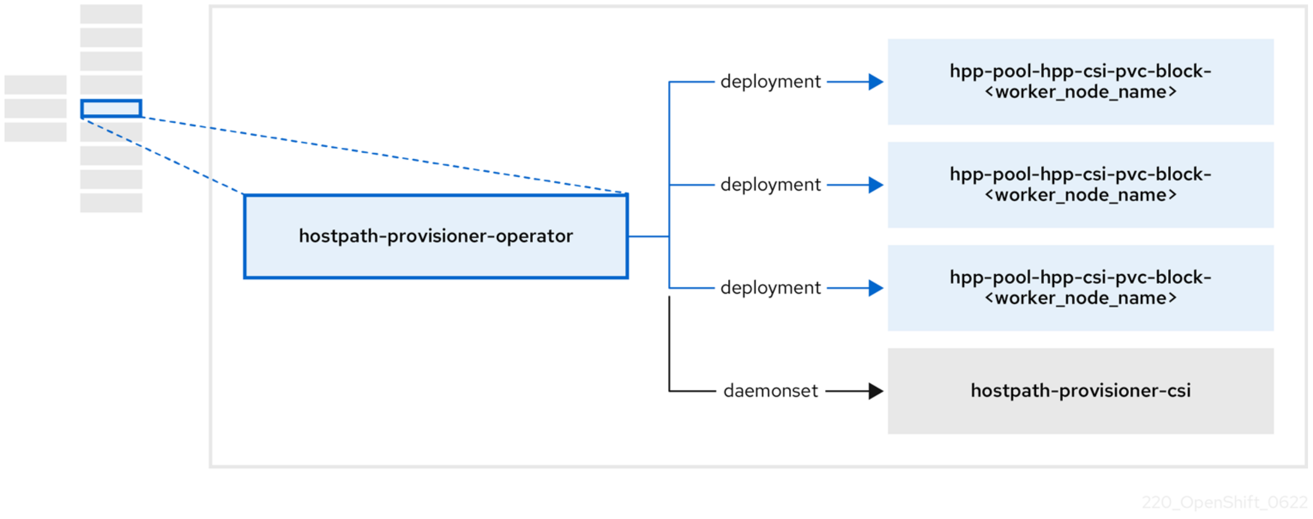

hostpath-provisioner-operator
deployment
deployment
deployment
daemonset
hpp-pool-hpp-csi-pvc-block-<worker_node_name>
hpp-pool-hpp-csi-pvc-block-<worker_node_name>
hpp-pool-hpp-csi-pvc-block-<worker_node_name>
hostpath-provisioner-csi
220_OpenShift_0622

Table 1.10. HPP Operator components

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

### 1.3.5. About the Scheduling, Scale, and Performance (SSP) Operator

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

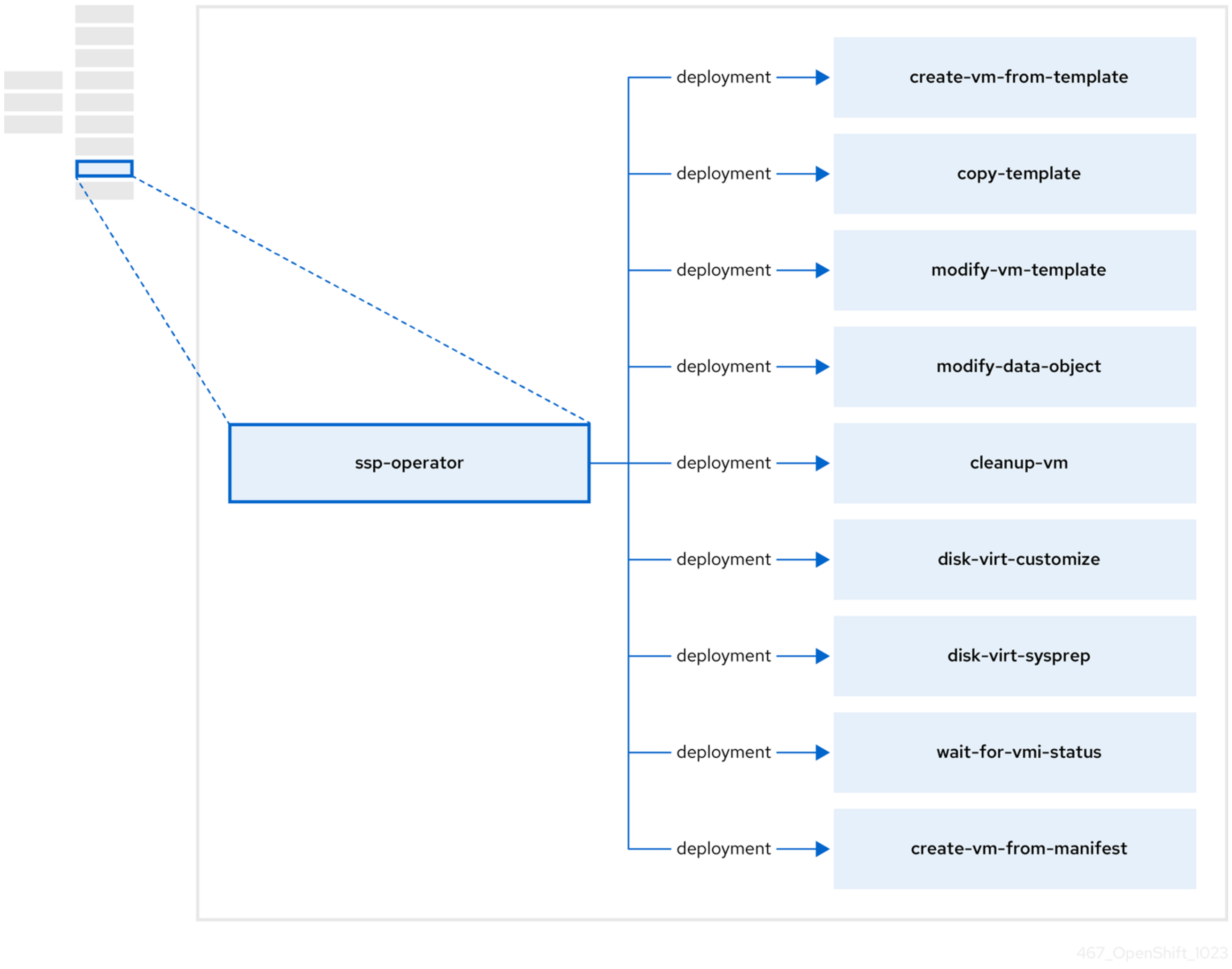


Table 1.11. SSP Operator components

| Component | Description |
|---|---|
| **deployment/create-vm-from-template** | Creates a VM from a template. |
| **deployment/copy-template** | Copies a VM template. |
| **deployment/modify-vm-template** | Creates or removes a VM template. |
| **deployment/modify-data-object** | Creates or removes data volumes or data sources. |
| **deployment/cleanup-vm** | Runs a script or a command on a VM, then stops or deletes the VM afterward. |
| **deployment/disk-virt-customize** | Runs a **customize** script on a target persistent volume claim (PVC) using **virt-customize**. |
| **deployment/disk-virt-sysprep** | Runs a **sysprep** script on a target PVC by using **virt-sysprep**. |

| Component | Description |
|---|---|
| **deployment/wait-for-vmi-status** | Waits for a specific virtual machine instance (VMI) status, then fails or succeeds according to that status. |
| **deployment/create-vm-from-manifest** | Creates a VM from a manifest. |

### 1.3.6. About the OpenShift Virtualization Operator

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

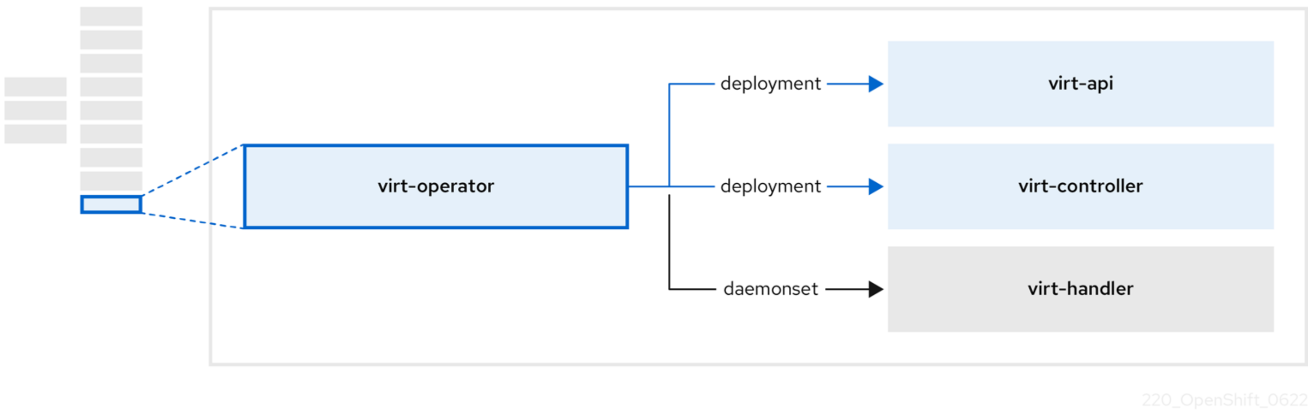


Table 1.12. virt-operator components

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

# CHAPTER 2. GETTING STARTED

## 2.1. 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.

### 2.1.1. Planning and installing OpenShift Virtualization

Plan and install OpenShift Virtualization on an Red Hat OpenShift Service on AWS cluster:

- 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.
- Specifying nodes for virtual machines.
- **Virtctl** commands.

### 2.1.2. Creating and managing virtual machines

Create a virtual machine (VM):

- Create a VM from a Red Hat image.
  You can create a VM by using a Red Hat template.
- Create a VM from a custom image.
  You can create a VM by importing a custom image from a container registry or a web page, by uploading an image from your local machine, or by cloning a persistent volume claim (PVC).

Connect a VM to a secondary network:

- Open Virtual Network (OVN)-Kubernetes secondary network.

NOTE

VMs are connected to the pod network by default.

Connect to a VM:

- Connect to the serial console or VNC console of a VM.
- Connect to a VM by using SSH .
- Connect to the desktop viewer for Windows VMs .

Manage a VM:

- Manage a VM by using the web console .
- Manage a VM by using the **virtctl** CLI tool.
- Export a VM .

### 2.1.3. Next steps

- Review postinstallation configuration options .
- Configure storage options and automatic boot source updates .
- Learn about monitoring and health checks .
- Learn about live migration .
- Tune and scale your cluster .

## 2.2. USING THE VIRTCTL AND LIBGUESTFS CLI TOOLS

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

You can access and modify virtual machine (VM) disk images by using the **libguestfs** command line tool. You deploy **libguestfs** by using the **virtctl libguestfs** command.

### 2.2.1. Installing virtctl

To install **virtctl** on Red Hat Enterprise Linux (RHEL) 9, Linux, Windows, and MacOS operating systems, you download and install the **virtctl** binary file.

To install **virtctl** on RHEL 8, you enable the OpenShift Virtualization repository and then install the **kubevirt-virtctl** package.

#### 2.2.1.1. Installing the virtctl binary on RHEL 9, Linux, Windows, or macOS

You can download the **virtctl** binary for your operating system from the Red Hat OpenShift Service on AWS web console and then install it.

**Procedure**

1. Navigate to the **Virtualization → Overview** page in the web console.
2. Click the **Download virtctl** link to download the **virtctl** binary for your operating system.
3. Install **virtctl**:
   - For RHEL 9 and other Linux operating systems:

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
```

#### 2.2.1.2. Installing the virtctl RPM on RHEL 8

You can install the **virtctl** RPM package on Red Hat Enterprise Linux (RHEL) 8 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 Red Hat OpenShift Service on AWS subscription.

**Procedure**

1. Enable the OpenShift Virtualization repository by using the **subscription-manager** CLI tool to run the following command:

```
# subscription-manager repos --enable cnv-4.16-for-rhel-8-x86_64-rpms
```

2. Install the **kubevirt-virtctl** package by running the following command:

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

## 2.2.2. 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 (VMIs) unless otherwise specified.

### 2.2.2.1. virtctl information commands

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

Table 2.1. Information commands

| Command | Description |
|---|---|
| **virtctl version** | View the **virtctl** client and server versions. |
| **virtctl help** | View a list of **virtctl** commands. |
| **virtctl <command> -h\|--help** | View a list of options for a specific command. |
| **virtctl options** | View a list of global command options for any **virtctl** command. |

### 2.2.2.2. VM information commands

You can use **virtctl** to view information about virtual machines (VMs) and virtual machine instances (VMIs).

Table 2.2. VM information commands

| Command | Description |
|---|---|
| **virtctl fslist <vm_name>** | View the file systems available on a guest machine. |
| **virtctl guestosinfo <vm_name>** | View information about the operating systems on a guest machine. |
| **virtctl userlist <vm_name>** | View the logged-in users on a guest machine. |

### 2.2.2.3. VM manifest creation commands

You can use **virtctl create** commands to create manifests for virtual machines, instance types, and preferences.

Table 2.3. VM manifest creation commands

| Command | Description |
|---|---|
| **virtctl create vm** | Create a **VirtualMachine** (VM) manifest. |
| **virtctl create vm --name <vm_name>** | Create a VM manifest, specifying a name for the VM. |
| **virtctl create vm --instancetype <instancetype_name>** | Create a VM manifest that uses an existing cluster-wide instance type. |
| **virtctl create vm --instancetype=virtualmachineinstancetype/<instancetype_name>** | Create a VM manifest that uses an existing namespaced instance type. |
| **virtctl create instancetype --cpu <cpu_value> --memory <memory_value> --name <instancetype_name>** | Create a manifest for a cluster-wide instance type. |
| **virtctl create instancetype --cpu <cpu_value> --memory <memory_value> --name <instancetype_name> --namespace <namespace_value>** | Create a manifest for a namespaced instance type. |
| **virtctl create preference --name <preference_name>** | Create a manifest for a cluster-wide VM preference, specifying a name for the preference. |
| **virtctl create preference --namespace <namespace_value>** | Create a manifest for a namespaced VM preference. |

### 2.2.2.4. VM management commands

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

Table 2.4. VM management commands

| Command | Description |
|---|---|
| **virtctl start <vm_name>** | Start a VM. |
| **virtctl start --paused <vm_name>** | Start a VM in a paused state. This option enables you to interrupt the boot process from the VNC console. |
| **virtctl stop <vm_name>** | Stop a VM. |

| Command | Description |
|---|---|
| **virtctl stop <vm_name> --grace-period 0 --force** | Force stop a VM. This option might cause data inconsistency or data loss. |
| **virtctl pause vm <vm_name>** | Pause a VM. The machine state is kept in memory. |
| **virtctl unpause vm <vm_name>** | Unpause a VM. |
| **virtctl migrate <vm_name>** | Migrate a VM. |
| **virtctl migrate-cancel <vm_name>** | Cancel a VM migration. |
| **virtctl restart <vm_name>** | Restart a VM. |

### 2.2.2.5. VM connection commands

You use **virtctl** connection commands to expose ports and connect to virtual machines (VMs) and virtual machine instances (VMIs).

Table 2.5. VM connection commands

| Command | Description |
|---|---|
| **virtctl console <vm_name>** | Connect to the serial console of a VM. |
| **virtctl expose vm <vm_name> --name <service_name> --type <ClusterIP\|NodePort\|LoadBalancer> --port <port>** | Create a service that forwards a designated port of a VM and expose the service on the specified port of the node.<br><br>Example: **virtctl expose vm rhel9_vm --name rhel9-ssh --type NodePort --port 22** |
| **virtctl scp -i <ssh_key> <file_name> <user_name>@<vm_name>** | 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. |
| **virtctl scp -i <ssh_key> <user_name@<vm_name>:<file_name> .** | 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. |
| **virtctl ssh -i <ssh_key> <user_name>@<vm_name>** | 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. |
| **virtctl vnc <vm_name>** | Connect to the VNC console of a VM.<br><br>You must have **virt-viewer** installed. |

| Command | Description |
|---|---|
| **virtctl vnc --proxy-only=true <vm_name>** | Display the port number and connect manually to a VM by using any viewer through the VNC connection. |
| **virtctl vnc --port=<port-number> <vm_name>** | Specify a port number to run the proxy on the specified port, if that port is available.<br><br>If a port number is not specified, the proxy runs on a random port. |

### 2.2.2.6. VM export commands

Use **virtctl vmexport** commands to create, download, or delete a volume exported from a VM, VM snapshot, or persistent volume claim (PVC). Certain manifests also contain a header secret, which grants access to the endpoint to import a disk image in a format that OpenShift Virtualization can use.

Table 2.6. VM export commands

| Command | Description |
|---|---|
| **virtctl vmexport create <vmexport_name> --vm\|snapshot\|pvc=<object_name>** | Create a **VirtualMachineExport** custom resource (CR) to export a volume from a VM, VM snapshot, or PVC.<br>● **--vm**: Exports the PVCs of a VM.<br>● **--snapshot**: Exports the PVCs contained in a **VirtualMachineSnapshot** CR.<br>● **--pvc**: Exports a PVC.<br>● Optional: **--ttl=1h** specifies the time to live. The default duration is 2 hours. |
| **virtctl vmexport delete <vmexport_name>** | Delete a **VirtualMachineExport** CR manually. |
| **virtctl vmexport download <vmexport_name> --output=<output_file> --volume=<volume_name>** | Download the volume defined in a **VirtualMachineExport** CR.<br>● **--output** specifies the file format. Example: **disk.img.gz**.<br>● **--volume** specifies the volume to download. This flag is optional if only one volume is available.<br><br>Optional:<br>● **--keep-vme** retains the **VirtualMachineExport** CR after download. The default behavior is to delete the **VirtualMachineExport** CR after download.<br>● **--insecure** enables an insecure HTTP connection. |

| Command | Description |
|---|---|
| **virtctl vmexport download <vmexport_name> --<vm\|snapshot\|pvc>=<object_name> --output=<output_file> --volume=<volume_name>** | Create a **VirtualMachineExport** CR and then download the volume defined in the CR. |
| **virtctl vmexport download export --manifest** | Retrieve the manifest for an existing export. The manifest does not include the header secret. |
| **virtctl vmexport download export --manifest --vm=example** | Create a VM export for a VM example, and retrieve the manifest. The manifest does not include the header secret. |
| **virtctl vmexport download export --manifest --snap=example** | Create a VM export for a VM snapshot example, and retrieve the manifest. The manifest does not include the header secret. |
| **virtctl vmexport download export --manifest --include-secret** | Retrieve the manifest for an existing export. The manifest includes the header secret. |
| **virtctl vmexport download export --manifest --manifest-output-format=json** | Retrieve the manifest for an existing export in json format. The manifest does not include the header secret. |
| **virtctl vmexport download export --manifest --include-secret --output=manifest.yaml** | Retrieve the manifest for an existing export. The manifest includes the header secret and writes it to the file specified. |

### 2.2.2.7. 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 hyperconverged 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 2.7. VM memory dump commands

| Command | Description |
|---|---|
| **virtctl memory-dump get <vm_name> --claim-name=<pvc_name>** | Save the memory dump of a VM on a PVC. The memory dump status is displayed in the **status** section of the**VirtualMachine** resource.<br><br>Optional:<br><br>● **--create-claim** creates a new PVC with the appropriate size. This flag has the following options:<br>○ **--storage-class=<storage_class>**: Specify a storage class for the PVC.<br>○ **--access-mode=<access_mode>**: Specify **ReadWriteOnce** or **ReadWriteMany**. |
| **virtctl memory-dump get <vm_name>** | Rerun the **virtctl memory-dump** command with the same PVC.<br><br>This command overwrites the previous memory dump. |
| **virtctl memory-dump remove <vm_name>** | Remove a memory dump.<br><br>You must remove a memory dump manually if you want to change the target PVC.<br><br>This command removes the association between the VM and the PVC, so that the memory dump is not displayed in the **status** section of the **VirtualMachine** resource. The PVC is not affected. |

#### 2.2.2.8. Hot plug and hot unplug commands

You use **virtctl** to add or remove resources from running virtual machines (VMs) and virtual machine instances (VMIs).

Table 2.8. Hot plug and hot unplug commands

| Command | Description |
|---|---|
| **virtctl addvolume <vm_name> --volume-name=<datavolume_or_PVC> [--persist] [--serial=<label>]** | Hot plug a data volume or persistent volume claim (PVC).<br><br>Optional:<br><br>● **--persist** mounts the virtual disk permanently on a VM.**This flag does not apply to VMIs.**<br><br>● **--serial=<label>** adds a label to the VM. If you do not specify a label, the default label is the data volume or PVC name. |
| **virtctl removevolume <vm_name> --volume-name=<virtual_disk>** | Hot unplug a virtual disk. |
| **virtctl addinterface <vm_name> --network-attachment-definition-name <net_attach_def_name> --name <interface_name>** | Hot plug a Linux bridge network interface. |
| **virtctl removeinterface <vm_name> --name <interface_name>** | Hot unplug a Linux bridge network interface. |

#### 2.2.2.9. Image upload commands

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

Table 2.9. Image upload commands

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

### 2.2.3. Deploying libguestfs 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.

### 2.2.3.1. 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 |
|---|---|
| **virt-edit -a /dev/vda /etc/motd** | Edit a file interactively in your terminal. |
| **virt-customize -a /dev/vda --ssh-inject root:string:<public key example>** | Inject an ssh key into the guest and create a login. |
| **virt-df -a /dev/vda -h** | See how much disk space is used by a VM. |
| **virt-customize -a /dev/vda --run-command 'rpm -qa > /rpm-list'** | See the full list of all RPMs installed on a guest by creating an output file containing the full list. |
| **virt-cat -a /dev/vda /rpm-list** | Display the output file list of all RPMs created using the **virt-customize -a /dev/vda --run-command 'rpm -qa > /rpm-list'** command in your terminal. |
| **virt-sysprep -a /dev/vda** | 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 |
|---|---|
| **--h** or **--help** | Provides help for **guestfs**. |

| Flag Option | Description |
|---|---|
| **-n <namespace>** option with a **<pvc_name>** argument | To use a PVC from a specific namespace.<br><br>If you do not use the **-n <namespace>** option, your current project is used. To change projects, use **oc project <namespace>**.<br><br>If you do not include a **<pvc_name>** argument, an error message appears. |
| **--image string** | Lists the **libguestfs-tools** container image.<br><br>You can configure the container to use a custom image by using the **--image** option. |
| **--kvm** | Indicates that **kvm** is used by the **libguestfs-tools** container.<br><br>By default, **virtctl guestfs** sets up **kvm** for the interactive container, which greatly speeds up the **libguest-tools** execution because it uses QEMU.<br><br>If a cluster does not have any **kvm** supporting nodes, you must disable **kvm** by setting the option **--kvm=false**.<br><br>If not set, the **libguestfs-tools** pod remains pending because it cannot be scheduled on any node. |
| **--pull-policy string** | Shows the pull policy for the **libguestfs** image.<br><br>You can also overwrite the image's pull policy by setting the **pull-policy** option. |

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 3. INSTALLING

## 3.1. PREPARING YOUR CLUSTER FOR OPENSHIFT VIRTUALIZATION

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

### 3.1.1. Supported platforms

You can use the following platforms with OpenShift Virtualization:

- Amazon Web Services bare metal instances.

#### 3.1.1.1. OpenShift Virtualization on Red Hat OpenShift Service on AWS

You can run OpenShift Virtualization on a Red Hat OpenShift Service on AWS (ROSA) Classic cluster.

Before you set up your cluster, review the following summary of supported features and limitations:

**Installing**

- You can install the cluster by using installer-provisioned infrastructure, ensuring that you specify bare-metal instance types for the worker nodes by editing the **install-config.yaml** file. For example, you can use the **c5n.metal** type value for a machine based on x86_64 architecture. For more information, see the Red Hat OpenShift Service on AWS documentation about installing on AWS.

**Accessing virtual machines (VMs)**

- There is no change to how you access VMs by using the **virtctl** CLI tool or the Red Hat OpenShift Service on AWS web console.
- You can expose VMs by using a **NodePort** or **LoadBalancer** service.
  - The load balancer approach is preferable because Red Hat OpenShift Service on AWS automatically creates the load balancer in AWS and manages its lifecycle. A security group is also created for the load balancer, and you can use annotations to attach existing security groups. When you remove the service, Red Hat OpenShift Service on AWS removes the load balancer and its associated resources.

**Networking**

- If your application requires a flat layer 2 network or control over the IP pool, consider using OVN-Kubernetes secondary overlay networks.

**Storage**

- You can use any storage solution that is certified by the storage vendor to work with the underlying platform.

IMPORTANT

AWS bare-metal and ROSA clusters might have different supported storage solutions. Ensure that you confirm support with your storage vendor.

- Using Amazon Elastic File System (EFS) or Amazon Elastic Block Store (EBS) with OpenShift Virtualization might cause performance and functionality limitations. Consider using CSI storage, which supports ReadWriteMany (RWX), cloning, and snapshots to enable live migration, fast VM creation, and VM snapshots capabilities.

**Additional resources**

- Connecting a virtual machine to an OVN-Kubernetes secondary network
- Exposing a virtual machine by using a service

### 3.1.2. Hardware and operating system requirements

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

#### 3.1.2.1. CPU requirements

- Supported by Red Hat Enterprise Linux (RHEL) 9.
  See Red Hat Ecosystem Catalog for supported CPUs.

  NOTE

  If your worker nodes have different CPUs, live migration failures might occur because different CPUs have different capabilities. You can mitigate this issue by ensuring that your worker nodes have CPUs with the appropriate capacity and by configuring node affinity rules for your virtual machines.

  See Configuring a required node affinity rule for details.

- Support for AMD and Intel 64-bit architectures (x86-64-v2).
- Support for Intel 64 or AMD64 CPU extensions.
- Intel VT or AMD-V hardware virtualization extensions enabled.
- NX (no execute) flag enabled.

#### 3.1.2.2. Operating system requirements

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

#### 3.1.2.3. Storage requirements

- Supported by Red Hat OpenShift Service on AWS.
- If the storage provisioner supports snapshots, you must associate a **VolumeSnapshotClass** object with the default storage class.

##### 3.1.2.3.1. About volume and access modes for virtual machine disks

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

For best results, use the **ReadWriteMany** (RWX) access mode and the **Block** volume mode. This is important for the following reasons:

- **ReadWriteMany** (RWX) access mode is required for live migration.
- The **Block** volume mode performs significantly better than 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.

IMPORTANT

You cannot live migrate virtual machines with the following configurations:

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

Set the **evictionStrategy** field to **None** for these virtual machines. The **None** strategy powers down VMs during node reboots.

### 3.1.3. Live migration requirements

- Shared storage with **ReadWriteMany** (RWX) access mode.
- Sufficient RAM and network bandwidth.

  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.

- If the virtual machine uses a host model CPU, the nodes must support the virtual machine’s host model CPU.
- A dedicated Multus network for live migration is highly recommended. A dedicated network minimizes the effects of network saturation on tenant workloads during migration.

### 3.1.4. Physical resource overhead requirements

OpenShift Virtualization is an add-on to Red Hat OpenShift Service on AWS 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 Red Hat OpenShift Service on AWS 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.

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

### Cluster memory overhead

```
Memory overhead per infrastructure node ≈ 150 MiB
```

```
Memory overhead per worker node ≈ 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 ≈ (1.002 × requested memory) \
              + 218 MiB \ 1
              + 8 MiB × (number of vCPUs) \ 2
              + 16 MiB × (number of graphics devices) \ 3
              + (additional memory overhead) 4
```

1 Required for the processes that run in the **virt-launcher** pod.

2 Number of virtual CPUs requested by the virtual machine.

3 Number of virtual graphics cards requested by the virtual machine.

4 Additional memory overhead:

- 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.
- If Secure Encrypted Virtualization (SEV) is enabled, add 256 MiB.
- If Trusted Platform Module (TPM) is enabled, add 53 MiB.

**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 ≈ 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 ≈ 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.

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

#### Cluster storage overhead

> Aggregated storage overhead per node ≈ 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.

#### 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.

**Additional resources**

- Glossary of common terms for Red Hat OpenShift Service on AWS storage

## 3.2. INSTALLING OPENSHIFT VIRTUALIZATION

Install OpenShift Virtualization to add virtualization functionality to your Red Hat OpenShift Service on AWS cluster.

### 3.2.1. Installing the OpenShift Virtualization Operator

Install the OpenShift Virtualization Operator by using the Red Hat OpenShift Service on AWS web console or the command line.

#### 3.2.1.1. Installing the OpenShift Virtualization Operator by using the web console

You can deploy the OpenShift Virtualization Operator by using the Red Hat OpenShift Service on AWS web console.

**Prerequisites**

- Install Red Hat OpenShift Service on AWS 4 on your cluster.
- Log in to the Red Hat OpenShift Service on AWS web console as a user with **cluster-admin** permissions.
- Create a machine pool based on a bare metal compute node instance type. For more information, see "Creating a machine pool" in the Additional resources of this section.

**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 Red Hat OpenShift Service on AWS 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 Red Hat OpenShift Service on AWS 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.

#### Additional resources

- Creating a machine pool

### 3.2.1.2. Installing the OpenShift Virtualization Operator by using the command line

Subscribe to the OpenShift Virtualization catalog and install the OpenShift Virtualization Operator by applying manifests to your cluster.

#### 3.2.1.2.1. 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.

#### Prerequisites

- Install Red Hat OpenShift Service on AWS 4 on your cluster.
- Install the OpenShift CLI (**oc**).
- Log in as a user with **cluster-admin** privileges.

#### Procedure

1. 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.

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

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

**Prerequisites**

- Subscribe to the OpenShift Virtualization catalog in the **openshift-cnv** namespace.
- Log in as a user with **cluster-admin** privileges.
- Create a machine pool based on a bare metal compute node instance type.

**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.v4.16.0   OpenShift Virtualization   4.16.0
Succeeded
```

**Additional resources**

- Creating a machine pool

### 3.2.2. Next steps

- 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.

## 3.3. 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.

### 3.3.1. 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.

#### 3.3.1.1. Deleting the HyperConverged custom resource

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

**Prerequisites**

- You have access to an Red Hat OpenShift Service on AWS 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.

### 3.3.1.2. 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 Red Hat OpenShift Service on AWS cluster web console using an account with **dedicated-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.

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

You can delete a namespace by using the Red Hat OpenShift Service on AWS web console.

#### Prerequisites

- You have access to an Red Hat OpenShift Service on AWS 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**.

### 3.3.1.4. 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 Red Hat OpenShift Service on AWS 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**.

## 3.3.2. Uninstalling OpenShift Virtualization by using the CLI

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

#### Prerequisites

- You have access to an Red Hat OpenShift Service on AWS 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 "kubevirts.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 4. POST-INSTALLATION CONFIGURATION

## 4.1. POSTINSTALLATION CONFIGURATION

The following procedures are typically performed after OpenShift Virtualization is installed. You can configure the components that are relevant for your environment:

- Node placement rules for OpenShift Virtualization Operators, workloads, and controllers
- Network configuration:
    - Enabling the creation of load balancer services by using the Red Hat OpenShift Service on AWS web console
- Storage configuration:
    - Defining a default storage class for the Container Storage Interface (CSI)
    - Configuring local storage by using the Hostpath Provisioner (HPP)

## 4.2. SPECIFYING NODES FOR OPENSHIFT VIRTUALIZATION COMPONENTS

The default scheduling for virtual machines (VMs) on bare metal nodes is appropriate. Optionally, you can 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 rules for some components after installing OpenShift Virtualization, but virtual machines cannot be present if you want to configure node placement rules for workloads.

### 4.2.1. About node placement rules for OpenShift Virtualization components

You can use node placement rules for the following tasks:

- Deploy virtual machines only on nodes intended for virtualization workloads.
- Deploy Operators only on infrastructure nodes.
- Maintain separation between workloads.

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, not a requirement. If a rule is a preference, pods are still scheduled when 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.

### 4.2.2. Applying node placement rules

You can apply node placement rules by editing a **HyperConverged** or **HostPathProvisioner** object using the command line.

#### Prerequisites

- The **oc** CLI tool is installed.
- You are logged in with cluster administrator permissions.

#### Procedure

1. Edit the object in your default editor by running the following command:

```
$ oc edit <resource_type> <resource_name> -n {CNVNamespace}
```

2. Save the file to apply the changes.

### 4.2.3. Node placement rule examples

You can specify node placement rules for a OpenShift Virtualization component by editing a **HyperConverged** or **HostPathProvisioner** object.

#### 4.2.3.1. HyperConverged object node placement rule example

To specify the nodes where OpenShift Virtualization deploys its components, you can edit the **nodePlacement** object in the HyperConverged custom resource (CR) file that you create during OpenShift Virtualization installation.

#### Example **HyperConverged** object with **nodeSelector** rule

```
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 1
  workloads:
    nodePlacement:
      nodeSelector:
        example.io/example-workloads-key: example-workloads-value 2
```

1 Infrastructure resources are placed on nodes labeled **example.io/example-infra-key = example-infra-value**.

2 workloads are placed on nodes labeled **example.io/example-workloads-key = example-workloads-value**.

**Example HyperConverged object with affinity rule**

```
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 1
  workloads:
    nodePlacement:
      affinity:
        nodeAffinity:
          requiredDuringSchedulingIgnoredDuringExecution:
            nodeSelectorTerms:
            - matchExpressions:
              - key: example.io/example-workloads-key 2
                operator: In
                values:
                - example-workloads-value
          preferredDuringSchedulingIgnoredDuringExecution:
          - weight: 1
            preference:
              matchExpressions:
              - key: example.io/num-cpus
                operator: Gt
                values:
                - 8 3
```

1 Infrastructure resources are placed on nodes labeled **example.io/example-infra-key = example-value**.

2 workloads are placed on nodes labeled **example.io/example-workloads-key = example-workloads-value**.

3 Nodes that have more than eight CPUs are preferred for workloads, but if they are not available, pods are still scheduled.

**Example HyperConverged object with tolerations rule**

```
apiVersion: hco.kubevirt.io/v1beta1
kind: HyperConverged
metadata:
  name: kubevirt-hyperconverged
  namespace: openshift-cnv
spec:
  workloads:
    nodePlacement:
      tolerations: 1
      - key: "key"
        operator: "Equal"
        value: "virtualization"
        effect: "NoSchedule"
```

1 Nodes reserved for OpenShift Virtualization components are labeled with the **key = virtualization:NoSchedule** taint. Only pods with matching tolerations are scheduled on reserved nodes.

### 4.2.3.2. HostPathProvisioner object node placement rule example

You can edit the **HostPathProvisioner** object directly or by using the web console.

> **WARNING**
>
> You must schedule the hostpath provisioner and the OpenShift Virtualization components on the same nodes. Otherwise, virtualization pods that use the hostpath provisioner cannot run. You cannot run virtual machines.

After you deploy a virtual machine (VM) with the hostpath provisioner (HPP) storage class, you can remove the hostpath provisioner pod from the same node by using the node selector. However, you must first revert that change, at least for that specific node, and wait for the pod to run before trying to delete the VM.

You can configure node placement rules by specifying **nodeSelector**, **affinity**, or **tolerations** for the **spec.workload** field of the **HostPathProvisioner** object that you create when you install the hostpath provisioner.

#### Example HostPathProvisioner object with nodeSelector rule

```
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 (1)
```

(1) Workloads are placed on nodes labeled **example.io/example-workloads-key = example-workloads-value**.

### 4.2.4. Additional resources

- Specifying nodes for virtual machines
- Placing pods on specific nodes using node selectors
- Controlling pod placement on nodes using node affinity rules

## 4.3. POSTINSTALLATION NETWORK CONFIGURATION

By default, OpenShift Virtualization is installed with a single, internal pod network.

### 4.3.1. Installing networking Operators

### 4.3.2. Configuring a Linux bridge network

After you install the Kubernetes NMState Operator, you can configure a Linux bridge network for live migration or external access to virtual machines (VMs).

#### 4.3.2.1. Creating a Linux bridge NNCP

You can create a **NodeNetworkConfigurationPolicy** (NNCP) manifest for a Linux bridge network.

**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.

#### 4.3.2.2. Creating a Linux bridge NAD by using the web console

You can create a network attachment definition (NAD) to provide layer-2 networking to pods and virtual machines by using the Red Hat OpenShift Service on AWS web console.

A Linux bridge network attachment definition is the most efficient method for connecting a virtual machine to a VLAN.

**WARNING**

Configuring IP address management (IPAM) in a network attachment definition for virtual machines is not supported.

**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**.

### 4.3.3. Configuring a network for live migration

After you have configured a Linux bridge network, you can configure a dedicated network for live migration. A dedicated network minimizes the effects of network saturation on tenant workloads during live migration.

#### 4.3.3.1. Configuring a dedicated secondary network for live migration

To configure a dedicated secondary network for live migration, you must first create a bridge network attachment definition (NAD) by using the CLI. Then, you 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.
- Each node has at least two Network Interface Cards (NICs).
- The NICs for live migration are connected to the same VLAN.

**Procedure**

1. Create a **NetworkAttachmentDefinition** manifest according to the following example:

   **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 Specify the name of the **NetworkAttachmentDefinition** object.

2 3 Specify the name of the NIC to be used for live migration.

4 Specify the name of the CNI plugin that provides the network for the NAD.

5 Specify an IP address range for the secondary network. This range must not overlap 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:

**Example HyperConverged manifest**

```
apiVersion: hco.kubevirt.io/v1beta1
kind: HyperConverged
metadata:
  name: kubevirt-hyperconverged
spec:
  liveMigrationConfig:
    completionTimeoutPerGiB: 800
    network: <network> 1
    parallelMigrationsPerCluster: 5
    parallelOutboundMigrationsPerNode: 2
    progressTimeout: 150
# ...
```

1 Specify 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}'
```

### 4.3.3.2. Selecting a dedicated network by using the web console

You can select a dedicated network for live migration by using the Red Hat OpenShift Service on AWS web console.

**Prerequisites**

- You configured a Multus network for live migration.

**Procedure**

1. Navigate to **Virtualization > Overview** in the Red Hat OpenShift Service on AWS web console.
2. Click the **Settings** tab and then click **Live migration**.
3. Select the network from the **Live migration network** list.

### 4.3.4. Enabling load balancer service creation by using the web console

You can enable the creation of load balancer services for a virtual machine (VM) by using the Red Hat OpenShift Service on AWS web console.

**Prerequisites**

- You have configured a load balancer for the cluster.
- You are logged in as a user with the **cluster-admin** role.

**Procedure**

1. Navigate to **Virtualization → Overview**.
2. On the **Settings** tab, click **Cluster**.
3. Expand **General settings** and **SSH configuration**.
4. Set **SSH over LoadBalancer service** to on.

## 4.4. POSTINSTALLATION STORAGE CONFIGURATION

The following storage configuration tasks are mandatory:

- You must configure storage profiles if your storage provider is not recognized by CDI. A storage profile provides recommended storage settings based on the associated storage class.

Optional: You can configure local storage by using the hostpath provisioner (HPP).

See the storage configuration overview for more options, including configuring the Containerized Data Importer (CDI), data volumes, and automatic boot source updates.

### 4.4.1. Configuring local storage by using the HPP

When you install the OpenShift Virtualization Operator, the Hostpath Provisioner (HPP) Operator is automatically installed. The HPP Operator creates the HPP provisioner.

The HPP is a local storage provisioner designed for OpenShift Virtualization. To use the HPP, you must create an HPP custom resource (CR).

IMPORTANT

HPP storage pools must not be in the same partition as the operating system. Otherwise, the storage pools might fill the operating system partition. If the operating system partition is full, performance can be effected or the node can become unstable or unusable.

#### 4.4.1.1. Creating a storage class for the CSI driver with the storagePools stanza

To use the hostpath provisioner (HPP) you must create an associated storage class for the Container Storage Interface (CSI) driver.

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.

NOTE

Virtual machines use data volumes that are based on local PVs. Local PVs are bound to specific nodes. While a 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.

##### Prerequisites

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

##### 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.

2. Save the file and exit.

3. Create the **StorageClass** object by running the following command:

```
$ oc create -f storageclass_csi.yaml
```

# CHAPTER 5. UPDATING

## 5.1. UPDATING OPENSHIFT VIRTUALIZATION

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

### 5.1.1. OpenShift Virtualization on RHEL 9

OpenShift Virtualization 4.16 is based on Red Hat Enterprise Linux (RHEL) 9. You can update to OpenShift Virtualization 4.16 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 4.16 supports live migration from RHEL 8 nodes to RHEL 9 nodes.

#### 5.1.1.1. RHEL 9 machine type

All VM templates that are included with OpenShift Virtualization now use the RHEL 9 machine type by default: **machineType: pc-q35-rhel9.<y>.0**, where **<y>** is a single digit corresponding to the latest minor version of RHEL 9. For example, the value **pc-q35-rhel9.2.0** is used for RHEL 9.2.

Updating OpenShift Virtualization does not change the **machineType** value of any existing VMs. These VMs continue to function as they did before the update. You can optionally change a VM's machine type so that it can benefit from RHEL 9 improvements.

IMPORTANT

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

### 5.1.2. About updating OpenShift Virtualization

- Operator Lifecycle Manager (OLM) manages the lifecycle of the OpenShift Virtualization Operator. The Marketplace Operator, which is deployed during Red Hat OpenShift Service on AWS 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 Red Hat OpenShift Service on AWS to the next minor version. You cannot update OpenShift Virtualization to the next minor version without first updating Red Hat OpenShift Service on AWS.
- OpenShift Virtualization subscriptions use a single update channel that is named **stable**. The **stable** channel ensures that your OpenShift Virtualization and Red Hat OpenShift Service on AWS 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 Red Hat OpenShift Service on AWS version. For example, you must run OpenShift Virtualization 4.16 on Red Hat OpenShift Service on AWS 4.16.
    - 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 Red Hat OpenShift Service on AWS 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 AWS Elastic Block Store (EBS) storage, they cannot be live migrated and might block an Red Hat OpenShift Service on AWS cluster update.

As a workaround, you can reconfigure the virtual machines so that they can be powered off automatically during a cluster update. Set the **evictionStrategy** field to **None** and the **runStrategy** field to **Always**.

#### 5.1.2.1. 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 **runStrategy: Always** set, 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.

## 5.1.3. 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 hyperconverged kubevirt-hyperconverged -n openshift-cnv
```

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.

### 5.1.4. Approving pending Operator updates

#### 5.1.4.1. 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 Red Hat OpenShift Service on AWS 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**.

## 5.1.5. Monitoring update status

### 5.1.5.1. 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 hyperconverged kubevirt-hyperconverged -n openshift-cnv \
  -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
```

#### 5.1.5.2. 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.

### 5.1.6. Additional resources

- What are Operators?
- Operator Lifecycle Manager concepts and resources
- Cluster service versions (CSVs)
- About live migration
- Configuring eviction strategies
- Configuring live migration limits and timeouts

# CHAPTER 6. VIRTUAL MACHINES

## 6.1. CREATING VMS FROM RED HAT IMAGES

### 6.1.1. Creating virtual machines from Red Hat images overview

Red Hat images are golden images. They are published as container disks in a secure registry. The Containerized Data Importer (CDI) polls and imports the container disks into your cluster and stores them in the **openshift-virtualization-os-images** project as snapshots or persistent volume claims (PVCs).

Red Hat images are automatically updated. You can disable and re-enable automatic updates for these images. See Managing Red Hat boot source updates .

Cluster administrators can enable automatic subscription for Red Hat Enterprise Linux (RHEL) virtual machines in the OpenShift Virtualization web console.

You can create virtual machines (VMs) from operating system images provided by Red Hat by using one of the following methods:

- Creating a VM from a template by using the web console
- Creating a VM from an instance type by using the web console
- Creating a VM from a **VirtualMachine** manifest by using the command line

IMPORTANT

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

#### 6.1.1.1. About golden images

A golden image is a preconfigured snapshot of a virtual machine (VM) that you can use as a resource to deploy new VMs. For example, you can use golden images to provision the same system environment consistently and deploy systems more quickly and efficiently.

##### 6.1.1.1.1. How do golden images work?

Golden images are created by installing and configuring an operating system and software applications on a reference machine or virtual machine. This includes setting up the system, installing required drivers, applying patches and updates, and configuring specific options and preferences.

After the golden image is created, it is saved as a template or image file that can be replicated and deployed across multiple clusters. The golden image can be updated by its maintainer periodically to incorporate necessary software updates and patches, ensuring that the image remains up to date and secure, and newly created VMs are based on this updated image.

##### 6.1.1.1.2. Red Hat implementation of golden images

Red Hat publishes golden images as container disks in the registry for versions of Red Hat Enterprise Linux (RHEL). Container disks are virtual machine images that are stored as a container image in a container image registry. Any published image will automatically be made available in connected clusters after the installation of OpenShift Virtualization. After the images are available in a cluster, they are ready to use to create VMs.

#### 6.1.1.2. About VM boot sources

Virtual machines (VMs) consist of a VM definition and one or more disks that are backed by data volumes. VM templates enable you to create VMs using predefined specifications.

Every template requires a boot source, which is a fully configured disk image including configured drivers. Each template contains a VM 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) and volume snapshots are created with the cluster's default storage class. If you select a different default storage class after configuration, you must delete the existing boot sources in the cluster namespace that are configured with the previous default storage class.

### 6.1.2. Creating virtual machines from templates

You can create virtual machines (VMs) from Red Hat templates by using the Red Hat OpenShift Service on AWS web console.

#### 6.1.2.1. About VM templates

**Boot sources**

You can expedite VM creation by using templates that have an available boot source. Templates with a boot source are labeled **Available boot source** if they do not have a custom label.
Templates without a boot source are labeled **Boot source required**. See Creating virtual machines from custom images.

**Customization**

You can customize the disk source and VM parameters before you start the VM.

See storage volume types and storage fields for details about disk source settings.

**NOTE**

If you copy a VM template with all its labels and annotations, your version of the template is marked as deprecated when a new version of the Scheduling, Scale, and Performance (SSP) Operator is deployed. You can remove this designation. See Customizing a VM template by using the web console.

**Single-node OpenShift**

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

#### 6.1.2.2. Creating a VM from a template

You can create a virtual machine (VM) from a template with an available boot source by using the Red Hat OpenShift Service on AWS web console.

Optional: You can customize template or VM parameters, such as data sources, cloud-init, or SSH keys, before you start the VM.

**Procedure**

1. Navigate to **Virtualization** → **Catalog** in the web console.
2. Click **Boot source available** to filter templates with boot sources.
   The catalog displays the default templates. Click **All Items** to view all available templates for your filters.
3. Click a template tile to view its details.
4. Click **Quick create VirtualMachine** to create a VM from the template.
   Optional: Customize the template or VM parameters:
   a. Click **Customize VirtualMachine**.
   b. Expand **Storage** or **Optional parameters** to edit data source settings.
   c. Click **Customize VirtualMachine parameters**.
      The **Customize and create VirtualMachine** pane displays the **Overview**, **YAML**, **Scheduling**, **Environment**, **Network interfaces**, **Disks**, **Scripts**, and **Metadata** tabs.
   d. Edit the parameters that must be set before the VM boots, such as cloud-init or a static SSH key.
   e. Click **Create VirtualMachine**.
      The **VirtualMachine details** page displays the provisioning status.

#### 6.1.2.2.1. Storage volume types

**Table 6.1. Storage volume types**

| 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 **PersistentVolumeClaim**. 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.<br><br>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 Red Hat OpenShift Service on AWS. There are some requirements for the disk to be used within a PVC. |

| Type | Description |
|---|---|
| dataVolume | Data volumes build on the **persistentVolumeClaim** 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.<br><br>Specify **type: dataVolume** or **type: ""**. If you specify any other value for **type**, such as **persistentVolumeClaim**, 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. |
| containerDisk | 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.<br><br>A **containerDisk** 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.<br><br>Only RAW and QCOW2 formats are supported disk types for the container image registry. QCOW2 is recommended for reduced image size.<br><br>NOTE<br><br>A **containerDisk** volume is ephemeral. It is discarded when the virtual machine is stopped, restarted, or deleted. A **containerDisk** volume is useful for read-only file systems such as CD-ROMs or for disposable virtual machines. |
| emptyDisk | 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.<br><br>The disk **capacity** size must also be provided. |

#### 6.1.2.2.2. Storage fields

| Field | Description |
|---|---|
| Blank (creates PVC) | Create an empty disk. |
| Import via URL (creates PVC) | Import content via URL (HTTP or HTTPS endpoint). |

| Field | Description |
|---|---|
| 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 | Name of the disk. The name can contain lowercase letters (**a-z**), numbers (**0-9**), 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 **virtIO**, **SATA**, and **SCSI**. |
| 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.

If you do not specify these parameters, the system uses the default storage profile values.

| Parameter | Option | Parameter description |
|---|---|---|
| Volume Mode | Filesystem | Stores the virtual disk on a file system-based volume. |
| | Block | Stores the virtual disk directly on the block volume. Only use **Block** if the underlying storage supports it. |
| Access Mode | 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. **NOTE** This mode is required for live migration. |

#### 6.1.2.2.3. Customizing a VM template by using the web console

You can customize an existing virtual machine (VM) template by modifying the VM or template parameters, such as data sources, cloud-init, or SSH keys, before you start the VM. If you customize a template by copying it and including all of its labels and annotations, the customized template is marked as deprecated when a new version of the Scheduling, Scale, and Performance (SSP) Operator is deployed.

You can remove the deprecated designation from the customized template.

**Procedure**

1. Navigate to **Virtualization** → **Templates** in the web console.
2. From the list of VM templates, click the template marked as deprecated.
3. Click **Edit** next to the pencil icon beside **Labels**.
4. Remove the following two labels:
   - **template.kubevirt.io/type: "base"**
   - **template.kubevirt.io/version: "version"**
5. Click **Save**.
6. Click the pencil icon beside the number of existing **Annotations**.
7. Remove the following annotation:
   - **template.kubevirt.io/deprecated**
8. Click **Save**.

### 6.1.3. Creating virtual machines from instance types

You can simplify virtual machine (VM) creation by using instance types, whether you use the Red Hat OpenShift Service on AWS web console or the CLI to create VMs.

NOTE

Creating a VM from an instance type in OpenShift Virtualization 4.15 and higher is supported on Red Hat OpenShift Service on AWS clusters. In OpenShift Virtualization 4.14, creating a VM from an instance type is a Technology Preview feature and is not supported on Red Hat OpenShift Service on AWS clusters.

#### 6.1.3.1. About instance types

An instance type is a reusable object where you can define resources and characteristics to apply to new VMs. You can define custom instance types or use the variety that are included when you install OpenShift Virtualization.

To create a new instance type, you must first create a manifest, either manually or by using the **virtctl** CLI tool. You then create the instance type object by applying the manifest to your cluster.

OpenShift Virtualization provides two CRDs for configuring instance types:

- A namespaced object: **VirtualMachineInstancetype**

- A cluster-wide object: **VirtualMachineClusterInstancetype**

These objects use the same **VirtualMachineInstancetypeSpec**.

#### 6.1.3.1.1. Required attributes

When you configure an instance type, you must define the **cpu** and **memory** attributes. Other attributes are optional.

NOTE

When you create a VM from an instance type, you cannot override any parameters defined in the instance type.

Because instance types require defined CPU and memory attributes, OpenShift Virtualization always rejects additional requests for these resources when creating a VM from an instance type.

You can manually create an instance type manifest. For example:

**Example YAML file with required fields**

```
apiVersion: instancetype.kubevirt.io/v1beta1
kind: VirtualMachineInstancetype
metadata:
  name: example-instancetype
spec:
  cpu:
    guest: 1 (1)
  memory:
    guest: 128Mi (2)
```

(1) Required. Specifies the number of vCPUs to allocate to the guest.

(2) Required. Specifies an amount of memory to allocate to the guest.

You can create an instance type manifest by using the **virtctl** CLI utility. For example:

**Example virtctl command with required fields**

```
$ virtctl create instancetype --cpu 2 --memory 256Mi
```

where:

**--cpu <value>**
: Specifies the number of vCPUs to allocate to the guest. Required.

**--memory <value>**
: Specifies an amount of memory to allocate to the guest. Required.

TIP

You can immediately create the object from the new manifest by running the following command:

```
$ virtctl create instancetype --cpu 2 --memory 256Mi | oc apply -f -
```

#### 6.1.3.1.2. Optional attributes

In addition to the required **cpu** and **memory** attributes, you can include the following optional attributes in the **VirtualMachineInstancetypeSpec**:

**annotations**
: List annotations to apply to the VM.

**gpus**
: List vGPUs for passthrough.

**hostDevices**
: List host devices for passthrough.

**ioThreadsPolicy**
: Define an IO threads policy for managing dedicated disk access.

**launchSecurity**
: Configure Secure Encrypted Virtualization (SEV).

**nodeSelector**
: Specify node selectors to control the nodes where this VM is scheduled.

**schedulerName**
: Define a custom scheduler to use for this VM instead of the default scheduler.

### 6.1.3.2. Pre-defined instance types

OpenShift Virtualization includes a set of pre-defined instance types called **common-instancetypes**. Some are specialized for specific workloads and others are workload-agnostic.

These instance type resources are named according to their series, version, and size. The size value follows the **.** delimiter and ranges from **nano** to **8xlarge**.

Table 6.2. **common-instancetypes** series comparison

| Use case | Series | Characteristics | vCPU to memory ratio | Example resource |
|---|---|---|---|---|
| Universal | U | • Burstable CPU performance | 1:4 | **u1.medium**<br>• 1 vCPUs<br>• 4 Gi memory |

| Use case | Series | Characteristics | vCPU to memory ratio | Example resource |
|---|---|---|---|---|
| Overcommitted | O | • Overcommitted memory<br>• Burstable CPU performance | 1:4 | **o1.small**<br>• 1 vCPU<br>• 2Gi memory |
| Compute-exclusive | CX | • Hugepages<br>• Dedicated CPU<br>• Isolated emulator threads<br>• vNUMA | 1:2 | **cx1.2xlarge**<br>• 8 vCPUs<br>• 16Gi memory |
| NVIDIA GPU | GN | • For VMs that use GPUs provided by the NVIDIA GPU Operator<br>• Has predefined GPUs<br>• Burstable CPU performance | 1:4 | **gn1.8xlarge**<br>• 32 vCPUs<br>• 128Gi memory |
| Memory-intensive | M | • Hugepages<br>• Burstable CPU performance | 1:8 | **m1.large**<br>• 2 vCPUs<br>• 16Gi memory |

| Use case | Series | Characteristics | vCPU to memory ratio | Example resource |
|---|---|---|---|---|
| Network-intensive | N | • Hugepages<br>• Dedicated CPU<br>• Isolated emulator threads<br>• Requires nodes capable of running DPDK workloads | 1:2 | **n1.medium**<br>• 4 vCPUs<br>• 4Gi memory |

### 6.1.3.3. Creating manifests by using the virtctl tool

You can use the **virtctl** CLI utility to simplify creating manifests for VMs, VM instance types, and VM preferences. For more information, see VM manifest creation commands.

If you have a **VirtualMachine** manifest, you can create a VM from the command line.

### 6.1.3.4. Creating a VM from an instance type by using the web console

You can create a virtual machine (VM) from an instance type by using the Red Hat OpenShift Service on AWS web console. You can also use the web console to create a VM by copying an existing snapshot or to clone a VM.

#### Procedure

1. In the web console, navigate to **Virtualization** → **Catalog** and click the **InstanceTypes** tab.
2. Select either of the following options:
   - Select a bootable volume.

     NOTE

     The bootable volume table lists only those volumes in the **openshift-virtualization-os-images** namespace that have the **instancetype.kubevirt.io/default-preference** label.

     - Optional: Click the star icon to designate a bootable volume as a favorite. Starred bootable volumes appear first in the volume list.
   - Click **Add volume** to upload a new volume or use an existing persistent volume claim (PVC), volume snapshot, or data source. Then click **Save**.
3. Click an instance type tile and select the resource size appropriate for your workload.
4. If you have not already added a public SSH key to your project, click the edit icon beside **Authorized SSH key** in the **VirtualMachine details** section.

5. Select one of the following options:
   - **Use existing**: Select a secret from the secrets list.
   - **Add new**:
     a. Browse to the public SSH key file or paste the file in the key field.
     b. Enter the secret name.
     c. Optional: Select **Automatically apply this key to any new VirtualMachine you create in this project**.
     d. Click **Save**.
6. Optional: Click **View YAML & CLI** to view the YAML file. Click **CLI** to view the CLI commands. You can also download or copy either the YAML file contents or the CLI commands.
7. Click **Create VirtualMachine**.

After the VM is created, you can monitor the status on the **VirtualMachine details** page.

### 6.1.4. Creating virtual machines from the command line

You can create virtual machines (VMs) from the command line by editing or creating a **VirtualMachine** manifest. You can simplify VM configuration by using an instance type in your VM manifest.

**NOTE**

You can also create VMs from instance types by using the web console .

#### 6.1.4.1. Creating manifests by using the virtctl tool

You can use the **virtctl** CLI utility to simplify creating manifests for VMs, VM instance types, and VM preferences. For more information, see VM manifest creation commands.

#### 6.1.4.2. Creating a VM from a VirtualMachine manifest

You can create a virtual machine (VM) from a **VirtualMachine** manifest.

**Procedure**

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

   **NOTE**

   This example manifest does not configure VM authentication.

   **Example manifest for a RHEL VM**

```
apiVersion: kubevirt.io/v1
kind: VirtualMachine
metadata:
  name: rhel-9-minimal
spec:
  dataVolumeTemplates:
    - metadata:
        name: rhel-9-minimal-volume
      spec:
        sourceRef:
          kind: DataSource
          name: rhel9 1
          namespace: openshift-virtualization-os-images 2
        storage: {}
  instancetype:
    name: u1.medium 3
  preference:
    name: rhel.9 4
  running: true
  template:
    spec:
      domain:
        devices: {}
      volumes:
        - dataVolume:
            name: rhel-9-minimal-volume
          name: rootdisk
```

1. The **rhel9** golden image is used to install RHEL 9 as the guest operating system.
2. Golden images are stored in the **openshift-virtualization-os-images** namespace.
3. The **u1.medium** instance type requests 1 vCPU and 4Gi memory for the VM. These resource values cannot be overridden within the VM.
4. The **rhel.9** preference specifies additional attributes that support the RHEL 9 guest operating system.

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> -n <namespace>
```

**Next steps**

- Configuring SSH access to virtual machines

## 6.2. CREATING VMS FROM CUSTOM IMAGES

### 6.2.1. Creating virtual machines from custom images overview

You can create virtual machines (VMs) from custom operating system images by using one of the following methods:

- Importing the image as a container disk from a registry .
  Optional: You can enable auto updates for your container disks. See Managing automatic boot source updates for details.
- Importing the image from a web page .
- Uploading the image from a local machine .
- Cloning a persistent volume claim (PVC) that contains the image .

The Containerized Data Importer (CDI) imports the image into a PVC by using a data volume. You add the PVC to the VM by using the Red Hat OpenShift Service on AWS web console or command line.

**IMPORTANT**

You must install the QEMU guest agent on VMs created from operating system images that are not provided by Red Hat.

You must also install VirtIO drivers on Windows VMs.

The QEMU guest agent is included with Red Hat images.

### 6.2.2. Creating VMs by using container disks

You can create virtual machines (VMs) by using container disks built from operating system images.

You can enable auto updates for your container disks. See Managing automatic boot source updates for details.

**IMPORTANT**

If the container disks are large, the I/O traffic might increase and cause worker nodes to be unavailable. You can prune **DeploymentConfig** objects to resolve this issue:

You create a VM from a container disk by performing the following steps:

1. Build an operating system image into a container disk and upload it to your container registry .
2. If your container registry does not have TLS, configure your environment to disable TLS for your registry.
3. Create a VM with the container disk as the disk source by using the web console or the command line.

**IMPORTANT**

You must install the QEMU guest agent on VMs created from operating system images that are not provided by Red Hat.

#### 6.2.2.1. Building and uploading a container disk

You can build a virtual machine (VM) image into a container disk and upload it to a registry.

The size of 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

- You must have **podman** installed.
- You must have a QCOW2 or RAW image file.

### Procedure

1. Create a Dockerfile to build the VM image into a container image. The VM 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 image in either QCOW2 or RAW format. If you use a remote image, replace **<vm_image>.qcow2** with the complete URL.

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
```

#### 6.2.2.2. Disabling TLS for a container 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

1. Open the **HyperConverged** CR in your default editor by running the following command:

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

2. Add a list of insecure registries to the **spec.storageImport.insecureRegistries** field.

**Example HyperConverged custom resource**

```
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.

#### 6.2.2.3. Creating a VM from a container disk by using the web console

You can create a virtual machine (VM) by importing a container disk from a container registry by using the Red Hat OpenShift Service on AWS web console.

**Procedure**

1. Navigate to **Virtualization** → **Catalog** in the web console.
2. Click a template tile without an available boot source.
3. Click **Customize VirtualMachine**.
4. On the **Customize template parameters** page, expand **Storage** and select **Registry (creates PVC)** from the **Disk source** list.
5. Enter the container image URL. Example: **https://mirror.arizona.edu/fedora/linux/releases/38/Cloud/x86_64/images/Fedora-Cloud-Base-38-1.6.x86_64.qcow2**
6. Set the disk size.
7. Click **Next**.
8. Click **Create VirtualMachine**.

#### 6.2.2.4. Creating a VM from a container disk by using the command line

You can create a virtual machine (VM) from a container disk by using the command line.

When the virtual machine (VM) is created, the data volume with the container disk is imported into persistent storage.

**Prerequisites**

- You must have access credentials for the container registry that contains the container disk.

**Procedure**

1. If the container registry requires authentication, create a **Secret** manifest, specifying the credentials, and save it as a **data-source-secret.yaml** file:

```
apiVersion: v1
kind: Secret
metadata:
  name: data-source-secret
  labels:
    app: containerized-data-importer
type: Opaque
data:
  accessKeyId: "" 1
  secretKey:   "" 2
```

1 Specify the Base64-encoded key ID or user name.

2 Specify the Base64-encoded secret key or password.

2. Apply the **Secret** manifest by running the following command:

```
$ oc apply -f data-source-secret.yaml
```

3. If the VM must communicate with servers that use self-signed certificates or certificates that are not signed by the system CA bundle, create a config map in the same namespace as the VM:

```
$ oc create configmap tls-certs 1
  --from-file=</path/to/file/ca.pem> 2
```

1 Specify the config map name.

2 Specify the path to the CA certificate.

4. Edit the **VirtualMachine** manifest and save it as a **vm-fedora-datavolume.yaml** file:

```
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:
        resources:
          requests:
            storage: 10Gi 3
        storageClassName: <storage_class> 4
      source:
        registry:
          url: "docker://kubevirt/fedora-cloud-container-disk-demo:latest" 5
          secretRef: data-source-secret 6
          certConfigMap: tls-certs 7
    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 VM.

2 Specify the name of the data volume.

3 Specify the size of the storage requested for the data volume.

4 Optional: If you do not specify a storage class, the default storage class is used.

5 Specify the URL of the container registry.

6 Optional: Specify the secret name if you created a secret for the container registry access credentials.

7 Optional: Specify a CA certificate config map.

5. Create the VM by running the following command:

```
$ oc create -f vm-fedora-datavolume.yaml
```

The **oc create** command creates the data volume and the VM. 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 VM.

Data volume provisioning happens in the background, so there is no need to monitor the process.

#### Verification

1. The importer pod downloads the container disk from the specified URL and stores it on the provisioned persistent volume. View the status of the importer pod by running the following command:

```
$ oc get pods
```

2. 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.

3. Verify that provisioning is complete and that the VM has started by accessing its serial console:

```
$ virtctl console vm-fedora-datavolume
```

### 6.2.3. Creating VMs by importing images from web pages

You can create virtual machines (VMs) by importing operating system images from web pages.

**IMPORTANT**

You must install the QEMU guest agent on VMs created from operating system images that are not provided by Red Hat.

#### 6.2.3.1. Creating a VM from an image on a web page by using the web console

You can create a virtual machine (VM) by importing an image from a web page by using the Red Hat OpenShift Service on AWS web console.

#### Prerequisites

- You must have access to the web page that contains the image.

#### Procedure

1. Navigate to **Virtualization → Catalog** in the web console.
2. Click a template tile without an available boot source.
3. Click **Customize VirtualMachine**.
4. On the **Customize template parameters** page, expand **Storage** and select **URL (creates PVC)** from the **Disk source** list.

5. Enter the image URL. Example: **https://access.redhat.com/downloads/content/69/ver=/rhel---7/7.9/x86_64/product-software**

6. Enter the container image URL. Example: **https://mirror.arizona.edu/fedora/linux/releases/38/Cloud/x86_64/images/Fedora-Cloud-Base-38-1.6.x86_64.qcow2**

7. Set the disk size.

8. Click **Next**.

9. Click **Create VirtualMachine**.

### 6.2.3.2. Creating a VM from an image on a web page by using the command line

You can create a virtual machine (VM) from an image on a web page by using the command line.

When the virtual machine (VM) is created, the data volume with the image is imported into persistent storage.

#### Prerequisites

- You must have access credentials for the web page that contains the image.

#### Procedure

1. If the web page requires authentication, create a **Secret** manifest, specifying the credentials, and save it as a **data-source-secret.yaml** file:

```
apiVersion: v1
kind: Secret
metadata:
  name: data-source-secret
  labels:
    app: containerized-data-importer
type: Opaque
data:
  accessKeyId: "" 1
  secretKey:   "" 2
```

1 Specify the Base64-encoded key ID or user name.

2 Specify the Base64-encoded secret key or password.

2. Apply the **Secret** manifest by running the following command:

```
$ oc apply -f data-source-secret.yaml
```

3. If the VM must communicate with servers that use self-signed certificates or certificates that are not signed by the system CA bundle, create a config map in the same namespace as the VM:

```
$ oc create configmap tls-certs 1
  --from-file=</path/to/file/ca.pem> 2
```

1 Specify the config map name.

2 Specify the path to the CA certificate.

4. Edit the **VirtualMachine** manifest and save it as a **vm-fedora-datavolume.yaml** file:

```
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:
        resources:
          requests:
            storage: 10Gi 3
        storageClassName: <storage_class> 4
      source:
        http:
          url: "https://mirror.arizona.edu/fedora/linux/releases/35/Cloud/x86_64/images/Fedora-
Cloud-Base-35-1.2.x86_64.qcow2" 5
        registry:
          url: "docker://kubevirt/fedora-cloud-container-disk-demo:latest" 6
          secretRef: data-source-secret 7
          certConfigMap: tls-certs 8
    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 VM.
2. Specify the name of the data volume.
3. Specify the size of the storage requested for the data volume.
4. Optional: If you do not specify a storage class, the default storage class is used.
5. 6 Specify the URL of the web page.
7. Optional: Specify the secret name if you created a secret for the web page access credentials.
8. Optional: Specify a CA certificate config map.

5. Create the VM by running the following command:

```
$ oc create -f vm-fedora-datavolume.yaml
```

The **oc create** command creates the data volume and the VM. 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 VM.

Data volume provisioning happens in the background, so there is no need to monitor the process.

**Verification**

1. The importer pod downloads the image from the specified URL and stores it on the provisioned persistent volume. View the status of the importer pod by running the following command:

```
$ oc get pods
```

2. 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.

3. Verify that provisioning is complete and that the VM has started by accessing its serial console:

```
$ virtctl console vm-fedora-datavolume
```

### 6.2.4. Creating VMs by uploading images

You can create virtual machines (VMs) by uploading operating system images from your local machine.

You can create a Windows VM by uploading a Windows image to a PVC. Then you clone the PVC when you create the VM.

IMPORTANT

You must install the QEMU guest agent on VMs created from operating system images that are not provided by Red Hat.

You must also install VirtIO drivers on Windows VMs.

#### 6.2.4.1. Creating a VM from an uploaded image by using the web console

You can create a virtual machine (VM) from an uploaded operating system image by using the Red Hat OpenShift Service on AWS web console.

**Prerequisites**

- You must have an **IMG**, **ISO**, or **QCOW2** image file.

**Procedure**

1. Navigate to **Virtualization** → **Catalog** in the web console.
2. Click a template tile without an available boot source.
3. Click **Customize VirtualMachine**.
4. On the **Customize template parameters** page, expand **Storage** and select **Upload (Upload a new file to a PVC)** from the **Disk source** list.
5. Browse to the image on your local machine and set the disk size.
6. Click **Customize VirtualMachine**.
7. Click **Create VirtualMachine**.

#### 6.2.4.2. Creating a Windows VM

You can create a Windows virtual machine (VM) by uploading a Windows image to a persistent volume claim (PVC) and then cloning the PVC when you create a VM by using the Red Hat OpenShift Service on AWS web console.

**Prerequisites**

- You created a Windows installation DVD or USB with the Windows Media Creation Tool. See Create Windows 10 installation media in the Microsoft documentation.
- You created an **autounattend.xml** answer file. See Answer files (unattend.xml) in the Microsoft documentation.

**Procedure**

1. Upload the Windows image as a new PVC:
   a. Navigate to **Storage** → **PersistentVolumeClaims** in the web console.
   b. Click **Create PersistentVolumeClaim** → **With Data upload form**.
   c. Browse to the Windows image and select it.

   d. Enter the PVC name, select the storage class and size and then click **Upload**.
      The Windows image is uploaded to a PVC.

2. Configure a new VM by cloning the uploaded PVC:
   a. Navigate to **Virtualization → Catalog**.
   b. Select a Windows template tile and click **Customize VirtualMachine**.
   c. Select **Clone (clone PVC)** from the **Disk source** list.
   d. Select the PVC project, the Windows image PVC, and the disk size.
3. Apply the answer file to the VM:
   a. Click **Customize VirtualMachine parameters**.
   b. On the **Sysprep** section of the **Scripts** tab, click **Edit**.
   c. Browse to the **autounattend.xml** answer file and click **Save**.
4. Set the run strategy of the VM:
   a. Clear **Start this VirtualMachine after creation** so that the VM does not start immediately.
   b. Click **Create VirtualMachine**.
   c. On the **YAML** tab, replace **running:false** with **runStrategy: RerunOnFailure** and click **Save**.
5. Click the options menu ⋮ and select **Start**.
   The VM boots from the **sysprep** disk containing the **autounattend.xml** answer file.

#### 6.2.4.2.1. Generalizing a Windows VM image

You can generalize a Windows operating system image to remove all system-specific configuration data before you use the image to create a new 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 VM with the QEMU guest agent installed.

**Procedure**

1. In the Red Hat OpenShift Service on AWS console, click **Virtualization → VirtualMachines**.
2. Select a Windows VM to open the **VirtualMachine details** page.
3. Click **Configuration → Disks**.
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.

#### 6.2.4.2.2. Specializing a Windows VM image

Specializing a Windows 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 Red Hat OpenShift Service on AWS console, click **Virtualization → Catalog**.
2. Select a Windows template and click **Customize VirtualMachine**.
3. Select **PVC (clone PVC)** from the **Disk source** list.
4. Select the PVC project and PVC name of the generalized Windows image.
5. Click **Customize VirtualMachine parameters**.
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.

**Additional resources for creating Windows VMs**

- Microsoft, Sysprep (Generalize) a Windows installation
- Microsoft, generalize
- Microsoft, specialize

### 6.2.4.3. Creating a VM from an uploaded image by using the command line

You can upload an operating system image by using the **virtctl** command line tool. You can use an existing data volume or create a new data volume for the image.

#### Prerequisites

- You must have an **ISO**, **IMG**, or **QCOW2** operating system image file.
- For best performance, compress the image file by using the virt-sparsify tool or the **xz** or **gzip** utilities.
- You must have **virtctl** installed.
- The client machine must be configured to trust the Red Hat OpenShift Service on AWS router's certificate.

#### Procedure

1. Upload the image by running the **virtctl image-upload** command:

```
$ 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 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. When you use the **--insecure** flag, the authenticity of the upload endpoint is **not** verified.

2. Optional. To verify that a data volume was created, view all data volumes by running the following command:

```
$ oc get dvs
```

### 6.2.5. Creating VMs by cloning PVCs

You can create virtual machines (VMs) by cloning existing persistent volume claims (PVCs) with custom images.

You must install the QEMU guest agent on VMs created from operating system images that are not provided by Red Hat.

You clone a PVC by creating a data volume that references a source PVC.

### 6.2.5.1. About cloning

When cloning a data volume, the Containerized Data Importer (CDI) chooses one of the following Container Storage Interface (CSI) clone methods:

- CSI volume cloning
- Smart cloning

Both CSI volume cloning and smart cloning methods are efficient, but they have certain requirements for use. If the requirements are not met, the CDI uses host-assisted cloning. Host-assisted cloning is the slowest and least efficient method of cloning, but it has fewer requirements than either of the other two cloning methods.

#### 6.2.5.1.1. CSI volume cloning

Container Storage Interface (CSI) cloning uses CSI driver features to more efficiently clone a source data volume.

CSI volume cloning has the following requirements:

- The CSI driver that backs the storage class of the persistent volume claim (PVC) must support volume cloning.
- For provisioners not recognized by the CDI, the corresponding storage profile must have the **cloneStrategy** set to CSI Volume Cloning.
- The source and target PVCs must have the same storage class and volume mode.
- If you create the data volume, you must have permission to create the **datavolumes/source** resource in the source namespace.
- The source volume must not be in use.

#### 6.2.5.1.2. Smart cloning

When a Container Storage Interface (CSI) plugin with snapshot capabilities is available, the Containerized Data Importer (CDI) creates a persistent volume claim (PVC) from a snapshot, which then allows efficient cloning of additional PVCs.

Smart cloning has the following requirements:

- A snapshot class associated with the storage class must exist.
- The source and target PVCs must have the same storage class and volume mode.
- If you create the data volume, you must have permission to create the **datavolumes/source** resource in the source namespace.
- The source volume must not be in use.

#### 6.2.5.1.3. Host-assisted cloning

When the requirements for neither Container Storage Interface (CSI) volume cloning nor smart cloning have been met, host-assisted cloning is used as a fallback method. Host-assisted cloning is less efficient than either of the two other cloning methods.

Host-assisted cloning uses a source pod and a target pod to copy data from the source volume to the target volume. The target persistent volume claim (PVC) is annotated with the fallback reason that explains why host-assisted cloning has been used, and an event is created.

**Example PVC target annotation**

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  annotations:
    cdi.kubevirt.io/cloneFallbackReason: The volume modes of source and target are incompatible
    cdi.kubevirt.io/clonePhase: Succeeded
    cdi.kubevirt.io/cloneType: copy
```

**Example event**

```
NAMESPACE   LAST SEEN   TYPE      REASON                    OBJECT                              MESSAGE
test-ns     0s          Warning   IncompatibleVolumeModes   persistentvolumeclaim/test-target   The
volume modes of source and target are incompatible
```

### 6.2.5.2. Creating a VM from a PVC by using the web console

You can create a virtual machine (VM) by importing an image from a web page by using the Red Hat OpenShift Service on AWS web console. You can create a virtual machine (VM) by cloning a persistent volume claim (PVC) by using the Red Hat OpenShift Service on AWS web console.

**Prerequisites**

- You must have access to the web page that contains the image.
- You must have access to the namespace that contains the source PVC.

**Procedure**

1. Navigate to **Virtualization → Catalog** in the web console.
2. Click a template tile without an available boot source.
3. Click **Customize VirtualMachine**.
4. On the **Customize template parameters** page, expand **Storage** and select **PVC (clone PVC)** from the **Disk source** list.
5. Enter the image URL. Example: **https://access.redhat.com/downloads/content/69/ver=/rhel---7/7.9/x86_64/product-software**
6. Enter the container image URL. Example: **https://mirror.arizona.edu/fedora/linux/releases/38/Cloud/x86_64/images/Fedora-Cloud-Base-38-1.6.x86_64.qcow2**
7. Select the PVC project and the PVC name.

8. Set the disk size.
9. Click **Next**.
10. Click **Create VirtualMachine**.

### 6.2.5.3. Creating a VM from a PVC by using the command line

You can create a virtual machine (VM) by cloning the persistent volume claim (PVC) of an existing VM by using the command line.

You can clone a PVC by using one of the following options:

- Cloning a PVC to a new data volume.
  This method creates a data volume whose lifecycle is independent of the original VM. Deleting the original VM does not affect the new data volume or its associated PVC.
- Cloning a PVC by creating a **VirtualMachine** manifest with a **dataVolumeTemplates** stanza.
  This method creates a data volume whose lifecycle is dependent on the original VM. Deleting the original VM deletes the cloned data volume and its associated PVC.

#### 6.2.5.3.1. Cloning a PVC to a data volume

You can clone the persistent volume claim (PVC) of an existing virtual machine (VM) disk to a data volume by using the command line.

You create a data volume that references the original source PVC. The lifecycle of the new data volume is independent of the original VM. Deleting the original VM does not affect the new data volume or its associated PVC.

Cloning between different volume modes is supported for host-assisted cloning, such as cloning from a block persistent volume (PV) to a file system PV, as long as the source and target PVs belong to the **kubevirt** content type.

**Prerequisites**

- The VM with the source PVC must be powered down.
- If you clone a PVC to a different namespace, you must have permissions to create resources in the target namespace.
- Additional prerequisites for smart-cloning:
  - Your storage provider must support snapshots.
  - The source and target PVCs must have the same storage provider and volume mode.
  - The value of the **driver** key of the **VolumeSnapshotClass** object must match the value of the **provisioner** key of the **StorageClass** object as shown in the following example:

    **Example VolumeSnapshotClass object**

    ```
    kind: VolumeSnapshotClass
    apiVersion: snapshot.storage.k8s.io/v1
    driver: openshift-storage.rbd.csi.ceph.com
    # ...
    ```

**Example StorageClass object**

```
kind: StorageClass
apiVersion: storage.k8s.io/v1
# ...
provisioner: openshift-storage.rbd.csi.ceph.com
```

**Procedure**

1. Create a **DataVolume** manifest as shown in the following example:

```
apiVersion: cdi.kubevirt.io/v1beta1
kind: DataVolume
metadata:
  name: <datavolume> 1
spec:
  source:
    pvc:
      namespace: "<source_namespace>" 2
      name: "<my_vm_disk>" 3
  storage: {}
```

1 Specify the name of the new data volume.

2 Specify the namespace of the source PVC.

3 Specify the name of the source PVC.

2. Create the data volume by running the following command:

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

**NOTE**

Data volumes prevent a VM from starting before the PVC is prepared. You can create a VM that references the new data volume while the PVC is being cloned.

#### 6.2.5.3.2. Creating a VM from a cloned PVC by using a data volume template

You can create a virtual machine (VM) that clones the persistent volume claim (PVC) of an existing VM by using a data volume template.

This method creates a data volume whose lifecycle is dependent on the original VM. Deleting the original VM deletes the cloned data volume and its associated PVC.

**Prerequisites**

- The VM with the source PVC must be powered down.

**Procedure**

1. Create a **VirtualMachine** manifest as shown in the following 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> (2)
          name: "<source_pvc>" (3)
```

(1) Specify the name of the VM.

(2) Specify the namespace of the source PVC.

(3) Specify the name of the source PVC.

2. Create the virtual machine with the PVC-cloned data volume:

```
$ oc create -f <vm-clone-datavolumetemplate>.yaml
```

### 6.2.6. Installing the QEMU guest agent and VirtIO drivers

The QEMU guest agent is a daemon that runs on the virtual machine (VM) and passes information to the host about the VM, users, file systems, and secondary networks.

You must install the QEMU guest agent on VMs created from operating system images that are not provided by Red Hat.

### 6.2.6.1. Installing the QEMU guest agent

#### 6.2.6.1.1. Installing the QEMU guest agent on a Linux VM

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 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. Log in to the VM by using a console or SSH.
2. Install the QEMU guest agent by running the following command:

```
$ yum install -y qemu-guest-agent
```

3. Ensure the service is persistent and start it:

```
$ systemctl enable --now qemu-guest-agent
```

**Verification**

- Run the following command to verify that **AgentConnected** is listed in the VM spec:

```
$ oc get vm <vm_name>
```

#### 6.2.6.1.2. Installing the QEMU guest agent on a Windows VM

For Windows virtual machines (VMs), the QEMU guest agent is included in the VirtIO drivers. You can install the drivers during a Windows installation or on an existing Windows 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 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, 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. Obtain a list of network services by running the following command:

```
$ net start
```

2. Verify that the output contains the **QEMU Guest Agent**.

### 6.2.6.2. Installing VirtIO drivers on Windows VMs

VirtIO drivers are paravirtualized device drivers required for Microsoft Windows virtual machines (VMs) to run in OpenShift Virtualization. The drivers are shipped with the rest of the images and do not require a separate download.

The **container-native-virtualization/virtio-win** container disk must be attached to the VM as a SATA CD drive to enable driver installation. You can install VirtIO drivers during Windows installation 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 VM.

**Table 6.3. Supported drivers**

| Driver name | Hardware ID | Description |
|---|---|---|
| **viostor** | VEN_1AF4&DEV_1001<br>VEN_1AF4&DEV_1042 | The block driver. Sometimes labeled as an **SCSI Controller** in the **Other devices** group. |
| **viorng** | VEN_1AF4&DEV_1005<br>VEN_1AF4&DEV_1044 | The entropy source driver. Sometimes labeled as a **PCI Device** in the **Other devices** group. |

| Driver name | Hardware ID | Description |
|---|---|---|
| **NetKVM** | VEN_1AF4&DEV_1000<br>VEN_1AF4&DEV_1041 | The network driver. Sometimes labeled as an **Ethernet Controller** in the **Other devices** group. Available only if a VirtIO NIC is configured. |

#### 6.2.6.2.1. Attaching VirtIO container disk to Windows VMs during installation

You must attach the VirtIO container disk to the Windows VM to install the necessary Windows drivers. This can be done during creation of the VM.

**Procedure**

1. When creating a Windows VM from a template, click **Customize VirtualMachine**.
2. Select **Mount Windows drivers disk**.
3. Click the **Customize VirtualMachine parameters**.
4. Click **Create VirtualMachine**.

After the VM is created, the **virtio-win** SATA CD disk will be attached to the VM.

#### 6.2.6.2.2. Attaching VirtIO container disk to an existing Windows VM

You must attach the VirtIO container disk to the Windows VM to install the necessary Windows drivers. This can be done to an existing VM.

**Procedure**

1. Navigate to the existing Windows VM, and click **Actions** → **Stop**.
2. Go to **VM Details** → **Configuration** → **Disks** and click **Add disk**.
3. Add **windows-driver-disk** from container source, set the **Type** to **CD-ROM**, and then set the **Interface** to **SATA**.
4. Click **Save**.
5. Start the VM, and connect to a graphical console.

#### 6.2.6.2.3. Installing VirtIO drivers during Windows installation

You can install the VirtIO drivers while installing Windows on a virtual machine (VM).

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 operating system, use the **File Explorer** to navigate to the **virtio-win** CD drive.
2. Double-click the drive to run the appropriate installer for your VM.
   For a 64-bit vCPU, select 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.

### 6.2.6.2.4. Installing VirtIO drivers from a SATA CD drive on an existing Windows VM

You can install the VirtIO drivers from a SATA CD drive on an existing Windows virtual machine (VM).

NOTE

This procedure uses a generic approach to adding drivers to Windows. See the installation documentation for your version of Windows for specific installation steps.

#### Prerequisites

- A storage device containing the virtio drivers must be attached to the VM as a SATA CD drive.

#### Procedure

1. Start the VM 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.

b. Right-click the device and select **Properties**.

c. Click the **Details** tab and select **Hardware Ids** in the **Property** list.

d. 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 VM to complete the driver installation.

#### 6.2.6.2.5. Installing VirtIO drivers from a container disk added as a SATA CD drive

You can install VirtIO drivers from a container disk that you add to a Windows virtual machine (VM) as a SATA CD drive.

### TIP

Downloading the **container-native-virtualization/virtio-win** container disk from the Red Hat Ecosystem Catalog is not mandatory, because the container disk is downloaded from the Red Hat registry if it not already present in the cluster. However, downloading reduces the installation time.

**Prerequisites**

- You must have access to the Red Hat registry or to the downloaded **container-native-virtualization/virtio-win** container disk in a restricted environment.

**Procedure**

1. Add the **container-native-virtualization/virtio-win** container disk as a CD drive by editing the **VirtualMachine** manifest:

```
# ...
spec:
  domain:
    devices:
      disks:
        - name: virtiocontainerdisk
          bootOrder: 2 1
          cdrom:
            bus: sata
volumes:
  - containerDisk:
      image: container-native-virtualization/virtio-win
    name: virtiocontainerdisk
```

1 OpenShift Virtualization boots the VM disks in the order defined in the **VirtualMachine** manifest. You can either define other VM disks that boot before the **container-native-**

2. Apply the changes:
   - If the VM is not running, run the following command:

     ```
     $ virtctl start <vm> -n <namespace>
     ```

   - If the VM is running, reboot the VM or run the following command:

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

3. After the VM has started, install the VirtIO drivers from the SATA CD drive.

#### 6.2.6.3. Updating VirtIO drivers

##### 6.2.6.3.1. Updating VirtIO drivers on a Windows VM

Update the **virtio** drivers on a Windows virtual machine (VM) by using the Windows Update service.

**Prerequisites**

- The cluster must be connected to the internet. Disconnected clusters cannot reach the Windows Update service.

**Procedure**

1. In the Windows Guest operating system, click the **Windows** key and select **Settings**.
2. Navigate to **Windows Update → Advanced Options → Optional Updates**.
3. Install all updates from **Red Hat, Inc.**
4. Reboot the VM.

**Verification**

1. On the Windows VM, navigate to the **Device Manager**.
2. Select a device.
3. Select the **Driver** tab.
4. Click **Driver Details** and confirm that the **virtio** driver details displays the correct version.

## 6.3. CONNECTING TO VIRTUAL MACHINE CONSOLES

You can connect to the following consoles to access running virtual machines (VMs):

- VNC console
- Serial console

- Desktop viewer for Windows VMs

### 6.3.1. Connecting to the VNC console

You can connect to the VNC console of a virtual machine by using the Red Hat OpenShift Service on AWS web console or the **virtctl** command line tool.

#### 6.3.1.1. Connecting to the VNC console by using the web console

You can connect to the VNC console of a virtual machine (VM) by using the Red Hat OpenShift Service on AWS web console.

NOTE

If you connect to a Windows VM with a vGPU assigned as a mediated device, you can switch between the default display and the vGPU display.

**Procedure**

1. On the **Virtualization** → **VirtualMachines** page, click a VM to open the **VirtualMachine details** page.
2. Click the **Console** tab. The VNC console session starts automatically.
3. Optional: To switch to the vGPU display of a Windows VM, select **Ctl + Alt + 2** from the **Send key** list.
   - Select **Ctl + Alt + 1** from the **Send key** list to restore the default display.
4. To end the console session, click outside the console pane and then click **Disconnect**.

#### 6.3.1.2. Connecting to the VNC console by using virtctl

You can use the **virtctl** command line tool to connect to the VNC console of a running virtual machine.

NOTE

If you run the **virtctl vnc** command on a remote machine over an SSH connection, you must forward the X session to your local machine by running the **ssh** command with the **-X** or **-Y** flags.

**Prerequisites**

- You must install the **virt-viewer** package.

**Procedure**

1. Run the following command to start the console session:

```
$ virtctl vnc <vm_name>
```

2. If the connection fails, run the following command to collect troubleshooting information:

```
$ virtctl vnc <vm_name> -v 4
```

### 6.3.1.3. Generating a temporary token for the VNC console

Generate a temporary authentication bearer token for the Kubernetes API to access the VNC of a virtual machine (VM).

NOTE

Kubernetes also supports authentication using client certificates, instead of a bearer token, by modifying the curl command.

#### Prerequisites

- A running virtual machine with OpenShift Virtualization 4.14 or later and **ssp-operator** 4.14 or later

#### Procedure

1. Enable the feature gate in the HyperConverged (**HCO**) custom resource (CR):

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

2. Generate a token by running the following command:

```
$ curl --header "Authorization: Bearer ${TOKEN}" \
    "https://api.
<cluster_fqdn>/apis/token.kubevirt.io/v1alpha1/namespaces/<namespace>/virtualmachines/<vm
_name>/vnc?duration=<duration>" 1
```

1 Duration can be in hours and minutes, with a minimum duration of 10 minutes. Example: **5h30m**. The token is valid for 10 minutes by default if this parameter is not set.

Sample output:

```
{ "token": "eyJhb..." }
```

3. Optional: Use the token provided in the output to create a variable:

```
$ export VNC_TOKEN="<token>"
```

You can now use the token to access the VNC console of a VM.

#### Verification

1. Log in to the cluster by running the following command:

```
$ oc login --token ${VNC_TOKEN}
```

2. Use **virtctl** to test access to the VNC console of the VM by running the following command:

```
$ virtctl vnc <vm_name> -n <namespace>
```

#### 6.3.1.3.1. Granting token generation permission for the VNC console by using the cluster role

As a cluster administrator, you can install a cluster role and bind it to a user or service account to allow access to the endpoint that generates tokens for the VNC console.

**Procedure**

- Choose to bind the cluster role to either a user or service account.
  - Run the following command to bind the cluster role to a user:

    ```
    $ kubectl create rolebinding "${ROLE_BINDING_NAME}" --
    clusterrole="token.kubevirt.io:generate" --user="${USER_NAME}"
    ```

  - Run the following command to bind the cluster role to a service account:

    ```
    $ kubectl create rolebinding "${ROLE_BINDING_NAME}" --
    clusterrole="token.kubevirt.io:generate" --
    serviceaccount="${SERVICE_ACCOUNT_NAME}"
    ```

## 6.3.2. Connecting to the serial console

You can connect to the serial console of a virtual machine by using the Red Hat OpenShift Service on AWS web console or the **virtctl** command line tool.

> **NOTE**
>
> Running concurrent VNC connections to a single virtual machine is not currently supported.

### 6.3.2.1. Connecting to the serial console by using the web console

You can connect to the serial console of a virtual machine (VM) by using the Red Hat OpenShift Service on AWS web console.

**Procedure**

1. On the **Virtualization → VirtualMachines** page, click a VM to open the **VirtualMachine details** page.
2. Click the **Console** tab. The VNC console session starts automatically.
3. Click **Disconnect** to end the VNC console session. Otherwise, the VNC console session continues to run in the background.
4. Select **Serial console** from the console list.
5. To end the console session, click outside the console pane and then click **Disconnect**.

### 6.3.2.2. Connecting to the serial console by using virtctl

You can use the **virtctl** command line tool to connect to the serial console of a running virtual machine.

**Procedure**

1. Run the following command to start the console session:

```
$ virtctl console <vm_name>
```

2. Press **Ctrl+]** to end the console session.

### 6.3.3. Connecting to the desktop viewer

You can connect to a Windows virtual machine (VM) by using the desktop viewer and the Remote Desktop Protocol (RDP).

#### 6.3.3.1. Connecting to the desktop viewer by using the web console

You can connect to the desktop viewer of a Windows virtual machine (VM) by using the Red Hat OpenShift Service on AWS web console.

**Prerequisites**

- You installed the QEMU guest agent on the Windows VM.
- You have an RDP client installed.

**Procedure**

1. On the **Virtualization** → **VirtualMachines** page, click a VM to open the **VirtualMachine details** page.
2. Click the **Console** tab. The VNC console session starts automatically.
3. Click **Disconnect** to end the VNC console session. Otherwise, the VNC console session continues to run in the background.
4. Select **Desktop viewer** from the console list.
5. Click **Create RDP Service** to open the **RDP Service** dialog.
6. Select **Expose RDP Service** and click **Save** to create a node port service.
7. Click **Launch Remote Desktop** to download an **.rdp** file and launch the desktop viewer.

## 6.4. CONFIGURING SSH ACCESS TO VIRTUAL MACHINES

You can configure SSH access to virtual machines (VMs) by using the following methods:

- **virtctl ssh** command
  You create an SSH key pair, add the public key to a VM, and connect to the VM by running the **virtctl ssh** command with the private key.

  You can add public SSH keys to Red Hat Enterprise Linux (RHEL) 9 VMs at runtime or at first boot to VMs with guest operating systems that can be configured by using a cloud-init data source.

- **virtctl port-forward** command

You add the **virtctl port-foward** command to your **.ssh/config** file and connect to the VM by using OpenSSH.

- Service
  You create a service, associate the service with the VM, and connect to the IP address and port exposed by the service.
- Secondary network
  You configure a secondary network, attach a virtual machine (VM) to the secondary network interface, and connect to the DHCP-allocated IP address.

### 6.4.1. Access configuration considerations

Each method for configuring access to a virtual machine (VM) has advantages and limitations, depending on the traffic load and client requirements.

Services provide excellent performance and are recommended for applications that are accessed from outside the cluster.

If the internal cluster network cannot handle the traffic load, you can configure a secondary network.

#### virtctl ssh and virtctl port-forwarding commands

- Simple to configure.
- Recommended for troubleshooting VMs.
- **virtctl port-forwarding** recommended for automated configuration of VMs with Ansible.
- Dynamic public SSH keys can be used to provision VMs with Ansible.
- Not recommended for high-traffic applications like Rsync or Remote Desktop Protocol because of the burden on the API server.
- The API server must be able to handle the traffic load.
- The clients must be able to access the API server.
- The clients must have access credentials for the cluster.

#### Cluster IP service

- The internal cluster network must be able to handle the traffic load.
- The clients must be able to access an internal cluster IP address.

#### Node port service

- The internal cluster network must be able to handle the traffic load.
- The clients must be able to access at least one node.

#### Load balancer service

- A load balancer must be configured.
- Each node must be able to handle the traffic load of one or more load balancer services.

**Secondary network**

- Excellent performance because traffic does not go through the internal cluster network.
- Allows a flexible approach to network topology.
- Guest operating system must be configured with appropriate security because the VM is exposed directly to the secondary network. If a VM is compromised, an intruder could gain access to the secondary network.

## 6.4.2. Using virtctl ssh

You can add a public SSH key to a virtual machine (VM) and connect to the VM by running the **virtctl ssh** command.

This method is simple to configure. However, it is not recommended for high traffic loads because it places a burden on the API server.

### 6.4.2.1. About static and dynamic SSH key management

You can add public SSH keys to virtual machines (VMs) statically at first boot or dynamically at runtime.

NOTE

Only Red Hat Enterprise Linux (RHEL) 9 supports dynamic key injection.

**Static SSH key management**
You can add a statically managed SSH key to a VM with a guest operating system that supports configuration by using a cloud-init data source. The key is added to the virtual machine (VM) at first boot.

You can add the key by using one of the following methods:

- Add a key to a single VM when you create it by using the web console or the command line.
- Add a key to a project by using the web console. Afterwards, the key is automatically added to the VMs that you create in this project.

**Use cases**

- As a VM owner, you can provision all your newly created VMs with a single key.

**Dynamic SSH key management**
You can enable dynamic SSH key management for a VM with Red Hat Enterprise Linux (RHEL) 9 installed. Afterwards, you can update the key during runtime. The key is added by the QEMU guest agent, which is installed with Red Hat boot sources.

You can disable dynamic key management for security reasons. Then, the VM inherits the key management setting of the image from which it was created.

**Use cases**

- Granting or revoking access to VMs: As a cluster administrator, you can grant or revoke remote VM access by adding or removing the keys of individual users from a **Secret** object that is applied to all VMs in a namespace.
- User access: You can add your access credentials to all VMs that you create and manage.
- Ansible provisioning:
  - As an operations team member, you can create a single secret that contains all the keys used for Ansible provisioning.
  - As a VM owner, you can create a VM and attach the keys used for Ansible provisioning.
- Key rotation:
  - As a cluster administrator, you can rotate the Ansible provisioner keys used by VMs in a namespace.
  - As a workload owner, you can rotate the key for the VMs that you manage.

### 6.4.2.2. Static key management

You can add a statically managed public SSH key when you create a virtual machine (VM) by using the Red Hat OpenShift Service on AWS web console or the command line. The key is added as a cloud-init data source when the VM boots for the first time.

TIP

You can also add the key to a project by using the Red Hat OpenShift Service on AWS web console. Afterwards, this key is added automatically to VMs that you create in the project.

#### 6.4.2.2.1. Adding a key when creating a VM from a template

You can add a statically managed public SSH key when you create a virtual machine (VM) by using the Red Hat OpenShift Service on AWS web console. The key is added to the VM as a cloud-init data source at first boot. This method does not affect cloud-init user data.

Optional: You can add a key to a project. Afterwards, this key is added automatically to VMs that you create in the project.

**Prerequisites**

- You generated an SSH key pair by running the **ssh-keygen** command.

**Procedure**

1. Navigate to **Virtualization → Catalog** in the web console.
2. Click a template tile.
   The guest operating system must support configuration from a cloud-init data source.
3. Click **Customize VirtualMachine**.
4. Click **Next**.
5. Click the **Scripts** tab.

6. If you have not already added a public SSH key to your project, click the edit icon beside **Authorized SSH key** and select one of the following options:
   - **Use existing**: Select a secret from the secrets list.
   - **Add new**:
     a. Browse to the SSH key file or paste the file in the key field.
     b. Enter the secret name.
     c. Optional: Select **Automatically apply this key to any new VirtualMachine you create in this project**.
7. Click **Save**.
8. Click **Create VirtualMachine**.
   The **VirtualMachine details** page displays the progress of the VM creation.

#### Verification

- Click the **Scripts** tab on the **Configuration** tab.
  The secret name is displayed in the **Authorized SSH key** section.

##### 6.4.2.2.2. Adding a key when creating a VM from an instance type by using the web console

You can create a virtual machine (VM) from an instance type by using the Red Hat OpenShift Service on AWS web console. You can also use the web console to create a VM by copying an existing snapshot or to clone a VM. You can add a statically managed SSH key when you create a virtual machine (VM) from an instance type by using the Red Hat OpenShift Service on AWS web console. The key is added to the VM as a cloud-init data source at first boot. This method does not affect cloud-init user data.

#### Procedure

1. In the web console, navigate to **Virtualization** → **Catalog** and click the **InstanceTypes** tab.
2. Select either of the following options:
   - Select a bootable volume.

     NOTE

     The bootable volume table lists only those volumes in the **openshift-virtualization-os-images** namespace that have the **instancetype.kubevirt.io/default-preference** label.

     - Optional: Click the star icon to designate a bootable volume as a favorite. Starred bootable volumes appear first in the volume list.
   - Click **Add volume** to upload a new volume or use an existing persistent volume claim (PVC), volume snapshot, or data source. Then click **Save**.
3. Click an instance type tile and select the resource size appropriate for your workload.
4. If you have not already added a public SSH key to your project, click the edit icon beside **Authorized SSH key** in the **VirtualMachine details** section.

5. Select one of the following options:
   - **Use existing**: Select a secret from the secrets list.
   - **Add new**:
     a. Browse to the public SSH key file or paste the file in the key field.
     b. Enter the secret name.
     c. Optional: Select **Automatically apply this key to any new VirtualMachine you create in this project**.
     d. Click **Save**.
6. Optional: Click **View YAML & CLI** to view the YAML file. Click **CLI** to view the CLI commands. You can also download or copy either the YAML file contents or the CLI commands.
7. Click **Create VirtualMachine**.

After the VM is created, you can monitor the status on the **VirtualMachine details** page.

#### 6.4.2.2.3. Adding a key when creating a VM by using the command line

You can add a statically managed public SSH key when you create a virtual machine (VM) by using the command line. The key is added to the VM at first boot.

The key is added to the VM as a cloud-init data source. This method separates the access credentials from the application data in the cloud-init user data. This method does not affect cloud-init user data.

**Prerequisites**

- You generated an SSH key pair by running the **ssh-keygen** command.

**Procedure**

1. Create a manifest file for a **VirtualMachine** object and a **Secret** object:

**Example manifest**

```
apiVersion: kubevirt.io/v1
kind: VirtualMachine
metadata:
  name: example-vm
  namespace: example-namespace
spec:
  dataVolumeTemplates:
    - metadata:
        name: example-vm-volume
      spec:
        sourceRef:
          kind: DataSource
          name: rhel9
          namespace: openshift-virtualization-os-images
        storage:
          resources: {}
  instancetype:
    name: u1.medium
  preference:
    name: rhel.9
  running: true
  template:
    spec:
      domain:
        devices: {}
      volumes:
        - dataVolume:
            name: example-vm-volume
          name: rootdisk
        - cloudInitNoCloud: (1)
            userData: |-
              #cloud-config
              user: cloud-user
          name: cloudinitdisk
      accessCredentials:
        - sshPublicKey:
            propagationMethod:
              noCloud: {}
            source:
              secret:
                secretName: authorized-keys (2)
---
apiVersion: v1
kind: Secret
metadata:
  name: authorized-keys
data:
  key: c3NoLXJzYSB... (3)
```

1. Specify the **cloudInitNoCloud** data source.
2. Specify the **Secret** object name.
3. Paste the public SSH key.

2. Create the **VirtualMachine** and **Secret** objects by running the following command:

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

3. Start the VM by running the following command:

```
$ virtctl start vm example-vm -n example-namespace
```

### Verification

- Get the VM configuration:

```
$ oc describe vm example-vm -n example-namespace
```

**Example output**

```
apiVersion: kubevirt.io/v1
kind: VirtualMachine
metadata:
  name: example-vm
  namespace: example-namespace
spec:
  template:
    spec:
      accessCredentials:
        - sshPublicKey:
            propagationMethod:
              noCloud: {}
            source:
              secret:
                secretName: authorized-keys
# ...
```

### 6.4.2.3. Dynamic key management

You can enable dynamic key injection for a virtual machine (VM) by using the Red Hat OpenShift Service on AWS web console or the command line. Then, you can update the key at runtime.

**NOTE**

Only Red Hat Enterprise Linux (RHEL) 9 supports dynamic key injection.

If you disable dynamic key injection, the VM inherits the key management method of the image from which it was created.

#### 6.4.2.3.1. Enabling dynamic key injection when creating a VM from a template

You can enable dynamic public SSH key injection when you create a virtual machine (VM) from a template by using the Red Hat OpenShift Service on AWS web console. Then, you can update the key at runtime.

**NOTE**

Only Red Hat Enterprise Linux (RHEL) 9 supports dynamic key injection.

The key is added to the VM by the QEMU guest agent, which is installed with RHEL 9.

**Prerequisites**

- You generated an SSH key pair by running the **ssh-keygen** command.

**Procedure**

1. Navigate to **Virtualization** → **Catalog** in the web console.
2. Click the **Red Hat Enterprise Linux 9 VM**tile.

3. Click **Customize VirtualMachine**.
4. Click **Next**.
5. Click the **Scripts** tab.
6. If you have not already added a public SSH key to your project, click the edit icon beside **Authorized SSH key** and select one of the following options:
   - **Use existing**: Select a secret from the secrets list.
   - **Add new**:
     a. Browse to the SSH key file or paste the file in the key field.
     b. Enter the secret name.
     c. Optional: Select **Automatically apply this key to any new VirtualMachine you create in this project**.
7. Set **Dynamic SSH key injection** to on.
8. Click **Save**.
9. Click **Create VirtualMachine**.
   The **VirtualMachine details** page displays the progress of the VM creation.

**Verification**

- Click the **Scripts** tab on the **Configuration** tab.
  The secret name is displayed in the **Authorized SSH key** section.

#### 6.4.2.3.2. Enabling dynamic key injection when creating a VM from an instance type by using the web console

You can create a virtual machine (VM) from an instance type by using the Red Hat OpenShift Service on AWS web console. You can also use the web console to create a VM by copying an existing snapshot or to clone a VM. You can enable dynamic SSH key injection when you create a virtual machine (VM) from an instance type by using the Red Hat OpenShift Service on AWS web console. Then, you can add or revoke the key at runtime.

**NOTE**

Only Red Hat Enterprise Linux (RHEL) 9 supports dynamic key injection.

The key is added to the VM by the QEMU guest agent, which is installed with RHEL 9.

**Procedure**

1. In the web console, navigate to **Virtualization** → **Catalog** and click the **InstanceTypes** tab.
2. Select either of the following options:
   - Select a bootable volume.

NOTE

The bootable volume table lists only those volumes in the **openshift-virtualization-os-images** namespace that have the **instancetype.kubevirt.io/default-preference** label.

  - Optional: Click the star icon to designate a bootable volume as a favorite. Starred bootable volumes appear first in the volume list.

- Click **Add volume** to upload a new volume or use an existing persistent volume claim (PVC), volume snapshot, or data source. Then click **Save**.

3. Click an instance type tile and select the resource size appropriate for your workload.

4. Click the **Red Hat Enterprise Linux 9 VM**tile.

5. If you have not already added a public SSH key to your project, click the edit icon beside **Authorized SSH key** in the **VirtualMachine details** section.

6. Select one of the following options:

   - **Use existing**: Select a secret from the secrets list.

   - **Add new**:

     a. Browse to the public SSH key file or paste the file in the key field.

     b. Enter the secret name.

     c. Optional: Select **Automatically apply this key to any new VirtualMachine you create in this project**.

     d. Click **Save**.

7. Set **Dynamic SSH key injection** in the **VirtualMachine details** section to on.

8. Optional: Click **View YAML & CLI** to view the YAML file. Click **CLI** to view the CLI commands. You can also download or copy either the YAML file contents or the CLI commands.

9. Click **Create VirtualMachine**.

After the VM is created, you can monitor the status on the **VirtualMachine details** page.

#### 6.4.2.3.3. Enabling dynamic SSH key injection by using the web console

You can enable dynamic key injection for a virtual machine (VM) by using the Red Hat OpenShift Service on AWS web console. Then, you can update the public SSH key at runtime.

The key is added to the VM by the QEMU guest agent, which is installed with Red Hat Enterprise Linux (RHEL) 9.

**Prerequisites**

- The guest operating system is RHEL 9.

**Procedure**

1. Navigate to **Virtualization → VirtualMachines** in the web console.
2. Select a VM to open the **VirtualMachine details** page.
3. On the **Configuration** tab, click **Scripts**.
4. If you have not already added a public SSH key to your project, click the edit icon beside **Authorized SSH key** and select one of the following options:
   - **Use existing**: Select a secret from the secrets list.
   - **Add new**:
     a. Browse to the SSH key file or paste the file in the key field.
     b. Enter the secret name.
     c. Optional: Select **Automatically apply this key to any new VirtualMachine you create in this project**.
5. Set **Dynamic SSH key injection** to on.
6. Click **Save**.

#### 6.4.2.3.4. Enabling dynamic key injection by using the command line

You can enable dynamic key injection for a virtual machine (VM) by using the command line. Then, you can update the public SSH key at runtime.

NOTE

Only Red Hat Enterprise Linux (RHEL) 9 supports dynamic key injection.

The key is added to the VM by the QEMU guest agent, which is installed automatically with RHEL 9.

**Prerequisites**

- You generated an SSH key pair by running the **ssh-keygen** command.

**Procedure**

1. Create a manifest file for a **VirtualMachine** object and a **Secret** object:

   **Example manifest**

```
apiVersion: kubevirt.io/v1
kind: VirtualMachine
metadata:
  name: example-vm
  namespace: example-namespace
spec:
  dataVolumeTemplates:
    - metadata:
        name: example-vm-volume
      spec:
        sourceRef:
          kind: DataSource
          name: rhel9
          namespace: openshift-virtualization-os-images
        storage:
          resources: {}
  instancetype:
    name: u1.medium
  preference:
    name: rhel.9
  running: true
  template:
    spec:
      domain:
        devices: {}
      volumes:
        - dataVolume:
            name: example-vm-volume
          name: rootdisk
        - cloudInitNoCloud: (1)
            userData: |-
              #cloud-config
              runcmd:
              - [ setsebool, -P, virt_qemu_ga_manage_ssh, on ]
          name: cloudinitdisk
      accessCredentials:
        - sshPublicKey:
            propagationMethod:
              qemuGuestAgent:
                users: ["cloud-user"]
            source:
              secret:
                secretName: authorized-keys (2)
---
apiVersion: v1
kind: Secret
metadata:
  name: authorized-keys
data:
  key: c3NoLXJzYSB... (3)
```

(1) Specify the **cloudInitNoCloud** data source.

(2) Specify the **Secret** object name.

(3) Paste the public SSH key.

2. Create the **VirtualMachine** and **Secret** objects by running the following command:

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

3. Start the VM by running the following command:

```
$ virtctl start vm example-vm -n example-namespace
```

### Verification

- Get the VM configuration:

```
$ oc describe vm example-vm -n example-namespace
```

**Example output**

```
apiVersion: kubevirt.io/v1
kind: VirtualMachine
metadata:
  name: example-vm
  namespace: example-namespace
spec:
  template:
    spec:
      accessCredentials:
        - sshPublicKey:
            propagationMethod:
              qemuGuestAgent:
                users: ["cloud-user"]
            source:
              secret:
                secretName: authorized-keys
# ...
```

### 6.4.2.4. Using the virtctl ssh command

You can access a running virtual machine (VM) by using the **virtcl ssh** command.

### Prerequisites

- You installed the **virtctl** command line tool.
- You added a public SSH key to the VM.
- You have an SSH client installed.
- 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

- Run the **virtctl ssh** command:

```
$ virtctl -n <namespace> ssh <username>@example-vm -i <ssh_key> 1
```

1 Specify the namespace, user name, and the SSH private key. The default SSH key location is **/home/user/.ssh**. If you save the key in a different location, you must specify the path.

**Example**

```
$ virtctl -n my-namespace ssh cloud-user@example-vm -i my-key
```

TIP

You can copy the **virtctl ssh** command in the web console by selecting **Copy SSH command** from the options ⋮ menu beside a VM on the **VirtualMachines** page.

## 6.4.3. Using the virtctl port-forward command

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>
```

## 6.4.4. Using a service for SSH access

You can create a service for a virtual machine (VM) and connect to the IP address and port exposed by the service.

Services provide excellent performance and are recommended for applications that are accessed from outside the cluster or within the cluster. Ingress traffic is protected by firewalls.

If the cluster network cannot handle the traffic load, consider using a secondary network for VM access.

### 6.4.4.1. 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 the **NodePort** and **LoadBalancer** types, exposure to the outside world.

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 port accessible from outside the cluster, as long as the node itself is externally accessible to the client.

LoadBalancer
: Creates an external load balancer in the current cloud (if supported) and assigns a fixed, external IP address to the service.

#### 6.4.4.2. Creating a service

You can create a service to expose a virtual machine (VM) by using the Red Hat OpenShift Service on AWS web console, **virtctl** command line tool, or a YAML file.

##### 6.4.4.2.1. Enabling load balancer service creation by using the web console

You can enable the creation of load balancer services for a virtual machine (VM) by using the Red Hat OpenShift Service on AWS web console.

**Prerequisites**

- You have configured a load balancer for the cluster.
- You are logged in as a user with the **cluster-admin** role.

**Procedure**

1. Navigate to **Virtualization** → **Overview**.
2. On the **Settings** tab, click **Cluster**.
3. Expand **General settings** and **SSH configuration**.
4. Set **SSH over LoadBalancer service** to on.

##### 6.4.4.2.2. Creating a service by using the web console

You can create a node port or load balancer service for a virtual machine (VM) by using the Red Hat OpenShift Service on AWS web console.

**Prerequisites**

- You configured the cluster network to support either a load balancer or a node port.
- To create a load balancer service, you enabled the creation of load balancer services.

#### Procedure

1. Navigate to **VirtualMachines** and select a virtual machine to view the **VirtualMachine details** page.
2. On the **Details** tab, select **SSH over LoadBalancer** from the **SSH service type** list.
3. Optional: Click the copy icon to copy the **SSH** command to your clipboard.

#### Verification

- Check the **Services** pane on the **Details** tab to view the new service.

### 6.4.4.2.3. Creating a service by using virtctl

You can create a service for a virtual machine (VM) by using the **virtctl** command line tool.

#### Prerequisites

- You installed the **virtctl** command line tool.
- You configured the cluster network to support the service.
- The environment where you installed **virtctl** has the cluster permissions required to access the VM. For example, you ran **oc login** or you set the **KUBECONFIG** environment variable.

#### Procedure

- Create a service by running the following command:

```
$ virtctl expose vm <vm_name> --name <service_name> --type <service_type> --port <port>
1
```

1 Specify the **ClusterIP**, **NodePort**, or **LoadBalancer** service type.

#### Example

```
$ virtctl expose vm example-vm --name example-service --type NodePort --port 22
```

#### Verification

- Verify the service by running the following command:

```
$ oc get service
```

#### Next steps

After you create a service with **virtctl**, you must add **special: key** to the **spec.template.metadata.labels** stanza of the **VirtualMachine** manifest. See Creating a service by using the command line .

### 6.4.4.2.4. Creating a service by using the command line

You can create a service and associate it with a virtual machine (VM) by using the command line.

**Prerequisites**

- You configured the cluster network to support the service.

**Procedure**

1. Edit the **VirtualMachine** manifest to add the label for service creation:

```
apiVersion: kubevirt.io/v1
kind: VirtualMachine
metadata:
  name: example-vm
  namespace: example-namespace
spec:
  running: false
  template:
    metadata:
      labels:
        special: key 1
# ...
```

1 Add **special: key** to the **spec.template.metadata.labels** stanza.

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: example-service
  namespace: example-namespace
spec:
# ...
  selector:
    special: key 1
  type: NodePort 2
  ports: 3
    protocol: TCP
    port: 80
    targetPort: 9376
    nodePort: 30000
```

1 Specify the label that you added to the **spec.template.metadata.labels** stanza of the **VirtualMachine** manifest.

2 Specify **ClusterIP**, **NodePort**, or **LoadBalancer**.

3 Specifies a collection of network ports and protocols that you want to expose from the virtual machine.

4. Save the **Service** manifest file.

5. Create the service by running the following command:

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

6. Restart the VM to apply the changes.

**Verification**

- Query the **Service** object to verify that it is available:

```
$ oc get service -n example-namespace
```

#### 6.4.4.3. Connecting to a VM exposed by a service by using SSH

You can connect to a virtual machine (VM) that is exposed by a service by using SSH.

**Prerequisites**

- You created a service to expose the VM.
- You have an SSH client installed.
- You are logged in to the cluster.

**Procedure**

- Run the following command to access the VM:

```
$ ssh <user_name>@<ip_address> -p <port> 1
```

1 Specify the cluster IP for a cluster IP service, the node IP for a node port service, or the external IP address for a load balancer service.

### 6.4.5. Using a secondary network for SSH access

You can configure a secondary network, attach a virtual machine (VM) to the secondary network interface, and connect to the DHCP-allocated IP address by using SSH.

**IMPORTANT**

Secondary networks provide excellent performance because the traffic is not handled by the cluster network stack. However, the VMs are exposed directly to the secondary network and are not protected by firewalls. If a VM is compromised, an intruder could gain access to the secondary network. You must configure appropriate security within the operating system of the VM if you use this method.

See the Multus and SR-IOV documentation in the OpenShift Virtualization Tuning & Scaling Guide for additional information about networking options.

**Prerequisites**

- You configured a secondary network.
- You created a network attachment definition.

### 6.4.5.1. Configuring a VM network interface by using the web console

You can configure a network interface for a virtual machine (VM) by using the Red Hat OpenShift Service on AWS web console.

**Prerequisites**

- You created a network attachment definition for the network.

**Procedure**

1. Navigate to **Virtualization** → **VirtualMachines**.
2. Click a VM to view the **VirtualMachine details** page.
3. On the **Configuration** tab, click the **Network interfaces** tab.
4. Click **Add network interface**.
5. Enter the interface name and select the network attachment definition from the **Network** list.
6. Click **Save**.
7. Restart the VM to apply the changes.

### 6.4.5.2. Connecting to a VM attached to a secondary network by using SSH

You can connect to a virtual machine (VM) attached to a secondary network by using SSH.

**Prerequisites**

- You attached a VM to a secondary network with a DHCP server.
- You have an SSH client installed.

**Procedure**

1. Obtain the IP address of the VM by running the following command:

```
$ oc describe vm <vm_name> -n <namespace>
```

**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
# ...
```

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

```
$ ssh <user_name>@<ip_address> -i <ssh_key>
```

**Example**

```
$ ssh cloud-user@10.244.0.37 -i ~/.ssh/id_rsa_cloud-user
```

## 6.5. EDITING VIRTUAL MACHINES

You can update a virtual machine (VM) configuration by using the Red Hat OpenShift Service on AWS web console. You can update the YAML file or the **VirtualMachine details** page.

You can also edit a VM by using the command line.

### 6.5.1. Editing a virtual machine by using the command line

You can edit a virtual machine (VM) by using the command line.

**Prerequisites**

- You installed the **oc** CLI.

**Procedure**

1. Obtain the virtual machine configuration by running the following command:

```
$ oc edit vm <vm_name>
```

2. Edit the YAML configuration.

3. 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 vm <vm_name> -n <namespace>
```

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

You can add a virtual disk to a virtual machine (VM) by using the Red Hat OpenShift Service on AWS web console.

**Procedure**

1. Navigate to **Virtualization** → **VirtualMachines** in the web console.
2. Select a VM to open the **VirtualMachine details** page.
3. On the **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 VM is running, you must restart the VM to apply the change.

### 6.5.2.1. Storage fields

| Field | Description |
|---|---|
| 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 | Name of the disk. The name can contain lowercase letters (**a-z**), numbers (**0-9**), 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 **virtIO**, **SATA**, and **SCSI**. |

| Field | Description |
|---|---|
| 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.

If you do not specify these parameters, the system uses the default storage profile values.

| Parameter | Option | Parameter description |
|---|---|---|
| Volume Mode | Filesystem | Stores the virtual disk on a file system-based volume. |
|  | Block | Stores the virtual disk directly on the block volume. Only use **Block** if the underlying storage supports it. |
| Access Mode | 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. **NOTE** This mode is required for live migration. |

## 6.5.3. 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 Red Hat OpenShift Service on AWS 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**

1. Click **Virtualization** → **VirtualMachines** from the side menu.
2. Select a virtual machine to open the **VirtualMachine details** page.
3. Click **Configuration** → **Environment**.

4. Click **Add Config Map, Secret or Service Account**
5. 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

## 6.6. 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.

### 6.6.1. 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.

## 6.6.2. 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.

## 6.6.3. 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 <vm_name> -n <namespace>
```

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.

### 6.6.4. 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.

## 6.7. DELETING VIRTUAL MACHINES

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

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

Deleting a virtual machine permanently removes it from the cluster.

**Procedure**

1. In the Red Hat OpenShift Service on AWS 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.

### 6.7.2. 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.

## 6.8. 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.

NOTE

You can migrate virtual machines between OpenShift Virtualization clusters by using the Migration Toolkit for Virtualization.

### 6.8.1. 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.

### 6.8.2. 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/exam
ple-export/external/manifests/all ①
      - type: auth-header-secret
        url: https://vmexport-
proxy.test.net/api/export.kubevirt.io/v1alpha1/namespaces/example/virtualmachineexports/exam
ple-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.

## 6.9. 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.

### 6.9.1. 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.

When you edit a VM, some settings might be applied to the VMIs dynamically and without the need for a restart. Any change made to a VM object that cannot be applied to the VMIs dynamically will trigger the **RestartRequired** VM condition. Changes are effective on the next reboot, and the condition is removed.

### 6.9.2. 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
  ```

### 6.9.3. 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.

### 6.9.4. 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 Red Hat OpenShift Service on AWS 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**.

### 6.9.5. 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>
```

### 6.9.6. 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 Red Hat OpenShift Service on AWS 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.

## 6.10. 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.

### 6.10.1. 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 and click **Start VirtualMachine**.
   - 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** → **Start**.

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.

### 6.10.2. 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 and click **Stop VirtualMachine**.
   - 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**.

### 6.10.3. 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 and click **Restart**.
   - 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**.

### 6.10.4. Pausing a virtual machine

You can pause 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 pause.
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 and click **Pause VirtualMachine**.
   - To view comprehensive information about the selected virtual machine before you pause it:
     a. Access the **VirtualMachine details** page by clicking the name of the virtual machine.
     b. Click **Actions → Pause**.

### 6.10.5. 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**.

**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. Click the Options menu ⋮ located at the far right end of the row and click **Unpause VirtualMachine**.
   - 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 **Actions → Unpause**.

## 6.11. 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.

### 6.11.1. 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.

A vTPM device also protects virtual machines by storing secrets without physical hardware. OpenShift Virtualization supports persisting vTPM device state by using Persistent Volume Claims (PVCs) for VMs. You must specify the storage class to be used by the PVC by setting the **vmStateStorageClass** attribute in the **HyperConverged** custom resource (CR):

```
kind: HyperConverged
metadata:
  name: kubevirt-hyperconverged
spec:
  vmStateStorageClass: <storage_class_name>

# ...
```

NOTE

The storage class must be of type **Filesystem** and support the **ReadWriteMany** (RWX) access mode.

### 6.11.2. 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 stores secrets for that VM.

#### Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have configured a Persistent Volume Claim (PVC) to use a storage class of type **Filesystem** that supports the **ReadWriteMany** (RWX) access mode. This is necessary for the vTPM device data to persist across VM reboots.

#### Procedure

1. Run the following command to update the VM configuration:

```
$ oc edit vm <vm_name> -n <namespace>
```

2. Edit the VM specification to add the vTPM device. For example:

```
apiVersion: kubevirt.io/v1
kind: VirtualMachine
metadata:
    name: example-vm
spec:
  template:
    spec:
      domain:
        devices:
          tpm: 1
            persistent: true 2
# ...
```

1 Adds the vTPM device to the VM.

2 Specifies that the vTPM device state persists after the VM is shut down. The default value is **false**.

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.

## 6.12. 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 Scheduling, Scale, and Performance (SSP) Operator integrates OpenShift Virtualization with OpenShift Pipelines. The SSP Operator includes 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 .

### 6.12.1. Prerequisites

- You have access to an Red Hat OpenShift Service on AWS cluster with **cluster-admin** permissions.
- You have installed the OpenShift CLI (**oc**).
- You have installed OpenShift Pipelines.

### 6.12.2. Deploying the Scheduling, Scale, and Performance (SSP) resources

The SSP Operator example Tekton Tasks and Pipelines are not deployed by default when you install OpenShift Virtualization. To deploy the SSP Operator's Tekton 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 hyperconverged kubevirt-hyperconverged -n openshift-cnv
```

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 Tekton resources by SSP operator.

> **NOTE**
>
> The tasks and example pipelines remain available even if you disable the feature gate later.

3. Save your changes and exit the editor.

### 6.12.3. Virtual machine tasks supported by the SSP Operator

The following table shows the tasks that are included as part of the SSP Operator.

**Table 6.4. Virtual machine tasks supported by the SSP Operator**

| Task | Description |
|---|---|

| Task | Description |
|---|---|
| **create-vm-from-manifest** | Create a virtual machine from a provided manifest or with **virtctl**. |
| **create-vm-from-template** | Create a virtual machine from a template. |
| **copy-template** | Copy a virtual machine template. |
| **modify-vm-template** | Modify a virtual machine template. |
| **modify-data-object** | Create or delete data volumes or data sources. |
| **cleanup-vm** | Run a script or a command in a virtual machine and stop or delete the virtual machine afterward. |
| **disk-virt-customize** | Use the **virt-customize** tool to run a customization script on a target PVC. |
| **disk-virt-sysprep** | Use the **virt-sysprep** tool to run a sysprep script on a target PVC. |
| **wait-for-vmi-status** | Wait for a specific status of a virtual machine instance and fail or succeed based on the status. |

NOTE

Virtual machine creation in pipelines now utilizes **ClusterInstanceType** and **ClusterPreference** instead of template-based tasks, which have been deprecated. The **create-vm-from-template**, **copy-template**, and **modify-vm-template** commands remain available but are not used in default pipeline tasks.

### 6.12.4. Example pipelines

The SSP 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 pipline 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.

> **NOTE**
>
> The example pipelines use a config map file with **sysprep** predefined by Red Hat OpenShift Service on AWS and suitable for Microsoft ISO files. For ISO files pertaining to different Windows editions, it may be necessary to create a new config map file with a system-specific sysprep definition.

### 6.12.4.1. 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.

### 6.12.4.2. 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
```

### 6.12.5. Additional resources

- Creating CI/CD solutions for applications using Red Hat OpenShift Pipelines
- Creating a Windows VM

## 6.13. ADVANCED VIRTUAL MACHINE MANAGEMENT

### 6.13.1. Working with resource quotas for virtual machines

Create and manage resource quotas for virtual machines.

#### 6.13.1.1. 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**

1. 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.

2. Save the **VirtualMachine** manifest.

#### 6.13.1.2. Additional resources

- Resource quotas per project
- Resource quotas across multiple projects

### 6.13.2. Specifying nodes for virtual machines

You can place virtual machines (VMs) on specific nodes by using node placement rules.

#### 6.13.2.1. 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.

**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.

NOTE

Affinity rules only apply during scheduling. Red Hat OpenShift Service on AWS does not reschedule running workloads if the constraints are no longer met.

#### 6.13.2.2. Node placement examples

The following example YAML file snippets use **nodePlacement**, **affinity**, and **tolerations** fields to customize node placement for virtual machines.

##### 6.13.2.2.1. 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
# ...
```

##### 6.13.2.2.2. 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.

#### 6.13.2.2.3. 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.

#### 6.13.2.2.4. 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"
# ...
```

### 6.13.2.3. Additional resources

- Specifying nodes for virtualization components
- Placing pods on specific nodes using node selectors
- Controlling pod placement on nodes using node affinity rules

## 6.13.3. Configuring certificate rotation

Configure certificate rotation parameters to replace existing certificates.

### 6.13.3.1. 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 hyperconverged kubevirt-hyperconverged -n openshift-cnv
```

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.

#### 6.13.3.2. 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.

## 6.13.4. 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.

### 6.13.4.1. 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 hyperconverged kubevirt-hyperconverged -n openshift-cnv
   ```

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.

### 6.13.5. Using UEFI mode for virtual machines

You can boot a virtual machine (VM) in Unified Extensible Firmware Interface (UEFI) mode.

#### 6.13.5.1. 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.

#### 6.13.5.2. 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:

   **Booting 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
```

#### 6.13.5.3. Enabling persistent EFI

You can enable EFI persistence in a VM by configuring an RWX storage class at the cluster level and adjusting the settings in the EFI section of the VM.

**Prerequisites**

- You must have cluster administrator privileges.
- You must have a storage class that supports RWX access mode and FS volume mode.

**Procedure**

- Enable the **VMPersistentState** feature gate by running the following command:

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

#### 6.13.5.4. Configuring VMs with persistent EFI

You can configure a VM to have EFI persistence enabled by editing its manifest file.

**Prerequisites**

- **VMPersistentState** feature gate enabled.

**Procedure**

- Edit the VM manifest file and save to apply settings.

```
apiVersion: kubevirt.io/v1
kind: VirtualMachine
metadata:
  name: vm
spec:
  template:
    spec:
      domain:
        firmware:
          bootloader:
            efi:
              persistent: true
# ...
```

### 6.13.6. 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.

#### 6.13.6.1. 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**

- 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
```

5. Wait for the virtual machine instance to run:

```
$ oc get vmi vmi-pxe-boot -o yaml | grep -i phase
  phase: Running
```

6. View the virtual machine instance using VNC:

```
$ virtctl vnc vmi-pxe-boot
```

7. Watch the boot screen to verify that the PXE boot is successful.

8. Log in to the virtual machine instance:

```
$ virtctl console vmi-pxe-boot
```

**Verification**

1. 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 Red Hat OpenShift Service on AWS.

```
$ 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
```

### 6.13.6.2. OpenShift Virtualization networking glossary

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 CRD introduced by the nmstate project, describing 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.

### 6.13.7. 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.

#### 6.13.7.1. 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. |

| Policy attribute | Description |
|---|---|
| forbid | The VM is not scheduled even if the feature is supported by the host CPU and CPU node discovery is enabled. |

### 6.13.7.2. 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.

### 6.13.7.3. 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.

### 6.13.7.4. 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.

### 6.13.7.5. Scheduling virtual machines with a custom scheduler

You can use a custom scheduler to schedule a virtual machine (VM) on a node.

#### Prerequisites

- A secondary scheduler is configured for your cluster.

#### Procedure

- Add the custom scheduler to the VM configuration by editing the **VirtualMachine** manifest. For example:

```
apiVersion: kubevirt.io/v1
kind: VirtualMachine
metadata:
  name: vm-fedora
spec:
  running: true
  template:
    spec:
      schedulerName: my-scheduler 1
      domain:
        devices:
          disks:
            - name: containerdisk
              disk:
                bus: virtio
# ...
```

1 The name of the custom scheduler. If the **schedulerName** value does not match an existing scheduler, the **virt-launcher** pod stays in a **Pending** state until the specified scheduler is found.

#### Verification

- Verify that the VM is using the custom scheduler specified in the **VirtualMachine** manifest by checking the **virt-launcher** pod events:

  a. View the list of pods in your cluster by entering the following command:

  ```
  $ oc get pods
  ```

  **Example output**

  ```
  NAME                              READY   STATUS    RESTARTS   AGE
  virt-launcher-vm-fedora-dpc87    2/2     Running   0          24m
  ```

  b. Run the following command to display the pod events:

  ```
  $ oc describe pod virt-launcher-vm-fedora-dpc87
  ```

  The value of the **From** field in the output verifies that the scheduler name matches the custom scheduler specified in the **VirtualMachine** manifest:

  **Example output**

  ```
  [...]
  Events:
    Type    Reason     Age   From              Message
    ----    ------     ----  ----              -------
    Normal  Scheduled  21m   my-scheduler  Successfully assigned default/virt-launcher-vm-fedora-dpc87 to node01
  [...]
  ```

### 6.13.8. About high availability for virtual machines

You can enable high availability for virtual machines (VMs) by configuring remediating nodes.

You can configure remediating nodes by installing the Self Node Remediation Operator from the OperatorHub and enabling machine health checks or node remediation checks.

For more information on remediation, fencing, and maintaining nodes, see the Workload Availability for Red Hat OpenShift documentation.

### 6.13.9. Virtual machine control plane tuning

OpenShift Virtualization offers the following tuning options at the control-plane level:

- The **highBurst** profile, which uses fixed **QPS** and **burst** rates, to create hundreds of virtual machines (VMs) in one batch
- Migration setting adjustment based on workload type

#### 6.13.9.1. Configuring a highBurst profile

Use the **highBurst** profile to create and maintain a large number of virtual machines (VMs) in one cluster.

**Procedure**

- Apply the following patch to enable the **highBurst** tuning policy profile:

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

**Verification**

- Run the following command to verify the **highBurst** tuning policy profile is enabled:

```
$ oc get kubevirt.kubevirt.io/kubevirt-kubevirt-hyperconverged \
  -n openshift-cnv -o go-template --template='{{range $config, \
  $value := .spec.configuration}} {{if eq $config "apiConfiguration" \
  "webhookConfiguration" "controllerConfiguration" "handlerConfiguration"}} \
  {{"\n"}} {{$config}} = {{$value}} {{end}} {{end}} {{"\n"}}
```

## 6.14. VM DISKS

### 6.14.1. Hot-plugging VM disks

You can add or remove virtual disks without stopping your virtual machine (VM) or virtual machine instance (VMI).

Only data volumes and persistent volume claims (PVCs) can be hot plugged and hot-unplugged. You cannot hot plug or hot-unplug container disks.

A hot plugged disk remains to the VM even after reboot. You must detach the disk to remove it from the VM.

You can make a hot plugged disk persistent so that it is permanently mounted on the VM.

NOTE

Each VM has a **virtio-scsi** controller so that hot plugged disks can use the **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.

#### 6.14.1.1. Hot plugging and hot unplugging a disk by using the web console

You can hot plug a disk by attaching it to a virtual machine (VM) while the VM is running by using the Red Hat OpenShift Service on AWS web console.

The hot plugged disk remains attached to the VM until you unplug it.

You can make a hot plugged disk persistent so that it is permanently mounted on the VM.

**Prerequisites**

- You must have a data volume or persistent volume claim (PVC) available for hot plugging.

**Procedure**

1. Navigate to **Virtualization → VirtualMachines** in the web console.
2. Select a running VM to view its details.
3. On the **VirtualMachine details** page, click **Configuration → Disks**.
4. Add a hot plugged disk:
   a. Click **Add disk**.
   b. In the **Add disk (hot plugged)** window, select the disk from the **Source** list and click **Save**.
5. Optional: Unplug a hot plugged disk:
   a. Click the options menu ⋮ beside the disk and select **Detach**.
   b. Click **Detach**.
6. Optional: Make a hot plugged disk persistent:
   a. Click the options menu ⋮ beside the disk and select **Make persistent**.
   b. Reboot the VM to apply the change.

#### 6.14.1.2. Hot plugging and hot unplugging a disk by using the command line

You can hot plug and hot unplug a disk while a virtual machine (VM) is running by using the command line.

You can make a hot plugged disk persistent so that it is permanently mounted on the VM.

### Prerequisites

- You must have at least one data volume or persistent volume claim (PVC) available for hot plugging.

### Procedure

- Hot plug a 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.

- Hot unplug a disk by running the following command:

  ```
  $ virtctl removevolume <virtual-machine|virtual-machine-instance> \
    --volume-name=<datavolume|PVC>
  ```

## 6.14.2. Expanding virtual machine disks

You can increase the size of a virtual machine (VM) disk by expanding the persistent volume claim (PVC) of the disk.

If your storage provider does not support volume expansion, you can expand the available virtual storage of a VM by adding blank data volumes.

You cannot reduce the size of a VM disk.

### 6.14.2.1. Expanding a VM disk PVC

You can increase the size of a virtual machine (VM) disk by expanding the persistent volume claim (PVC) of the disk.

If the PVC uses the file system volume mode, the disk image file expands to the available 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.

### Additional resources for volume expansion

- 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

#### 6.14.2.2. Expanding available virtual storage by adding blank data volumes

You can expand the available storage of a virtual machine (VM) by adding blank data volumes.

### Prerequisites

- You must have at least one persistent volume.

### Procedure

1. Create a **DataVolume** manifest as shown in the following example:

**Example DataVolume manifest**

```
apiVersion: cdi.kubevirt.io/v1beta1
kind: DataVolume
metadata:
 name: blank-image-datavolume
spec:
 source:
   blank: {}
 storage:
   resources:
     requests:
       storage: <2Gi> 1
 storageClassName: "<storage_class>" 2
```

1. Specify the amount of available space requested for the data volume.
2. Optional: If you do not specify a storage class, the default storage class is used.

2. Create the data volume by running the following command:

```
$ oc create -f <blank-image-datavolume>.yaml
```

### Additional resources for data volumes

- Configuring preallocation mode for data volumes
- Managing data volume annotations

# CHAPTER 7. NETWORKING

## 7.1. NETWORKING OVERVIEW

OpenShift Virtualization provides advanced networking functionality by using custom resources and plugins. Virtual machines (VMs) are integrated with Red Hat OpenShift Service on AWS networking and its ecosystem.

> **NOTE**
>
> You cannot run OpenShift Virtualization on a single-stack IPv6 cluster.

### 7.1.1. OpenShift Virtualization networking glossary

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 CRD introduced by the nmstate project, describing 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.

### 7.1.2. Using the default pod network

**Connecting a virtual machine to the default pod network**

Each VM is connected by default to the default internal pod network. You can add or remove network interfaces by editing the VM specification.

**Exposing a virtual machine as a service**

You can expose a VM within the cluster or outside the cluster by creating a **Service** object.

### 7.1.3. Configuring VM secondary network interfaces

**Connecting a virtual machine to an OVN-Kubernetes secondary network**

You can connect a VM to an Open Virtual Network (OVN)-Kubernetes secondary network. OpenShift Virtualization supports the layer 2 and localnet topologies for OVN-Kubernetes.

- A layer 2 topology connects workloads by a cluster-wide logical switch. The OVN-

Kubernetes Container Network Interface (CNI) plug-in uses the Geneve (Generic Network Virtualization Encapsulation) protocol to create an overlay network between nodes. You can use this overlay network to connect VMs on different nodes, without having to configure any additional physical networking infrastructure.

- A localnet topology connects the secondary network to the physical underlay. This enables both east-west cluster traffic and access to services running outside the cluster, but it requires additional configuration of the underlying Open vSwitch (OVS) system on cluster nodes.

To configure an OVN-Kubernetes secondary network and attach a VM to that network, perform the following steps:

1. Configure an OVN-Kubernetes secondary network by creating a network attachment definition (NAD).
2. Connect the VM to the OVN-Kubernetes secondary network by adding the network details to the VM specification.

**Configuring and viewing IP addresses**

You can configure an IP address of a secondary network interface when you create a VM. The IP address is provisioned with cloud-init. You can view the IP address of a VM by using the Red Hat OpenShift Service on AWS web console or the command line. The network information is collected by the QEMU guest agent.

### 7.1.4. Integrating with OpenShift Service Mesh

**Connecting a virtual machine to a service mesh**

OpenShift Virtualization is integrated with OpenShift Service Mesh. You can monitor, visualize, and control traffic between pods and virtual machines.

### 7.1.5. Managing MAC address pools

**Managing MAC address pools for network interfaces**

The KubeMacPool component allocates MAC addresses for VM network interfaces from a shared MAC address pool. This ensures that each network interface is assigned a unique MAC address. A virtual machine instance created from that VM retains the assigned MAC address across reboots.

### 7.1.6. Configuring SSH access

**Configuring SSH access to virtual machines**

You can configure SSH access to VMs by using the following methods:

- **virtctl ssh** command
  You create an SSH key pair, add the public key to a VM, and connect to the VM by running the **virtctl ssh** command with the private key.

  You can add public SSH keys to Red Hat Enterprise Linux (RHEL) 9 VMs at runtime or at first boot to VMs with guest operating systems that can be configured by using a cloud-init data source.

- **virtctl port-forward** command

You add the **virtctl port-foward** command to your **.ssh/config** file and connect to the VM by using OpenSSH.

- Service
  You create a service, associate the service with the VM, and connect to the IP address and port exposed by the service.

- Secondary network
  You configure a secondary network, attach a VM to the secondary network interface, and connect to its allocated IP address.

## 7.2. CONNECTING A VIRTUAL MACHINE TO 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 passing through network interfaces to the default pod network is interrupted during live migration.

### 7.2.1. 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.

#### Procedure

1. Edit the **interfaces** spec of your virtual machine configuration file:

```
apiVersion: kubevirt.io/v1
kind: VirtualMachine
metadata:
  name: example-vm
spec:
  template:
    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
```

### 7.2.2. 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 Red Hat OpenShift Service on AWS cluster must use the OVN-Kubernetes Container Network Interface (CNI) network plugin configured for dual-stack.

#### Procedure

1. 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
spec:
```

```
template:
  spec:
    domain:
      devices:
        interfaces:
          - name: default
            masquerade: {} (1)
            ports:
              - port: 80 (2)
# ...
    networks:
    - name: default
      pod: {}
    volumes:
    - cloudInitNoCloud:
        networkData: |
          version: 2
          ethernets:
            eth0:
              dhcp4: true
              addresses: [ fd10:0:2::2/120 ] (3)
              gateway6: fd10:0:2::1 (4)
```

1. Connect using masquerade mode.
2. Allows incoming traffic on port 80 to the virtual machine.
3. 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**.
4. 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**.

2. 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}"
```

### 7.2.3. 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.

## 7.3. EXPOSING A VIRTUAL MACHINE BY USING A SERVICE

You can expose a virtual machine within the cluster or outside the cluster by creating a **Service** object.

### 7.3.1. 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 the **NodePort** and **LoadBalancer** types, exposure to the outside world.

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 port accessible from outside the cluster, as long as the node itself is externally accessible to the client.

LoadBalancer

Creates an external load balancer in the current cloud (if supported) and assigns a fixed, external IP address to the service.

### 7.3.2. 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]**

### 7.3.3. Creating a service by using the command line

You can create a service and associate it with a virtual machine (VM) by using the command line.

#### Prerequisites

- You configured the cluster network to support the service.

#### Procedure

1. Edit the **VirtualMachine** manifest to add the label for service creation:

```
apiVersion: kubevirt.io/v1
kind: VirtualMachine
metadata:
  name: example-vm
  namespace: example-namespace
spec:
  running: false
  template:
    metadata:
      labels:
        special: key (1)
# ...
```

(1) Add **special: key** to the **spec.template.metadata.labels** stanza.

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: example-service
  namespace: example-namespace
```

```
spec:
# ...
  selector:
    special: key (1)
  type: NodePort (2)
  ports: (3)
    protocol: TCP
    port: 80
    targetPort: 9376
    nodePort: 30000
```

(1) Specify the label that you added to the **spec.template.metadata.labels** stanza of the **VirtualMachine** manifest.

(2) Specify **ClusterIP**, **NodePort**, or **LoadBalancer**.

(3) Specifies a collection of network ports and protocols that you want to expose from the virtual machine.

4. Save the **Service** manifest file.

5. Create the service by running the following command:

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

6. Restart the VM to apply the changes.

**Verification**

- Query the **Service** object to verify that it is available:

```
$ oc get service -n example-namespace
```

## 7.4. CONNECTING A VIRTUAL MACHINE TO AN OVN-KUBERNETES SECONDARY NETWORK

You can connect a virtual machine (VM) to an Open Virtual Network (OVN)-Kubernetes secondary network. OpenShift Virtualization supports the layer 2 and localnet topologies for OVN-Kubernetes.

- A layer 2 topology connects workloads by a cluster-wide logical switch. The OVN-Kubernetes Container Network Interface (CNI) plug-in uses the Geneve (Generic Network Virtualization Encapsulation) protocol to create an overlay network between nodes. You can use this overlay network to connect VMs on different nodes, without having to configure any additional physical networking infrastructure.

- A localnet topology connects the secondary network to the physical underlay. This enables both east-west cluster traffic and access to services running outside the cluster, but it requires additional configuration of the underlying Open vSwitch (OVS) system on cluster nodes.

To configure an OVN-Kubernetes secondary network and attach a VM to that network, perform the following steps:

1. Configure an OVN-Kubernetes secondary network by creating a network attachment definition (NAD).
2. Connect the VM to the OVN-Kubernetes secondary network by adding the network details to the VM specification.

### 7.4.1. Creating an OVN-Kubernetes NAD

You can create an OVN-Kubernetes layer 2 or localnet network attachment definition (NAD) by using the Red Hat OpenShift Service on AWS web console or the CLI.

NOTE

Configuring IP address management (IPAM) in a network attachment definition for virtual machines is not supported.

#### 7.4.1.1. Creating a NAD for layer 2 topology using the CLI

You can create a network attachment definition (NAD) which describes how to attach a pod to the layer 2 overlay network.

**Prerequisites**

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

**Procedure**

1. Create a **NetworkAttachmentDefinition** object:

```
apiVersion: k8s.cni.cncf.io/v1
kind: NetworkAttachmentDefinition
metadata:
  name: l2-network
  namespace: my-namespace
spec:
  config: |2
    {
            "cniVersion": "0.3.1", 1
            "name": "my-namespace-l2-network", 2
            "type": "ovn-k8s-cni-overlay", 3
            "topology":"layer2", 4
            "mtu": 1300, 5
            "netAttachDefName": "my-namespace/l2-network" 6
    }
```

1 The CNI specification version. The required value is **0.3.1**.

2 The name of the network. This attribute is not namespaced. For example, you can have a network named **l2-network** referenced from two different **NetworkAttachmentDefinition** objects that exist in two different namespaces. This feature is useful to connect VMs in different namespaces.

3 The name of the CNI plug-in to be configured. The required value is **ovn-k8s-cni-overlay**.

4 The topological configuration for the network. The required value is **layer2**.

5 Optional: The maximum transmission unit (MTU) value. The default value is automatically set by the kernel.

6 The value of the **namespace** and **name** fields in the **metadata** stanza of the **NetworkAttachmentDefinition** object.

NOTE

The above example configures a cluster-wide overlay without a subnet defined. This means that the logical switch implementing the network only provides layer 2 communication. You must configure an IP address when you create the virtual machine by either setting a static IP address or by deploying a DHCP server on the network for a dynamic IP address.

2. Apply the manifest:

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

### 7.4.1.2. Creating a NAD for localnet topology using the CLI

You can create a network attachment definition (NAD) which describes how to attach a pod to the underlying physical network.

#### Prerequisites

- You have access to the cluster as a user with **cluster-admin** privileges.
- You have installed the OpenShift CLI (**oc**).
- You have installed the Kubernetes NMState Operator.
- You have created a **NodeNetworkConfigurationPolicy** object to map the OVN-Kubernetes secondary network to an Open vSwitch (OVS) bridge.

#### Procedure

1. Create a **NetworkAttachmentDefinition** object:

```
apiVersion: k8s.cni.cncf.io/v1
kind: NetworkAttachmentDefinition
metadata:
  name: localnet-network
  namespace: default
spec:
  config: |2
   {
          "cniVersion": "0.3.1", 1
          "name": "localnet-network", 2
          "type": "ovn-k8s-cni-overlay", 3
```

```
        "topology": "localnet", (4)
        "netAttachDefName": "default/localnet-network" (5)
}
```

1. The CNI specification version. The required value is **0.3.1**.
2. The name of the network. This attribute must match the value of the **spec.desiredState.ovn.bridge-mappings.localnet** field of the **NodeNetworkConfigurationPolicy** object that defines the OVS bridge mapping.
3. The name of the CNI plug-in to be configured. The required value is **ovn-k8s-cni-overlay**.
4. The topological configuration for the network. The required value is **localnet**.
5. The value of the **namespace** and **name** fields in the **metadata** stanza of the **NetworkAttachmentDefinition** object.

2. Apply the manifest:

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

### 7.4.2. Attaching a virtual machine to the OVN-Kubernetes secondary network

You can attach a virtual machine (VM) to the OVN-Kubernetes secondary network interface by using the Red Hat OpenShift Service on AWS web console or the CLI.

#### 7.4.2.1. Attaching a virtual machine to an OVN-Kubernetes secondary network using the CLI

You can connect a virtual machine (VM) to the OVN-Kubernetes secondary network by including the network details in the VM configuration.

##### Prerequisites

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

##### Procedure

1. Edit the **VirtualMachine** manifest to add the OVN-Kubernetes secondary network interface details, as in the following example:

```
apiVersion: kubevirt.io/v1
kind: VirtualMachine
metadata:
  name: vm-server
spec:
  running: true
  template:
    spec:
      domain:
        devices:
          interfaces:
          - name: default
            masquerade: {}
          - name: secondary (1)
            bridge: {}
        resources:
          requests:
            memory: 1024Mi
      networks:
      - name: default
        pod: {}
      - name: secondary (2)
        multus:
          networkName: <nad_name> (3)
# ...
```

(1) The name of the OVN-Kubernetes secondary interface.

(2) The name of the network. This must match the value of the **spec.template.spec.domain.devices.interfaces.name** field.

(3) The name of the **NetworkAttachmentDefinition** object.

2. Apply the **VirtualMachine** manifest:

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

3. Optional: If you edited a running virtual machine, you must restart it for the changes to take effect.

#### 7.4.2.2. Creating a NAD for layer 2 topology by using the web console

You can create a network attachment definition (NAD) that describes how to attach a pod to the layer 2 overlay network.

**Prerequisites**

- You have access to the cluster as a user with **cluster-admin** privileges.

**Procedure**

1. Go to **Networking → NetworkAttachmentDefinitions** in the web console.
2. Click **Create Network Attachment Definition** The network attachment definition must be in the same namespace as the pod or virtual machine using it.
3. Enter a unique **Name** and optional **Description**.
4. Select **OVN Kubernetes L2 overlay network** from the **Network Type** list.
5. Click **Create**.

#### 7.4.2.3. Creating a NAD for localnet topology using the web console

You can create a network attachment definition (NAD) to connect workloads to a physical network by using the Red Hat OpenShift Service on AWS web console.

**Prerequisites**

- You have access to the cluster as a user with **cluster-admin** privileges.
- Use **nmstate** to configure the localnet to OVS bridge mappings.

**Procedure**

1. Navigate to **Networking** → **NetworkAttachmentDefinitions** in the web console.
2. Click **Create Network Attachment Definition** The network attachment definition must be in the same namespace as the pod or virtual machine using it.
3. Enter a unique **Name** and optional **Description**.
4. Select **OVN Kubernetes secondary localnet network**from the **Network Type** list.
5. Enter the name of your pre-configured localnet identifier in the **Bridge mapping** field.
6. Optional: You can explicitly set MTU to the specified value. The default value is chosen by the kernel.
7. Optional: Encapsulate the traffic in a VLAN. The default value is none.
8. Click **Create**.

## 7.5. 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.

### 7.5.1. Adding a virtual machine to a 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.

**IMPORTANT**

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.

**Prerequisites**

- You installed the Service Mesh Operators.
- You created the Service Mesh control plane.
- You added the VM project to the Service Mesh member roll.

**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.

### 7.5.2. Additional resources

- Installing the Service Mesh Operators
- Creating the Service Mesh control plane
- Adding projects to the Service Mesh member roll

## 7.6. CONFIGURING A DEDICATED NETWORK FOR LIVE MIGRATION

You can configure a dedicated secondary network for live migration. A dedicated network minimizes the effects of network saturation on tenant workloads during live migration.

### 7.6.1. Configuring a dedicated secondary network for live migration

To configure a dedicated secondary network for live migration, you must first create a bridge network attachment definition (NAD) by using the CLI. Then, you 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.

- Each node has at least two Network Interface Cards (NICs).
- The NICs for live migration are connected to the same VLAN.

**Procedure**

1. Create a **NetworkAttachmentDefinition** manifest according to the following example:

   **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) Specify the name of the **NetworkAttachmentDefinition** object.

   (2) (3) Specify the name of the NIC to be used for live migration.

   (4) Specify the name of the CNI plugin that provides the network for the NAD.

   (5) Specify an IP address range for the secondary network. This range must not overlap 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:

   **Example HyperConverged manifest**

   ```
   apiVersion: hco.kubevirt.io/v1beta1
   kind: HyperConverged
   metadata:
     name: kubevirt-hyperconverged
   spec:
     liveMigrationConfig:
       completionTimeoutPerGiB: 800
   ```

```
    network: <network> (1)
    parallelMigrationsPerCluster: 5
    parallelOutboundMigrationsPerNode: 2
    progressTimeout: 150
# ...
```

(1) Specify 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}'
```

### 7.6.2. Selecting a dedicated network by using the web console

You can select a dedicated network for live migration by using the Red Hat OpenShift Service on AWS web console.

**Prerequisites**

- You configured a Multus network for live migration.

**Procedure**

1. Navigate to **Virtualization > Overview** in the Red Hat OpenShift Service on AWS web console.
2. Click the **Settings** tab and then click **Live migration**.
3. Select the network from the **Live migration network** list.

### 7.6.3. Additional resources

- Configuring live migration limits and timeouts

## 7.7. CONFIGURING AND VIEWING IP ADDRESSES

You can configure an IP address when you create a virtual machine (VM). The IP address is provisioned with cloud-init.

You can view the IP address of a VM by using the Red Hat OpenShift Service on AWS web console or the command line. The network information is collected by the QEMU guest agent.

### 7.7.1. Configuring IP addresses for virtual machines

You can configure a static IP address when you create a virtual machine (VM) by using the web console or the command line.

You can configure a dynamic IP address when you create a VM by using the command line.

The IP address is provisioned with cloud-init.

#### 7.7.1.1. Configuring an IP address when creating a virtual machine by using the command line

You can configure a static or dynamic IP address when you create a virtual machine (VM). The IP address is provisioned with cloud-init.

**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
            ethernets:
              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
         ethernets:
           eth1: (1)
             addresses:
             - 10.10.10.14/24 (2)
```

(1) Specify the interface name.

(2) Specify the static IP address.

### 7.7.2. Viewing IP addresses of virtual machines

You can view the IP address of a VM by using the Red Hat OpenShift Service on AWS web console or the command line.

The network information is collected by the QEMU guest agent.

#### 7.7.2.1. Viewing the IP address of a virtual machine by using the web console

You can view the IP address of a virtual machine (VM) by using the Red Hat OpenShift Service on AWS web console.

**NOTE**

You must install the QEMU guest agent on a VM to view the IP address of a secondary network interface. A pod network interface does not require the QEMU guest agent.

**Procedure**

1. In the Red Hat OpenShift Service on AWS console, click **Virtualization** → **VirtualMachines** from the side menu.

2. Select a VM to open the **VirtualMachine details** page.

3. Click the **Details** tab to view the IP address.

#### 7.7.2.2. Viewing the IP address of a virtual machine by using the command line

You can view the IP address of a virtual machine (VM) by using the command line.

**NOTE**

You must install the QEMU guest agent on a VM to view the IP address of a secondary network interface. A pod network interface does not require the QEMU guest agent.

**Procedure**

- Obtain the virtual machine instance configuration by running the following command:

```
$ 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
```

### 7.7.3. Additional resources

- Installing the QEMU guest agent

## 7.8. MANAGING MAC ADDRESS POOLS FOR NETWORK INTERFACES

The *KubeMacPool* component allocates MAC addresses for virtual machine (VM) network interfaces from a shared MAC address pool. This ensures that each network interface is assigned a unique MAC address.

A virtual machine instance created from that VM retains the assigned MAC address across reboots.

**NOTE**

KubeMacPool does not handle virtual machine instances created independently from a virtual machine.

### 7.8.1. Managing KubeMacPool by using the command line

You can disable and re-enable KubeMacPool by using the command line.

KubeMacPool is enabled by default.

**Procedure**

- To disable KubeMacPool in two namespaces, run the following command:

```
$ oc label namespace <namespace1> <namespace2>
mutatevirtualmachines.kubemacpool.io=ignore
```

- To re-enable KubeMacPool in two namespaces, run the following command:

```
$ oc label namespace <namespace1> <namespace2>
mutatevirtualmachines.kubemacpool.io-
```

# CHAPTER 8. STORAGE

## 8.1. STORAGE CONFIGURATION OVERVIEW

You can configure a default storage class, storage profiles, Containerized Data Importer (CDI), data volumes, and automatic boot source updates.

### 8.1.1. Storage

The following storage configuration tasks are mandatory:

**Configure storage profiles**

You must configure storage profiles if your storage provider is not recognized by CDI. A storage profile provides recommended storage settings based on the associated storage class.

The following storage configuration tasks are optional:

**Reserve additional PVC space for file system overhead**

By default, 5.5% of a file system PVC is reserved for overhead, reducing the space available for VM disks by that amount. You can configure a different overhead value.

**Configure local storage by using the hostpath provisioner**

You can configure local storage for virtual machines by using the hostpath provisioner (HPP). When you install the OpenShift Virtualization Operator, the HPP Operator is automatically installed.

**Configure user permissions to clone data volumes between namespaces**

You can configure RBAC roles to enable users to clone data volumes between namespaces.

### 8.1.2. Containerized Data Importer

You can perform the following Containerized Data Importer (CDI) configuration tasks:

**Override the resource request limits of a namespace**

You can configure CDI to import, upload, and clone VM disks into namespaces that are subject to CPU and memory resource restrictions.

**Configure CDI scratch space**

CDI requires scratch space (temporary storage) to complete some operations, such as importing and uploading VM images. During this process, CDI provisions a scratch space PVC equal to the size of the PVC backing the destination data volume (DV).

### 8.1.3. Data volumes

You can perform the following data volume configuration tasks:

**Enable preallocation for data volumes**

CDI can preallocate disk space to improve write performance when creating data volumes. You can enable preallocation for specific data volumes.

**Manage data volume annotations**

Data volume 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.

### 8.1.4. Boot source updates

You can perform the following boot source update configuration task:

**Manage 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, CDI imports, polls, and updates the images so that they are ready to be cloned for new VMs. By default, CDI automatically updates Red Hat boot sources. You can enable automatic updates for custom boot sources.

## 8.2. CONFIGURING STORAGE PROFILES

A storage profile provides recommended storage settings based on the associated storage class. A storage profile is allocated for each storage class.

If the Containerized Data Importer (CDI) does not recognize your storage provider, you must configure storage profiles.

For recognized storage types, 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.

### 8.2.1. 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.

You cannot modify storage class parameters. To make changes, delete and re-create the storage class. You must then reapply any customizations that were previously made to the storage profile.

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 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 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.

#### 8.2.1.1. 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.

## 8.3. MANAGING AUTOMATIC BOOT SOURCE UPDATES

You can manage automatic updates for the following boot sources:

- All Red Hat boot sources
- All custom boot sources
- Individual Red Hat or custom boot sources

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 Red Hat boot sources.

### 8.3.1. Managing Red Hat boot source updates

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 boot source 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 boot source. An administrator can manually provide a boot source by creating a new persistent volume claim (PVC) or volume snapshot for the **DataSource** object, then populating it with an operating system image.

#### 8.3.1.1. 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 hyperconverged 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 hyperconverged kubevirt-hyperconverged -n openshift-cnv \
      --type json -p '[{"op": "replace", "path": \
      "/spec/featureGates/enableCommonBootImageImport", \
      "value": true}]'
    ```

### 8.3.2. Managing custom boot source updates

*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).

IMPORTANT

You must configure a storage profile. Otherwise, the cluster cannot receive automated updates for custom boot sources. See Configure storage profiles for details.

#### 8.3.2.1. Configuring a storage class for custom boot source updates

You can override the default storage class by editing 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 hyperconverged kubevirt-hyperconverged -n openshift-cnv
```

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
      schedule: "0 */12 * * *" 2
      managedDataSource: <data_source> 3
# ...
```

1 Define the storage class.

2 Required: Schedule for the job specified in cron format.

3 Required: The data source to use.

```
For the custom image to be detected as an available boot source, the value of the
`spec.dataVolumeTemplates.spec.sourceRef.name` parameter in the VM template must
match this value.
```

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 storageclass
```

**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.

#### 8.3.2.2. 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.

#### 8.3.2.3. Enabling volume snapshot boot sources

Enable volume snapshot boot sources by setting the parameter in the **StorageProfile** associated with the storage class that stores operating system base images. Although **DataImportCron** was originally designed to maintain only PVC sources, **VolumeSnapshot** sources scale better than PVC sources for certain storage types.

**NOTE**

Use volume snapshots on a storage profile that is proven to scale better when cloning from a single snapshot.

### Prerequisites

- You must have access to a volume snapshot with the operating system image.
- The storage must support snapshotting.

### Procedure

1. Open the storage profile object that corresponds to the storage class used to provision boot sources by running the following command:

   ```
   $ oc edit storageprofile <storage_class>
   ```

2. Review the **dataImportCronSourceFormat** specification of the **StorageProfile** to confirm whether or not the VM is using PVC or volume snapshot by default.

3. Edit the storage profile, if needed, by updating the **dataImportCronSourceFormat** specification to **snapshot**.

   #### Example storage profile

   ```
   apiVersion: cdi.kubevirt.io/v1beta1
   kind: StorageProfile
   metadata:
   # ...
   spec:
     dataImportCronSourceFormat: snapshot
   ```

### Verification

1. Open the storage profile object that corresponds to the storage class used to provision boot sources.

   ```
   $ oc get storageprofile <storage_class>  -oyaml
   ```

2. Confirm that the **dataImportCronSourceFormat** specification of the **StorageProfile** is set to 'snapshot', and that any **DataSource** objects that the **DataImportCron** points to now reference volume snapshots.

You can now use these boot sources to create virtual machines.

## 8.3.3. 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.

## 8.3.4. 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 hyperconverged kubevirt-hyperconverged -n openshift-cnv -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.

## 8.4. RESERVING PVC SPACE FOR FILE SYSTEM OVERHEAD

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 VM disk and 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.

### 8.4.1. 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 hyperconverged kubevirt-hyperconverged -n openshift-cnv
```

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}'
```

## 8.5. CONFIGURING LOCAL STORAGE BY USING THE HOSTPATH PROVISIONER

You can configure local storage for virtual machines by using the hostpath provisioner (HPP).

When you install the OpenShift Virtualization Operator, the Hostpath Provisioner Operator is automatically installed. HPP is a local storage provisioner designed for OpenShift Virtualization that is created by the Hostpath Provisioner Operator. To use HPP, you create an HPP custom resource (CR) with a basic storage pool.

### 8.5.1. 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.

IMPORTANT

Do not create storage pools 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.

#### Prerequisites

- The directories specified in **spec.storagePools.path** must have read/write access.

#### 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
```

### 8.5.1.1. 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.

### 8.5.1.2. Creating a storage class for the CSI driver with the storagePools stanza

To use the hostpath provisioner (HPP) you must create an associated storage class for the Container Storage Interface (CSI) driver.

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.

NOTE

Virtual machines use data volumes that are based on local PVs. Local PVs are bound to specific nodes. While a 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.

#### Prerequisites

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

#### 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.

2. Save the file and exit.

3. Create the **StorageClass** object by running the following command:

```
$ oc create -f storageclass_csi.yaml
```

### 8.5.2. 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.

### 8.5.2.1. 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).

**IMPORTANT**

Do not create storage pools 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.

**Prerequisites**

- The directories specified in **spec.storagePools.path** must have read/write access.

**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
```

## 8.6. 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.

### 8.6.1. Creating RBAC resources for cloning data volumes

Create a new cluster role that enables permissions for all actions for the **datavolumes** resource.

#### Prerequisites

- You must have cluster admin privileges.

#### 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.

## 8.7. CONFIGURING CDI TO OVERRIDE CPU AND MEMORY QUOTAS

You can configure the Containerized Data Importer (CDI) to import, upload, and clone virtual machine disks into namespaces that are subject to CPU and memory resource restrictions.

### 8.7.1. 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.

When the **AutoResourceLimits** feature gate is enabled, OpenShift Virtualization automatically manages CPU and memory limits. If a namespace has both CPU and memory quotas, the memory limit is set to double the base allocation and the CPU limit is one per vCPU.

### 8.7.2. 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 hyperconverged kubevirt-hyperconverged -n openshift-cnv
```

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.

### 8.7.3. Additional resources

- Resource quotas per project

## 8.8. PREPARING CDI SCRATCH SPACE

### 8.8.1. 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.

### 8.8.2. 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. |

### 8.8.3. 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 hyperconverged kubevirt-hyperconverged -n openshift-cnv
```

2. 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
```

1 If you do not specify a storage class, CDI uses the storage class of the persistent volume claim that is being populated.

3. Save and exit your default editor to update the **HyperConverged** CR.

### 8.8.4. 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 (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 (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

### 8.8.5. Additional resources

- Dynamic provisioning

## 8.9. 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.

### 8.9.1. 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.

### 8.9.2. 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)
    registry:
      url: <image_url> (2)
  storage:
    resources:
      requests:
        storage: 1Gi
# ...
```

1 All CDI source types support preallocation. However, preallocation is ignored for cloning operations.

2 Specify the URL of the data source in your registry.

## 8.10. 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.

### 8.10.1. 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: datavolume-example
  annotations:
    v1.multus-cni.io/default-network: bridge-network 1
# ...
```

1 Multus network annotation

# CHAPTER 9. LIVE MIGRATION

## 9.1. ABOUT LIVE MIGRATION

Live migration is the process of moving a running virtual machine (VM) to another node in the cluster without interrupting the virtual workload. By default, live migration traffic is encrypted using Transport Layer Security (TLS).

### 9.1.1. Live migration requirements

Live migration has the following requirements:

- The cluster must have shared storage with **ReadWriteMany** (RWX) access mode.
- The cluster must have sufficient RAM and network bandwidth.

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.

- If a VM uses a host model CPU, the nodes must support the CPU.
- Configuring a dedicated Multus network for live migration is highly recommended. A dedicated network minimizes the effects of network saturation on tenant workloads during migration.

### 9.1.2. Common live migration tasks

You can perform the following live migration tasks:

- Configure live migration settings
- Initiate and cancel live migration
- Monitor the progress of all live migrations in the **Migration** tab of the OpenShift Virtualization web console.
- View VM migration metrics in the **Metrics** tab of the web console.

### 9.1.3. Additional resources

- Prometheus queries for live migration
- VM migration tuning
- VM run strategies

- VM and cluster eviction strategies

## 9.2. CONFIGURING LIVE MIGRATION

You can configure live migration settings to ensure that the migration processes do not overwhelm the cluster.

You can configure live migration policies to apply different migration configurations to groups of virtual machines (VMs).

### 9.2.1. 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 hyperconverged kubevirt-hyperconverged -n openshift-cnv
  ```

  **Example configuration file**

  ```
  apiVersion: hco.kubevirt.io/v1beta1
  kind: HyperConverged
  metadata:
    name: kubevirt-hyperconverged
    namespace: openshift-cnv
  spec:
    liveMigrationConfig:
      bandwidthPerMigration: 64Mi 1
      completionTimeoutPerGiB: 800 2
      parallelMigrationsPerCluster: 5 3
      parallelOutboundMigrationsPerNode: 2 4
      progressTimeout: 150 5
  ```

  1. Bandwidth limit of each migration, where the value is the quantity of bytes per second. For example, a value of **2048Mi** means 2048 MiB/s. Default: **0**, which is unlimited.
  2. The migration is canceled if it has not completed in this time, in seconds per GiB of memory. For example, a VM with 6GiB memory times out if it has not completed migration in 4800 seconds. If the **Migration Method** is **BlockMigration**, the size of the migrating disks is included in the calculation.
  3. Number of migrations running in parallel in the cluster. Default: **5**.
  4. Maximum number of outbound migrations per node. Default: **2**.
  5. The migration is canceled if memory copy fails to make progress in this time, in seconds. Default: **150**.

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**.

## 9.2.2. Live migration policies

You can create live migration policies to apply different migration configurations to groups of VMs that are defined by VM or project labels.

### TIP

You can create live migration policies by using the OpenShift Virtualization web console.

### 9.2.2.1. Creating a live migration policy by using the command line

You can create a live migration policy by using the command line. A live migration policy is applied to selected virtual machines (VMs) by using any combination of labels:

- VM labels such as **size**, **os**, or **gpu**
- Project labels such as **priority**, **bandwidth**, or **hpc-workload**

For the policy to apply to a specific group of VMs, all labels on the group of VMs must match the labels of the policy.

NOTE

If multiple live migration policies apply to a VM, the policy with the greatest number of matching labels takes precedence.

If multiple policies meet this criteria, the policies are sorted by alphabetical order of the matching label keys, and the first one in that order takes precedence.

**Procedure**

1. Create a **MigrationPolicy** object as in the following example:

```
apiVersion: migrations.kubevirt.io/v1alpha1
kind: MigrationPolicy
metadata:
  name: <migration_policy>
spec:
  selectors:
    namespaceSelector: (1)
      hpc-workloads: "True"
      xyz-workloads-type: ""
    virtualMachineInstanceSelector: (2)
      workload-type: "db"
      operating-system: ""
```

(1) Specify project labels.

2 Specify VM labels.

2. Create the migration policy by running the following command:

```
$ oc create migrationpolicy -f <migration_policy>.yaml
```

### 9.2.3. Additional resources

- Configuring a dedicated Multus network for live migration

## 9.3. INITIATING AND CANCELING LIVE MIGRATION

You can initiate the live migration of a virtual machine (VM) to another node by using the Red Hat OpenShift Service on AWS web console or the command line.

You can cancel a live migration by using the web console or the command line. The VM remains on its original node.

TIP

You can also initiate and cancel live migration by using the **virtctl migrate <vm_name>** and **virtctl migrate-cancel <vm_name>** commands.

### 9.3.1. Initiating live migration

#### 9.3.1.1. Initiating live migration by using the web console

You can live migrate a running virtual machine (VM) to a different node in the cluster by using the Red Hat OpenShift Service on AWS web console.

NOTE

The **Migrate** action is visible to all users but only cluster administrators can initiate a live migration.

**Prerequisites**

- The VM must be migratable.
- If the VM is configured with a host model CPU, the cluster must have an available node that supports the CPU model.

**Procedure**

1. Navigate to **Virtualization** → **VirtualMachines** in the web console.
2. Select **Migrate** from the Options menu ⋮ beside a VM.
3. Click **Migrate**.

#### 9.3.1.2. Initiating live migration by using the command line

You can initiate the live migration of a running virtual machine (VM) by using the command line to create a **VirtualMachineInstanceMigration** object for the VM.

**Procedure**

1. Create a **VirtualMachineInstanceMigration** manifest for the VM that you want to migrate:

```
apiVersion: kubevirt.io/v1
kind: VirtualMachineInstanceMigration
metadata:
  name: <migration_name>
spec:
  vmiName: <vm_name>
```

2. Create the object by running the following command:

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

   The **VirtualMachineInstanceMigration** object triggers a live migration of the VM. This object exists in the cluster for as long as the virtual machine instance is running, unless manually deleted.

**Verification**

- Obtain the VM status by running the following command:

```
$ oc describe vmi <vm_name> -n <namespace>
```

  **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
```

### 9.3.2. Canceling live migration

#### 9.3.2.1. Canceling live migration by using the web console

You can cancel the live migration of a virtual machine (VM) by using the Red Hat OpenShift Service on AWS web console.

**Procedure**

1. Navigate to **Virtualization** → **VirtualMachines** in the web console.
2. Select **Cancel Migration** on the Options menu ⋮ beside a VM.

### 9.3.2.2. Canceling live migration by using the command line

Cancel the live migration of a virtual machine 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
  ```

# CHAPTER 10. NODES

## 10.1. NODE MAINTENANCE

Nodes can be placed into maintenance mode by using the **oc adm** utility or **NodeMaintenance** custom resources (CRs).

NOTE

The **node-maintenance-operator** (NMO) is no longer shipped with OpenShift Virtualization. It is deployed as a standalone Operator from the **OperatorHub** in the Red Hat OpenShift Service on AWS web console or by using the OpenShift CLI (**oc**).

For more information on remediation, fencing, and maintaining nodes, see the Workload Availability for Red Hat OpenShift documentation.

IMPORTANT

Virtual machines (VMs) 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 Red Hat OpenShift Service on AWS custom resource processing.

### 10.1.1. Eviction strategies

Placing a node into maintenance marks the node as unschedulable and drains all the VMs and pods from it.

You can configure eviction strategies for virtual machines (VMs) or for the cluster.

#### VM eviction strategy

The VM **LiveMigrate** eviction strategy ensures that a virtual machine instance (VMI) is not interrupted if the node is placed into maintenance or drained. VMIs with this eviction strategy will be live migrated to another node.
You can configure eviction strategies for virtual machines (VMs) by using the OpenShift Virtualization web console or the command line.

IMPORTANT

The default eviction strategy is **LiveMigrate**. A non-migratable VM with a **LiveMigrate** eviction strategy might prevent nodes from draining or block an infrastructure upgrade because the VM is not evicted from the node. This situation causes a migration to remain in a **Pending** or **Scheduling** state unless you shut down the VM manually.

You must set the eviction strategy of non-migratable VMs to **LiveMigrateIfPossible**, which does not block an upgrade, or to **None**, for VMs that should not be migrated.

#### 10.1.1.1. Configuring a VM eviction strategy using the command line

You can configure an eviction strategy for a virtual machine (VM) by using the command line.

IMPORTANT

The default eviction strategy is **LiveMigrate**. A non-migratable VM with a **LiveMigrate** eviction strategy might prevent nodes from draining or block an infrastructure upgrade because the VM is not evicted from the node. This situation causes a migration to remain in a **Pending** or **Scheduling** state unless you shut down the VM manually.

You must set the eviction strategy of non-migratable VMs to **LiveMigrateIfPossible**, which does not block an upgrade, or to **None**, for VMs that should not be migrated.

**Procedure**

1. Edit the **VirtualMachine** resource by running the following command:

```
$ oc edit vm <vm_name> -n <namespace>
```

**Example eviction strategy**

```
apiVersion: kubevirt.io/v1
kind: VirtualMachine
metadata:
  name: <vm_name>
spec:
  template:
    spec:
      evictionStrategy: LiveMigrateIfPossible (1)
# ...
```

(1) Specify the eviction strategy. The default value is **LiveMigrate**.

2. Restart the VM to apply the changes:

```
$ virtctl restart <vm_name> -n <namespace>
```

### 10.1.2. Run strategies

A virtual machine (VM) configured with **spec.running: true** is immediately restarted. The **spec.runStrategy** key provides greater flexibility for determining how a VM behaves under certain conditions.

IMPORTANT

The **spec.runStrategy** and **spec.running** keys are mutually exclusive. Only one of them can be used.

A VM configuration with both keys is invalid.

#### 10.1.2.1. Run strategies

The **spec.runStrategy** key has four possible values:

**Always**
: The virtual machine instance (VMI) is always present when a virtual machine (VM) is created on another node. A new VMI is created if the original stops for any reason. This is the same behavior as **running: true**.

**RerunOnFailure**
: The VMI is re-created on another node if the previous instance fails. The instance is not re-created if the VM stops successfully, such as when it is shut down.

**Manual**
: You control the VMI state manually with the **start**, **stop**, and **restart** virtctl client commands. The VM is not automatically restarted.

**Halted**
: No VMI is present when a VM is created. This is the same behavior as **running: false**.

Different combinations of the **virtctl start**, **stop** and **restart** commands affect the run strategy.

The following table describes a VM’s transition between states. The first column shows the VM’s initial run strategy. The remaining columns show a virtctl command and the new run strategy after that command is run.

Table 10.1. Run strategy before and after**virtctl** commands

| Initial run strategy | Start | Stop | Restart |
|---|---|---|---|
| Always | - | Halted | Always |
| RerunOnFailure | - | Halted | RerunOnFailure |
| Manual | Manual | Manual | Manual |
| Halted | Always | - | - |

NOTE

If a node in a cluster installed by using installer-provisioned infrastructure fails the machine health check and is unavailable, VMs with **runStrategy: Always** or **runStrategy: RerunOnFailure** are rescheduled on a new node.

#### 10.1.2.2. Configuring a VM run strategy by using the command line

You can configure a run strategy for a virtual machine (VM) by using the command line.

**IMPORTANT**

The **spec.runStrategy** and **spec.running** keys are mutually exclusive. A VM configuration that contains values for both keys is invalid.

**Procedure**

- Edit the **VirtualMachine** resource by running the following command:

```
$ oc edit vm <vm_name> -n <namespace>
```

**Example run strategy**

```
apiVersion: kubevirt.io/v1
kind: VirtualMachine
spec:
  runStrategy: Always
# ...
```

### 10.1.3. Maintaining bare metal nodes

When you deploy Red Hat OpenShift Service on AWS 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.

### 10.1.4. Additional resources

- About live migration

## 10.2. 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.

### 10.2.1. 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 10.1. 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.

### 10.2.2. 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 10.2. 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 10.3. CPU features supported by **Haswell**

```
aes
apic
avx
avx2
bmi1
bmi2
clflush
cmov
cx16
cx8
de
erms
fma
fpu
fsgsbase
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 10.4. 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
```

### 10.2.3. 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.

## 10.3. PREVENTING NODE RECONCILIATION

Use **skip-node** annotation to prevent the **node-labeller** from reconciling a node.

### 10.3.1. 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.

### 10.3.2. Additional resources

- Managing node labeling for obsolete CPU models

# CHAPTER 11. MONITORING

## 11.1. MONITORING OVERVIEW

You can monitor the health of your cluster and virtual machines (VMs) with the following tools:

**Monitoring OpenShift Virtualization VM health status**

View the overall health of your OpenShift Virtualization environment in the web console by navigating to the **Home** → **Overview** page in the Red Hat OpenShift Service on AWS web console. The **Status** card displays the overall health of OpenShift Virtualization based on the alerts and conditions.

**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.

**Runbooks**

Diagnose and resolve issues that trigger OpenShift Virtualization alerts in the Red Hat OpenShift Service on AWS web console.

## 11.2. PROMETHEUS QUERIES FOR VIRTUAL RESOURCES

Use the Red Hat OpenShift Service on AWS monitoring dashboard to query virtualization metrics. OpenShift Virtualization provides metrics that you can use to monitor the consumption of cluster infrastructure resources, including network, storage, and guest memory swapping. You can also use metrics to query live migration status.

### 11.2.1. Prerequisites

- For guest memory swapping queries to return data, memory swapping must be enabled on the virtual guests.

### 11.2.2. Querying metrics

The Red Hat OpenShift Service on AWS 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 **dedicated-admin**, you can query one or more namespaces at a time for metrics about 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.

#### 11.2.2.1. Querying metrics for all projects as a cluster administrator

As a **dedicated-admin** or as a user with view permissions for all projects, you can access metrics for all default Red Hat OpenShift Service on AWS and user-defined projects in the Metrics UI.

NOTE

Only dedicated administrators have access to the third-party UIs provided with Red Hat OpenShift Service on AWS monitoring.

### Prerequisites

- You have access to the cluster as a user with the **dedicated-admin** role or with view permissions for all projects.
- You have installed the OpenShift CLI (**oc**).

### Procedure

1. From the **Administrator** perspective in the Red Hat OpenShift Service on AWS web console, select **Observe → Metrics**.
2. To add one or more queries, do any of the following:

| Option | Description |
|---|---|
| Create a custom query. | Add your Prometheus Query Language (PromQL) query to the **Expression** field.<br><br>As you type a PromQL expression, autocomplete suggestions appear in a drop-down 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. |
| Add multiple queries. | Select **Add query**. |
| Duplicate an existing query. | Select the Options menu ⋮ next to the query, then choose **Duplicate query**. |
| Disable a query from being run. | Select the Options menu ⋮ next to the query and choose **Disable query**. |

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 **Hide all series**. |
| 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:<br>● Visually select the time range by clicking and dragging on the plot horizontally.<br>● Use the menu in the left upper corner to select the time range. |
| Reset the time range. | Select **Reset zoom**. |
| 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 **Hide graph**. |

### 11.2.2.2. 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. Developers cannot access the third-party UIs provided with Red Hat OpenShift Service on AWS monitoring.

**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 Red Hat OpenShift Service on AWS 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. | Either:<br>• Visually select the time range by clicking and dragging on the plot horizontally.<br>• Use the menu in the left upper corner to select the time range. |
| Reset the time range. | Select **Reset zoom**. |
| 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. |

### 11.2.3. 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.

#### 11.2.3.1. 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.

#### 11.2.3.2. Storage metrics

##### 11.2.3.2.1. 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.

##### 11.2.3.2.2. Storage snapshot data

**kubevirt_vmsnapshot_disks_restored_from_source**

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{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.

#### 11.2.3.2.3. 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.

### 11.2.3.3. 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**

Returns the total amount (in bytes) of memory the virtual guest is swapping in. Type: Gauge.

**kubevirt_vmi_memory_swap_out_traffic_bytes**

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[6m])) + sum
by (name, namespace) (rate(kubevirt_vmi_memory_swap_out_traffic_bytes[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.

#### 11.2.3.4. Live migration metrics

The following metrics can be queried to show live migration status:

**kubevirt_vmi_migration_data_processed_bytes**
The amount of guest operating system data that has migrated to the new virtual machine (VM). Type: Gauge.

**kubevirt_vmi_migration_data_remaining_bytes**
The amount of guest operating system data that remains to be migrated. Type: Gauge.

**kubevirt_vmi_migration_memory_transfer_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_vmi_migrations_in_pending_phase**
The number of pending migrations. Type: Gauge.

**kubevirt_vmi_migrations_in_scheduling_phase**
The number of scheduling migrations. Type: Gauge.

**kubevirt_vmi_migrations_in_running_phase**
The number of running migrations. Type: Gauge.

**kubevirt_vmi_migration_succeeded**
The number of successfully completed migrations. Type: Gauge.

**kubevirt_vmi_migration_failed**
The number of failed migrations. Type: Gauge.

### 11.2.4. Additional resources

- Monitoring overview
- Querying Prometheus
- Prometheus query examples

## 11.3. EXPOSING CUSTOM METRICS FOR VIRTUAL MACHINES

Red Hat OpenShift Service on AWS includes a preconfigured, preinstalled, 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 Red Hat OpenShift Service on AWS 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.

### 11.3.1. 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 Red Hat OpenShift Service on AWS 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
```

### 11.3.2. 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
```

3. 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"
```

4. 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
```

5. 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
```

## 11.3.3. 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 Red Hat OpenShift Service on AWS 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.

### 11.3.3.1. 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
```

### 11.3.4. 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
```

#### 11.3.4.1. 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
```

### 11.3.5. Additional resources

- Creating and using config maps
- Controlling virtual machine states

## 11.4. VIRTUAL MACHINE HEALTH CHECKS

You can configure virtual machine (VM) health checks by defining readiness and liveness probes in the **VirtualMachine** resource.

### 11.4.1. 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.

#### 11.4.1.1. Defining an HTTP readiness probe

Define an HTTP readiness probe by setting the **spec.readinessProbe.httpGet** field of the virtual machine (VM) configuration.

**Procedure**

1. Include details of the readiness probe in the VM configuration file.

   **Sample readiness probe with an HTTP GET test**

```
apiVersion: kubevirt.io/v1
kind: VirtualMachine
metadata:
  annotations:
  name: fedora-vm
  namespace: example-namespace
# ...
spec:
  template:
    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.

2. Create the VM by running the following command:

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

### 11.4.1.2. Defining a TCP readiness probe

Define a TCP readiness probe by setting the **spec.readinessProbe.tcpSocket** field of the virtual machine (VM) configuration.

**Procedure**

1. Include details of the TCP readiness probe in the VM configuration file.

**Sample readiness probe with a TCP socket test**

```
apiVersion: kubevirt.io/v1
kind: VirtualMachine
metadata:
  annotations:
  name: fedora-vm
  namespace: example-namespace
# ...
spec:
  template:
    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**.

2. Create the VM by running the following command:

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

### 11.4.1.3. 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

1. Include details of the HTTP liveness probe in the VM configuration file.

**Sample liveness probe with an HTTP GET test**

```
apiVersion: kubevirt.io/v1
kind: VirtualMachine
metadata:
  annotations:
  name: fedora-vm
  namespace: example-namespace
```

```
# ...
spec:
  template:
    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**.

2. Create the VM by running the following command:

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

### 11.4.2. Defining a watchdog

You can define a watchdog to monitor the health of the guest operating system by performing the following steps:

1. Configure a watchdog device for the virtual machine (VM).
2. 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.

#### 11.4.2.1. 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
     ```

#### 11.4.2.2. 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
   ```

## 11.5. OPENSHIFT 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 in the **Virtualization → Overview** tab in the web console.

### 11.5.1. 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.

## 11.5.2. 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. Find Containerized Data Importer (CDI) pods with more than three restarts:

```
$ oc get pods --all-namespaces -l app=containerized-data-importer -o=jsonpath='{range
.items[?(@.status.containerStatuses[0].restartCount>3)]}{.metadata.name}{"/"}
{.metadata.namespace}{"\n"}'
```

2. Obtain the details of the pods:

```
$ oc -n <namespace> describe pods <pod>
```

3. Check the pod logs for error messages:

```
$ oc -n <namespace> 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.

### 11.5.3. CDIDefaultStorageClassDegraded

**Meaning**
This alert fires when there is no default storage class that supports smart cloning (CSI or snapshot-based) or the ReadWriteMany access mode.

**Impact**
If the default storage class does not support smart cloning, the default cloning method is host-assisted cloning, which is much less efficient.

If the default storage class does not support ReadWriteMany, virtual machines (VMs) cannot be live migrated.

**NOTE**

A default OpenShift Virtualization storage class has precedence over a default Red Hat OpenShift Service on AWS storage class when creating a VM disk.

**Diagnosis**

1. Get the default OpenShift Virtualization storage class by running the following command:

```
$ oc get sc -o jsonpath='{.items[?(@.metadata.annotations.storageclass\.kubevirt\.io/is-default-virt-class=="true")].metadata.name}'
```

2. If a default OpenShift Virtualization storage class exists, check that it supports ReadWriteMany by running the following command:

```
$ oc get storageprofile <storage_class> -o json | jq '.status.claimPropertySets'| grep ReadWriteMany
```

3. If there is no default OpenShift Virtualization storage class, get the default Red Hat OpenShift Service on AWS storage class by running the following command:

```
$ oc get sc -o jsonpath='{.items[?(@.metadata.annotations.storageclass\.kubevirt\.io/is-default-class=="true")].metadata.name}'
```

4. If a default Red Hat OpenShift Service on AWS storage class exists, check that it supports ReadWriteMany by running the following command:

```
$ oc get storageprofile <storage_class> -o json | jq '.status.claimPropertySets'| grep ReadWriteMany
```

**Mitigation**

Ensure that you have a default storage class, either Red Hat OpenShift Service on AWS or OpenShift Virtualization, and that the default storage class supports smart cloning and ReadWriteMany.

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.

### 11.5.4. CDIMultipleDefaultVirtStorageClasses

**Meaning**

This alert fires when more than one storage class has the annotation **storageclass.kubevirt.io/is-default-virt-class: "true"**.

**Impact**

The **storageclass.kubevirt.io/is-default-virt-class: "true"** annotation defines a default OpenShift Virtualization storage class.

If more than one default OpenShift Virtualization storage class is defined, a data volume with no storage class specified receives the most recently created default storage class.

**Diagnosis**

Obtain a list of default OpenShift Virtualization storage classes by running the following command:

```
$ oc get sc -o jsonpath='{.items[?(@.metadata.annotations.storageclass\.kubevirt\.io/is-default-virt-class=="true")].metadata.name}'
```

**Mitigation**

Ensure that only one default OpenShift Virtualization storage class is defined by removing the annotation from the other storage classes.

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.

### 11.5.5. CDINoDefaultStorageClass

**Meaning**

This alert fires when no default Red Hat OpenShift Service on AWS or OpenShift Virtualization storage class is defined.

**Impact**

If no default Red Hat OpenShift Service on AWS or OpenShift Virtualization storage class is defined, a data volume requesting a default storage class (the storage class is not specified), remains in a "pending" state.

**Diagnosis**

1. Check for a default Red Hat OpenShift Service on AWS storage class by running the following command:

   ```
   $ oc get sc -o jsonpath='{.items[?(@.metadata.annotations.storageclass\.kubevirt\.io/is-default-class=="true")].metadata.name}'
   ```

2. Check for a default OpenShift Virtualization storage class by running the following command:

   ```
   $ oc get sc -o jsonpath='{.items[?(@.metadata.annotations.storageclass\.kubevirt\.io/is-default-virt-class=="true")].metadata.name}'
   ```

**Mitigation**
Create a default storage class for either Red Hat OpenShift Service on AWS or OpenShift Virtualization or for both.

A default OpenShift Virtualization storage class has precedence over a default Red Hat OpenShift Service on AWS storage class for creating a virtual machine disk image.

- Create a default Red Hat OpenShift Service on AWS storage class by running the following command:

  ```
  $ oc patch storageclass <storage-class-name> -p '{"metadata": {"annotations":
  {"storageclass.kubernetes.io/is-default-class":"true"}}}'
  ```

- Create a default OpenShift Virtualization storage class by running the following command:

  ```
  $ oc patch storageclass <storage-class-name> -p '{"metadata": {"annotations":
  {"storageclass.kubevirt.io/is-default-virt-class":"true"}}}'
  ```

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.

### 11.5.6. 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.

### 11.5.7. 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**

1. Set the **CDI_NAMESPACE** environment variable:

```
$ export CDI_NAMESPACE="$(oc get deployment -A | grep cdi-operator | \
  awk '{print $1}')"
```

2. Check whether the **cdi-operator** pod is currently running:

```
$ oc -n $CDI_NAMESPACE get pods -l name=cdi-operator
```

3. Obtain the details of the **cdi-operator** pod:

```
$ oc -n $CDI_NAMESPACE describe pods -l name=cdi-operator
```

4. 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.

### 11.5.8. 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 <storage_class> --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.

### 11.5.9. 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.

### 11.5.10. HCOInstallationIncomplete

**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.

### 11.5.11. 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.

### 11.5.12. HPPOperatorDown

**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.

### 11.5.13. HPPSharingPoolPathWithOS

**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.

### 11.5.14. 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}')"
```

2. Set the **KMP_NAME** environment variable:

```
$ export KMP_NAME="$(oc get pod -A --no-headers -l \
  control-plane=mac-controller-manager | awk '{print $2}')"
```

3. Obtain the **KubeMacPool-manager** pod details:

```
$ oc describe pod -n $KMP_NAMESPACE $KMP_NAME
```

–

4. 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.

### 11.5.15. 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**

1. 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"
```

2. 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**

1. Update the VMs to remove the duplicate MAC addresses.

2. Restart the **kubemacpool-mac-controller** pod:

```
$ oc delete pod -n <namespace> <kubemacpool_mac_controller>
```

### 11.5.16. 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.

### 11.5.17. 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.

### 11.5.18. KubeVirtCRModified

**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.

### 11.5.19. KubeVirtDeprecatedAPIRequested

**Meaning**
This alert fires when a deprecated **KubeVirt** API is used.

**Impact**
Using a deprecated API is not recommended because the request will fail when the API is removed in a future release.

**Diagnosis**

- Check the **Description** and **Summary** sections of the alert to identify the deprecated API as in the following example:
  **Description**

  **Detected requests to the deprecated virtualmachines.kubevirt.io/v1alpha3 API.**

  **Summary**

  **2 requests were detected in the last 10 minutes.**

**Mitigation**
Use fully supported APIs. The alert resolves itself after 10 minutes if the deprecated API is not used.

### 11.5.20. KubeVirtNoAvailableNodesToRunVMs

**Meaning**
This alert fires when the node CPUs in the cluster do not support virtualization or the virtualization extensions are not enabled.

#### Impact

The nodes must support virtualization and the virtualization features must be enabled in the BIOS to run virtual machines (VMs).

#### Diagnosis

- Check the nodes for hardware virtualization support:

```
$ oc get nodes -o json|jq '.items[]|{"name": .metadata.name, "kvm":
.status.allocatable["devices.kubevirt.io/kvm"]}'
```

**Example output**

```
{
  "name": "shift-vwpsz-master-0",
  "kvm": null
}
{
  "name": "shift-vwpsz-master-1",
  "kvm": null
}
{
  "name": "shift-vwpsz-master-2",
  "kvm": null
}
{
  "name": "shift-vwpsz-worker-8bxkp",
  "kvm": "1k"
}
{
  "name": "shift-vwpsz-worker-ctgmc",
  "kvm": "1k"
}
{
  "name": "shift-vwpsz-worker-gl5zl",
  "kvm": "1k"
}
```

Nodes with **"kvm": null** or **"kvm": 0** do not support virtualization extensions.

Nodes with **"kvm": "1k"** do support virtualization extensions.

#### Mitigation

Ensure that hardware and CPU virtualization extensions are enabled on all nodes and that the nodes are correctly labeled.

See OpenShift Virtualization reports no nodes are available, cannot start VMs for details.

If you cannot resolve the issue, log in to the Customer Portal and open a support case.

### 11.5.21. 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**

1. Obtain the **virt-launcher** pod details:

```
$ oc get pod <virt-launcher> -o yaml
```

2. 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
```

### 11.5.22. 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**

1. 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"
}
```

2. 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"
}
```

3. Log in to the worker node and verify that the **kubelet** service is running:

```
$ systemctl status kubelet
```

4. 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.

### 11.5.23. 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.

### 11.5.24. 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.

### 11.5.25. 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**

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. Obtain the details 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.

### 11.5.26. 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**

1. Set the **NAMESPACE** environment variable:

```
$ export NAMESPACE="$(oc get kubevirt -A \
  -o custom-columns="":.metadata.namespace)"
```

2. Check the number of available **virt-api** pods:

```
$ oc get deployment -n $NAMESPACE virt-api \
  -o jsonpath='{.status.readyReplicas}'
```

3. 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.

### 11.5.27. 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 create 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.

### 11.5.28. 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.

### 11.5.29. 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.

### 11.5.30. 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.

### 11.5.31. 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.

### 11.5.32. 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 not 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.

### 11.5.33. 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.

### 11.5.34. 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 --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):

```
$ virtctl 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.

### 11.5.35. SingleStackIPv6Unsupported

**Meaning**
This alert fires when you install OpenShift Virtualization on a single stack IPv6 cluster.

**Impact**
You cannot create virtual machines.

**Diagnosis**

- Check the cluster network configuration by running the following command:

```
$ oc get network.config cluster -o yaml
```

The output displays only an IPv6 CIDR for the cluster network.

**Example output**

```
apiVersion: config.openshift.io/v1
kind: Network
```

```
metadata:
  name: cluster
spec:
  clusterNetwork:
  - cidr: fd02::/48
    hostPrefix: 64
```

**Mitigation**
Install OpenShift Virtualization on a single stack IPv4 cluster or on a dual stack IPv4/IPv6 cluster.

### 11.5.36. 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.

### 11.5.37. 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.

### 11.5.38. 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.

### 11.5.39. 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.

### 11.5.40. 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.

### 11.5.41. UnsupportedHCOModification

**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.

### 11.5.42. 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.

### 11.5.43. 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.

### 11.5.44. 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.

### 11.5.45. 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.

### 11.5.46. 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.

### 11.5.47. 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.

### 11.5.48. 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.

### 11.5.49. 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.

## 11.5.50. 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. List the available **virt-handler** pods to identify the failing **virt-handler** pod:

```
$ oc get pods -n $NAMESPACE -l=kubevirt.io=virt-handler
```

3. Check the failing **virt-handler** pod log for API server connectivity errors:

```
$ oc logs -n $NAMESPACE <virt-handler>
```

Example error message:

```
{"component":"virt-handler","level":"error","msg":"Can't patch node my-
node","pos":"heartbeat.go:96","reason":"the server has received too many API requests and
has asked us to try again later","timestamp":"2023-11-
06T11:11:41.099883Z","uid":"132c50c2-8d82-4e49-8857-dc737adcd6cc"}
```

**Mitigation**
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.

### 11.5.51. 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.

### 11.5.52. 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.

### 11.5.53. 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

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.

### 11.5.54. 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**

1. Check the VMI configuration to determine whether the value of **evictionStrategy** is **LiveMigrate**:

```
$ oc get vmis -o yaml
```

2. 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 **None** or resolve the issue that prevents the VMI from migrating. The **None** startegy shuts down VMs in case of node drains and pod evictions.

### 11.5.55. VMStorageClassWarning

**Meaning**

This alert fires when the storage class is incorrectly configured. A system-wide, shared dummy page causes CRC errors when data is written and read across different processes or threads.

**Impact**

A large number of CRC errors might cause the cluster to display severe performance degradation.

### Diagnosis

1. Navigate to **Observe** → **Metrics** in the web console.

2. Obtain a list of virtual machines with incorrectly configured storage classes by running the following PromQL query:

   ```
   kubevirt_ssp_vm_rbd_volume{rxbounce_enabled="false", volume_mode="Block"} == 1
   ```

   The output displays a list of virtual machines that use a storage class without **rxbounce_enabled**.

   **Example output**

   ```
   kubevirt_ssp_vm_rbd_volume{name="testvmi-gwgdqp22k7", namespace="test_ns",
   pv_name="testvmi-gwgdqp22k7", rxbounce_enabled="false", volume_mode="Block"} 1
   ```

3. Obtain the storage class name by running the following command:

   ```
   $ oc get pv <pv_name> -o=jsonpath='{.spec.storageClassName}'
   ```

### Mitigation

Create a default OpenShift Virtualization storage class with the **krbd:rxbounce** map option. See Optimizing ODF PersistentVolumes for Windows VMs for details.

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.

# CHAPTER 12. SUPPORT

## 12.1. 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.

### 12.1.1. Web console

The Red Hat OpenShift Service on AWS web console displays resource usage, alerts, events, and trends for your cluster and for OpenShift Virtualization components and resources.

**Table 12.1. Web console pages for monitoring and troubleshooting**

| Page | Description |
|---|---|
| **Overview** page | Cluster details, status, alerts, inventory, and resource usage |
| **Virtualization** → **Overview** tab | OpenShift Virtualization resources, usage, alerts, and status |
| **Virtualization** → **Top consumers** tab | Top consumers of CPU, memory, and storage |
| **Virtualization** → **Migrations** tab | Progress of live migrations |
| **VirtualMachines** → **VirtualMachine** → **VirtualMachine details** → **Metrics** tab | VM resource usage, storage, network, and migration |
| **VirtualMachines** → **VirtualMachine** → **VirtualMachine details** → **Events** tab | List of VM events |
| **VirtualMachines** → **VirtualMachine** → **VirtualMachine details** → **Diagnostics** tab | VM status conditions and volume snapshot status |

### 12.1.2. 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 Red Hat OpenShift Service on AWS and OpenShift Virtualization.

**Collecting data about VMs**

Collect **must-gather** data and memory dumps from VMs.

### 12.1.3. 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.

**Troubleshooting data volumes**

Troubleshoot data volumes by analyzing conditions and events.

## 12.2. COLLECTING DATA FOR RED HAT SUPPORT

When you submit a support case to Red Hat Support, it is helpful to provide debugging information for Red Hat OpenShift Service on AWS and OpenShift Virtualization by using the following tools:

**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 Red Hat OpenShift Service on AWS monitoring stack, see About Red Hat OpenShift Service on AWS monitoring.

### 12.2.1. 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**

- Collect Prometheus metrics for the cluster.

### 12.2.2. 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, connect by using the desktop viewer to determine whether there is a problem with the connection software.

**Procedure**

1. Collect screenshots of VMs that have crashed *before* you restart them.
2. Collect memory dumps from VMs *before* remediation attempts.
3. Record factors that the malfunctioning VMs have in common. For example, the VMs have the same host or network.

## 12.3. TROUBLESHOOTING

OpenShift Virtualization provides tools and logs for troubleshooting virtual machines (VMs) 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.

### 12.3.1. Events

Red Hat OpenShift Service on AWS 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>
  ```

### 12.3.2. Pod logs

You can view logs for OpenShift Virtualization pods by using the web console or the CLI. You can also view aggregated logs by using the LokiStack in the web console.

#### 12.3.2.1. 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**

1. 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
```

2. 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.

3. Apply your changes by saving and exiting the editor.

#### 12.3.2.2. Viewing virt-launcher pod logs with the web console

You can view the **virt-launcher** pod logs for a virtual machine by using the Red Hat OpenShift Service on AWS web console.

**Procedure**

1. Navigate to **Virtualization** → **VirtualMachines**.
2. Select a virtual machine to open the **VirtualMachine details** page.
3. On the **General** tile, click the pod name to open the **Pod details** page.
4. Click the **Logs** tab to view the logs.

#### 12.3.2.3. Viewing OpenShift Virtualization pod logs with the CLI

You can view logs for the OpenShift Virtualization pods by using the **oc** CLI tool.

**Procedure**

1. View a list of pods in the OpenShift Virtualization namespace by running the following command:

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

–

**Example 12.1. 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
```

2. 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 12.2. 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 mtrr: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"}
```

### 12.3.3. Guest system logs

Viewing the boot logs of VM guests can help diagnose issues. You can configure access to guests' logs and view them by using either the Red Hat OpenShift Service on AWS web console or the **oc** CLI.

This feature is disabled by default. If a VM does not explicitly have this setting enabled or disabled, it inherits the cluster-wide default setting.

IMPORTANT

If sensitive information such as credentials or other personally identifiable information (PII) is written to the serial console, it is logged with all other visible text. Red Hat recommends using SSH to send sensitive data instead of the serial console.

##### 12.3.3.1. Enabling default access to VM guest system logs with the web console

You can enable default access to VM guest system logs by using the web console.

**Procedure**

1. From the side menu, click **Virtualization** → **Overview**.
2. Click the **Settings** tab.
3. Click **Cluster** → **Guest management**.
4. Set **Enable guest system log access**to on.

##### 12.3.3.2. Enabling default access to VM guest system logs with the CLI

You can enable default access to VM guest system logs 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. Update the **disableSerialConsoleLog** value. For example:

```
kind: HyperConverged
metadata:
  name: kubevirt-hyperconverged
spec:
  virtualMachineOptions:
    disableSerialConsoleLog: true (1)
#...
```

(1) Set the value of **disableSerialConsoleLog** to **false** if you want serial console access to be enabled on VMs by default.

##### 12.3.3.3. Setting guest system log access for a single VM with the web console

You can configure access to VM guest system logs for a single VM by using the web console. This setting takes precedence over the cluster-wide default configuration.

**Procedure**

1. Click **Virtualization** → **VirtualMachines** from the side menu.
2. Select a virtual machine to open the **VirtualMachine details** page.
3. Click the **Configuration** tab.
4. Set **Guest system log access** to on or off.

#### 12.3.3.4. Setting guest system log access for a single VM with the CLI

You can configure access to VM guest system logs for a single VM by editing the **VirtualMachine** CR. This setting takes precedence over the cluster-wide default configuration.

**Procedure**

1. Edit the virtual machine manifest by running the following command:

   ```
   $ oc edit vm <vm_name>
   ```

2. Update the value of the **logSerialConsole** field. For example:

   ```
   apiVersion: kubevirt.io/v1
   kind: VirtualMachine
   metadata:
     name: example-vm
   spec:
     template:
       spec:
         domain:
           devices:
             logSerialConsole: true (1)
   #...
   ```

   (1) To enable access to the guest's serial console log, set the **logSerialConsole** value to **true**.

3. Apply the new configuration to the VM by running the following command:

   ```
   $ oc apply vm <vm_name>
   ```

4. Optional: If you edited a running VM, restart the VM to apply the new configuration. For example:

   ```
   $ virtctl restart <vm_name> -n <namespace>
   ```

#### 12.3.3.5. Viewing guest system logs with the web console

You can view the serial console logs of a virtual machine (VM) guest by using the web console.

**Prerequisites**

- Guest system log access is enabled.

**Procedure**

1. Click **Virtualization** → **VirtualMachines** from the side menu.
2. Select a virtual machine to open the **VirtualMachine details** page.
3. Click the **Diagnostics** tab.
4. Click **Guest system logs** to load the serial console.

#### 12.3.3.6. Viewing guest system logs with the CLI

You can view the serial console logs of a VM guest by running the **oc logs** command.

**Prerequisites**

- Guest system log access is enabled.

**Procedure**

- View the logs by running the following command, substituting your own values for **<namespace>** and **<vm_name>**:

  ```
  $ oc logs -n <namespace> -l kubevirt.io/domain=<vm_name> --tail=-1 -c guest-console-log
  ```

### 12.3.4. Log aggregation

You can facilitate troubleshooting by aggregating and filtering logs.

#### 12.3.4.1. 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.

#### 12.3.4.2. 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 12.2. OpenShift Virtualization LogQL example queries

| Component | LogQL query |
|---|---|
| All | `{log_type=~".+"}\|json \|kubernetes_labels_app_kubernetes_io_part_of="hyperconverged-cluster"` |
| **cdi-apiserver**<br><br>**cdi-deployment**<br><br>**cdi-operator** | `{log_type=~".+"}\|json \|kubernetes_labels_app_kubernetes_io_part_of="hyperconverged-cluster" \|kubernetes_labels_app_kubernetes_io_component="storage"` |
| **hco-operator** | `{log_type=~".+"}\|json \|kubernetes_labels_app_kubernetes_io_part_of="hyperconverged-cluster" \|kubernetes_labels_app_kubernetes_io_component="deployment"` |
| **kubemacpool** | `{log_type=~".+"}\|json \|kubernetes_labels_app_kubernetes_io_part_of="hyperconverged-cluster" \|kubernetes_labels_app_kubernetes_io_component="network"` |
| **virt-api**<br><br>**virt-controller**<br><br>**virt-handler**<br><br>**virt-operator** | `{log_type=~".+"}\|json \|kubernetes_labels_app_kubernetes_io_part_of="hyperconverged-cluster" \|kubernetes_labels_app_kubernetes_io_component="compute"` |
| **ssp-operator** | `{log_type=~".+"}\|json \|kubernetes_labels_app_kubernetes_io_part_of="hyperconverged-cluster" \|kubernetes_labels_app_kubernetes_io_component="schedule"` |

| Component | LogQL query |
|---|---|
| Container | `{log_type=~".+",kubernetes_container_name=~"<container>\|<container>"}` (1) `\|json\|kubernetes_labels_app_kubernetes_io_part_of="hyperconverged-cluster"`<br>(1) Specify one or more containers separated by a pipe (**\|**). |
| **virt-launcher** | You must select **application** from the log type list before running this query.<br>`{log_type=~".+", kubernetes_container_name="compute"}\|json` `\|!= "custom-ga-command"` (1)<br>(1) **\|!= "custom-ga-command"** excludes libvirt logs that contain the string**custom-ga-command**. (BZ#2177684) |

You can filter log lines to include or exclude strings or regular expressions by using line filter expressions.

Table 12.3. Line filter expressions

| Line filter expression | Description |
|---|---|
| **\|= "<string>"** | Log line contains string |
| **!= "<string>"** | Log line does not contain string |
| **\|~ "<regex>"** | Log line contains regular expression |
| **!~ "<regex>"** | 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"
```

### Additional resources for LokiStack and LogQL

- About log storage
- Deploying the LokiStack
- LogQL log queries in the Grafana documentation

### 12.3.5. 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.

### 12.3.6. Troubleshooting data volumes

You can check the **Conditions** and **Events** sections of the **DataVolume** object to analyze and resolve issues.

#### 12.3.6.1. 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 contains **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.

#### 12.3.6.2. 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
  ```

# CHAPTER 13. BACKUP AND RESTORE

## 13.1. BACKUP AND RESTORE BY USING VM SNAPSHOTS

You can back up and restore virtual machines (VMs) by using snapshots. Snapshots are supported by the following storage providers:

- Any 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.

To create snapshots of an online (Running state) VM with the highest integrity, install the QEMU guest agent if it is not included with your operating system. The QEMU guest agent is included with the default Red Hat templates.

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.

### 13.1.1. About 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.

You can perform the following snapshot actions:

- Create a new snapshot
- Create a copy of a virtual machine from a snapshot
- List all snapshots attached to a specific VM
- Restore a VM from a snapshot
- Delete an existing VM snapshot

### VM snapshot controller and custom resources

The VM snapshot feature introduces three new API objects defined as custom resource definitions (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.

## 13.1.2. Creating snapshots

You can create snapshots of virtual machines (VMs) by using the Red Hat OpenShift Service on AWS web console or the command line.

### 13.1.2.1. Creating a snapshot by using the web console

You can create a snapshot of a virtual machine (VM) by using the Red Hat OpenShift Service on AWS web console.

The VM snapshot includes disks that meet the following requirements:

- Either a data volume or a persistent volume claim
- Belong to a storage class that supports Container Storage Interface (CSI) volume snapshots

**Procedure**

1. Navigate to **Virtualization** → **VirtualMachines** in the web console.
2. Select a VM to open the **VirtualMachine details** page.
3. If the VM is running, click the options menu ⋮ and select **Stop** to power it down.
4. Click the **Snapshots** tab and then click **Take Snapshot**.
5. Enter the snapshot name.
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 wish to proceed, select **I am aware of this warning and wish to proceed**.
8. Click **Save**.

### 13.1.2.2. Creating a snapshot by using the command line

You can create a virtual machine (VM) snapshot for an offline or online VM by creating a **VirtualMachineSnapshot** object.

### 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 as in the following example:

   ```
   apiVersion: snapshot.kubevirt.io/v1alpha1
   kind: VirtualMachineSnapshot
   metadata:
     name: <snapshot_name>
   spec:
     source:
       apiGroup: kubevirt.io
       kind: VirtualMachine
       name: <vm_name>
   ```

2. Create the **VirtualMachineSnapshot** object:

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

   The snapshot controller creates a **VirtualMachineSnapshotContent** object, binds it to the **VirtualMachineSnapshot**, and updates the **status** and **readyToUse** fields of the **VirtualMachineSnapshot** object.

3. Optional: If you are taking an online snapshot, you can use the **wait** command and monitor the status of the snapshot:

   a. Enter the following command:

      ```
      $ oc wait <vm_name> <snapshot_name> --for condition=Ready
      ```

   b. 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 operaton 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

1. Verify that the **VirtualMachineSnapshot** object is created and bound with **VirtualMachineSnapshotContent** and that the **readyToUse** flag is set to **true**:

```
$ oc describe vmsnapshot <snapshot_name>
```

**Example output**

```
apiVersion: snapshot.kubevirt.io/v1alpha1
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/v1alpha1/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.

### 13.1.3. Verifying online snapshots by using 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

- You must have attempted to create an online VM snapshot.

#### Procedure

1. Display the output from the snapshot indications by performing one of the following actions:
   - Use the command line to view indicator output in the **status** stanza of the **VirtualMachineSnapshot** object YAML.
   - In the web console, click **VirtualMachineSnapshot** → **Status** in the **Snapshot details** screen.
2. Verify the status of your online VM snapshot by viewing the values of the **status.indications** parameter:
   - **Online** indicates that the VM was running during online snapshot creation.
   - **GuestAgent** indicates that the QEMU guest agent 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.

### 13.1.4. Restoring virtual machines from snapshots

You can restore virtual machines (VMs) from snapshots by using the Red Hat OpenShift Service on AWS web console or the command line.

#### 13.1.4.1. Restoring a VM from a snapshot by using the web console

You can restore a virtual machine (VM) to a previous configuration represented by a snapshot in the Red Hat OpenShift Service on AWS web console.

**Procedure**

1. Navigate to **Virtualization → VirtualMachines** in the web console.
2. Select a VM to open the **VirtualMachine details** page.
3. If the VM is running, click the options menu ⋮ and select **Stop** to power it down.
4. Click the **Snapshots** tab to view a list of snapshots associated with the VM.
5. Select a snapshot to open the **Snapshot Details** screen.
6. Click the options menu ⋮ and select **Restore VirtualMachine from snapshot**
7. Click **Restore**.

#### 13.1.4.2. Restoring a VM from a snapshot by using the command line

You can restore an existing virtual machine (VM) to a previous configuration by using the command line. You can only restore from an offline VM snapshot.

**Prerequisites**

- Power down the VM you want to restore.

**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 as in the following example:

```
apiVersion: snapshot.kubevirt.io/v1beta1
kind: VirtualMachineRestore
metadata:
  name: <vm_restore>
spec:
  target:
    apiGroup: kubevirt.io
    kind: VirtualMachine
    name: <vm_name>
  virtualMachineSnapshotName: <snapshot_name>
```

2. Create the **VirtualMachineRestore** object:

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

The snapshot controller updates the status fields of the **VirtualMachineRestore** object and replaces the existing VM configuration with the snapshot content.

## Verification

- Verify that the VM is restored to the previous state represented by the snapshot and that the **complete** flag is set to **true**:

```
$ oc get vmrestore <vm_restore>
```

### Example output

```
apiVersion: snapshot.kubevirt.io/v1alpha1
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/v1alpha1/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.

### 13.1.5. Deleting snapshots

You can delete snapshots of virtual machines (VMs) by using the Red Hat OpenShift Service on AWS web console or the command line.

#### 13.1.5.1. Deleting a snapshot by using the web console

You can delete an existing virtual machine (VM) snapshot by using the web console.

**Procedure**

1. Navigate to **Virtualization** → **VirtualMachines** in the web console.
2. Select a VM to open the **VirtualMachine details** page.
3. Click the **Snapshots** tab to view a list of snapshots associated with the VM.
4. Click the options menu ⋮ beside a snapshot and select **Delete snapshot**.
5. Click **Delete**.

#### 13.1.5.2. 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:

  ```
  $ oc delete vmsnapshot <snapshot_name>
  ```

  The snapshot controller deletes the **VirtualMachineSnapshot** along with the associated **VirtualMachineSnapshotContent** object.

### Verification

- Verify that the snapshot is deleted and no longer attached to this VM:

  ```
  $ oc get vmsnapshot
  ```